Handbook of Research on

Healthcare Administration and Management



Nilmini Wickramasinghe

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Handbook of Research on Healthcare Administration and Management

Nilmini Wickramasinghe
Epworth HealthCare, Australia & Deakin University, Australia

A volume in the Advances in Healthcare Information Systems and Administration (AHISA) Book Series



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Hellenic Society for Quality & Safety in Healthcare and P. & A. Kyriakou Children's Hospital, Greece

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For Goody & To the Memory of Aunty Nina

May 2016

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With the plethora of mHealth solutions developed being digital, this necessitates the need for accurate data and information integrity. Lack of data accuracy and information integrity in mHealth can cause serious harm to patients and limit the benefits of such promising technology. Thus, this exploratory study investigates data accuracy and information integrity in mHealth by examining a mobile health solution for diabetes, with the aim of incorporating Machine Learning to detect sources of inaccurate data and deliver quality information.

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Mohamad Rahim Hatami, Iran Medical School of Science, Iran

Breast cancer is a major health issue in all countries affecting thousands of women. Its causes are unknown and the national and international strategies to reduce its morbidity and mortality levels are based on early detection of cancer through screening and treatment according to clinical guidelines. Thus, knowledge of which women are at risk and why they are at risk is therefore essential component of disease prevention and screening. In 2015, an estimated 231,840 new cases of invasive breast cancer are expected to be diagnosed in women in the United States, along with 60,290 new cases of non-invasive (in situ) breast cancer. The purpose of this study is to provide a more detailed analysis of the breast cancer distribution in the United States by comparing the spatial distribution of breast cancer cases against physical environmental factors using Geographic Information System (GIS). Further, it gives background information to the GIS and its applications in health-related research.

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This chapter discusses clinical practice guidelines (CPGs) and their incorporation into healthcare IT (HIT) applications. CPGs provide guidance on treatment options based on evidence. This chapter provides a brief background on challenges in CPG development and adherence, and offers examples of data-driven approaches to improve usability of CPGs and their applications in HIT. A focus is given to clinical pathways, which translate CPG recommendations into actionable plans for patient management in community practices. Approaches for developing data-driven clinical pathways from electronic health record data are presented, including statistical, process mining, and machine learning algorithms. Further, efforts on using CPGs for decision support through visual analytics, and deployments of CPGs into mobile applications are described. Data-driven approaches can facilitate incorporation of practice-based evidence into CPG development after validation by clinical experts, potentially bridging the gap between available CPGs and changing clinical needs and workflow management.

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Healthcare big data streams from multiple information sources at an alarming volume, velocity, and variety. The challenge that faces the healthcare industry is extracting meaningful value from such sources. This chapter investigates the diversity and forms of data in the healthcare sector, reviews the methods used to search and analyze these data throughout the past years, and the use of machine learning and data mining techniques to mine useful knowledge from such data. The chapter will also highlight innovations of particular systems and tools which spot the fine approaches for different healthcare data, raise the standard of care and recap the tools and data collection methods. The authors emphasize some of ethical issues regarding processing these records and some data privacy issues.

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Leveraging Key Aspects of Collaborative Techniques to Assist Clinical Decisions..... 59
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Employing collaborative systems in healthcare contexts is an important approach towards designing and developing intelligent computer solutions. The objective of this study is to develop a real-time collaborative system using the Intelligent Risk Detection Model (IRD) to improve decision efficiency for the care of patients undergoing hip and knee arthroplasty (THA, TKA). Expected benefits include increasing awareness, supporting communication, improving decision making processes and also improving information sharing between surgeons, patients, families and consultants as key collaborative parties. The research question under investigation is: How can key information technologies be designed, developed and adopted to support clinical decision making in the context of THA and TKA? This research in progress has identified the value and benefit of developing a systematic and technology supported tool to facilitate the identification of various risks associated with THA and TKA.

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According to WHO, there are 60 - 80 million infertile couples worldwide with the highest incidence in some regions of Sub-Saharan Africa. The social stigma of infertility weighs especially heavily on women, who bear the sole blame for barren marriages in many developing countries and may face divorce as a result. Interviews were conducted with gynecologists at one of the Teaching Hospitals in Nigeria in order to identify likelihood variables for infertility. 14 risk factors were identified and data collected from 39 patients from the hospital was pre-processed and the variables used to formulate the predictive model for the likelihood of infertility in women using three different decision trees algorithms. The predictive model was simulated using WEKA environment. The results revealed that C4.5 algorithm had the highest accuracy of 74.4% while the least performance was for the random tree algorithm with a value of 53.8%. This chapter presents a predictive model which can assist gynecologists in making more objective decisions concerning infertility likelihood.

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Topic of discussions over the last decades, the literature related to the care of patients suffering from poly-trauma, under the assistance point of view, is sufficiently consolidated concerning to the adoption of best practices, what, usually are conducted and disseminated by accrediting organizations. However, expanding the search frontier beyond the assistance dimension, it's noticed the divergences between the recent researches or theoretical shortcomings regarding to the design and management of these operations. In face of this finding, noticed from a literature review in the most important bases of operations management and health, it's adopted a conceptual model which covers relevant elements of the project of an operation, such as: strategy, capacity, human resources, incentive systems, organizational structure and decision making; in order to systematize the current stage of the field, highlighting the differences between recent studies and proposing a set of practices and premises, which are necessary for the operationalization of the proposed model.

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This chapter explains the overview of Lean production; the overview of value stream mapping (VSM); the applications of Lean production in global health care; the implementation of Lean production in global health care; and the challenges and implications of Lean production in global health care. Lean production can be used to identify and eliminate the wastes in any health care activity performed within a health care facility. Lean production can be applied to hospitals and health care organizations

to redesign health care processes toward improving the quality of care and reducing costs and wastes. Successful Lean health care efforts result in the measurable improvements in patient outcomes, such as improved quality, less harm due to preventable errors, better access, shorter waiting times, and better service. Implementing Lean production has the potential to enhance health care performance and gain sustainable competitive advantage in global health care.

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New words are generated in quality & productivity every year. Some words point to basis & the words have an advertisement aspect for management consultant firms. Apart from these words, considering that the most important goal of any organization is obtaining (acquisition) high possible productivity or optimum productivity. We should have comprehensive & adequate acquaintance of organizational culture & present situation for making a choice of the best way of increasing productivity. We can say the way of increasing productivity is different in each organization considering important difference in organizational culture & present situation. In this chapter we explore productivity topic (subject) & practical mechanism for productivity establishment & ways of increasing productivity, then we survey established EFQM model (TQM) on Hasheminejad Hospital (Tehran, Iran) as a case study. Ultimately the first place (step) in attainment way toward excellence quality & productivity organization is presented based on output of questionnaire by utilization MADM methods.

Section 3
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The Importance of Telemedicine in Global Health Care 157
Kijpokin Kasemsap, Suan Sunandha Rajabhat University, Thailand

The chapter explains the challenges facing health care systems; the overview of telemedicine; the technological devices of telemedicine systems; telemedicine and chronic diseases; telemedicine and technology acceptance model (TAM); the applications of telemedicine in the oil and gas industry; and the importance of telemedicine in global health care. Telemedicine brings the health care value through its ability for the remote visits with patients, immediate access to health care professionals, real-time access to health data, and health monitoring capabilities. Telemedicine is an effective health care measure that can manage the new and affordable technology with the potential to deliver the convenient and effective care to patients, and provides an alternative way for the health care organizations to deliver the essential health outcomes. The chapter argues that applying telemedicine has the potential to increase health care performance and gain sustainable competitive advantage in global health care.

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What E-Mental Health Can Offer to Saudi Arabia Using an Example of Australian E-Mental Health 178
Yamam Abuzinadah, Ministry of Education, Saudi Arabia, & RMIT University, Australia
Bader Binhadyan, Ministry of Education, Saudi Arabia, & RMIT University, Australia
Nilmini Wickramasinghe, Epworth HealthCare, Australia & Deakin University, Australia

Mental health have become a very influential topic around the world due to the increase of mental health issues that have been reported through national research and surveys. Many studies have been done along the years around the barriers in regards to seeking help in deferent countries and communities. This research aims to look closely into these barriers targeting issues and potential solutions, specifically for Saudi Arabia. Recently, the use of e-mental health services have proven to be an effective method to improve is barriers to mental health treatment. However, this chapter addresses the application and suitably of e-mental health programs for Saudi Arabia mental health services. To do so, a case study of Australian e-mental health services was selected to assist with the investigations.

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Smart Medication Management, Current Technologies, and Future Directions 188
Seyed Ali Rokni, Washington State University, USA
Hassan Ghasemzadeh, Washington State University, USA
Niloofar Hezarjaribi, Washington State University, USA

Medication non-adherence is a major healthcare challenge with irreversible consequences in terms of healthcare costs and quality of care. While recent years have seen some effort in developing sensor-based technologies to detect medication adherence and provide interventions, the community lacks a comprehensive study on the clinical utility, reliability, and effectiveness of such medication intake monitoring solutions. Furthermore, many opportunities inspired machine learning algorithms have largely remained unexplored. In an effort to highlight these knowledge gaps, in this paper, we take an interdisciplinary approach to (1) review and compare existing engineering products for medication intake monitoring; (2) discuss clinical applications where such technologies have demonstrated to be effective; (3) explore research gaps and shed light on unmet needs and future research opportunities in the area of medication management from both clinical and technology development points of view. The results of this paper may open several new avenues in the area of technology-based medication.

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Chaotic Function Based ECG Encryption System 205
Butta Singh, Guru Nanak Dev University, India
Manjit Singh, Guru Nanak Dev University, India
Dixit Sharma, Guru Nanak Dev University, India

Remote health-care monitoring systems communicate biomedical information (e.g. Electrocardiogram (ECG)) over insecure networks. Protection of the integrity, authentication and confidentiality of the medical data is a challenging issue. This chapter proposed an encryption process having a 4-round five steps -encryption structure includes: the random pixel insertion, row separation, substitution of each separated row, row combination and rotation. Accuracy and security analysis of proposed method for 2D ECG encryption is evaluated on MIT-BIH arrhythmia database.

Chapter 14
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Kijpokin Kasemsap, Suan Sunandha Rajabhat University, Thailand

This chapter describes the overview of electronic health record (EHR); the trends and issues with EHR; EHR and clinical decision support system (CDSS); the trust and privacy concerns of EHR systems; and the significance of EHR in global health care. EHR systems are very important in health care settings and have the potential to transform the health care system from a mostly paper-based industry to the one that utilizes the clinical data and other pieces of information to assist health care providers in delivering the higher quality of care to their patients. EHRs and their ability to electronically exchange health information can help health care providers effectively provide higher quality and safer care for patients while creating tangible enhancements in global health care.

Chapter 15
The Development of a Secure Hospital Messaging and Communication Platform..... 243
Hoda Moghimi, RMIT University, Australia
Nilmini Wickramasinghe, Epworth HealthCare, Australia & Deakin University, Australia

Pagers and phone conversations have been the stalwarts of hospital communication. With good reason - they are simple, reliable and relatively inexpensive. However, with the increasing complexity of patient care, the need for greater speed and the general inexorable progress of health technology, hospital communication systems appear to be increasingly inefficient, non-secure, and inadequate. Thus, this study is proposed to answer the key research question: How can ICT (information communication technology) solutions ameliorate the current challenges regarding communication inefficiencies within healthcare? To answer this question, the study will design and develop a bespoke ICT solution for a specific context using three strong theories; communication theory, activity theory and agency theory to make a robust body of knowledge for the proposed solution. Further, it will serve to establish proof of concept, usability and feasibility of the proffered solution. The study participants will be selected from medical and nursing staff.

Chapter 16
Emerging Technologies and ICT Solutions in Healthcare..... 268
Dipali Bansal, Manav Rachna International University, India

The reaction of a human body under stress, on the onset of a disease or on being physically challenged is reflected by the fine changes in the human physiological parameters and hence is required to be repeatedly measured. The acquisition of data if done in real time enhances the sense of connectedness with the health care providers by sharing raw or interpreted physiological data. Emerging ICT tools in healthcare sector help in creating modular, software-defined test systems with improved throughput and flexibility for lesser overall costs. They also assist in designing advanced algorithms and developing prototype on off-the shelf hardware in a remarkable time frame. This chapter thus focuses on design and development of a system to acquire vital human physiological parameters like ECG, EMG and Carotid pulse waveform using latest technologically advanced ICT tools.

Chapter 17
Analyzing the Role of Health Information Technology in Global Health Care 287
Kijpokin Kasemsap, Suan Sunandha Rajabhat University, Thailand

This chapter explains the perspectives on global health, the overview of health information technology (health IT), the applications of electronic health record (EHR), and the importance of health IT in global health care. Health IT is the area of IT involving the design, development, creation, utilization, and maintenance of information systems for the health care industry. Health IT makes it possible for health care providers to better manage patient care through the secure use and sharing of health information. Effective health IT can lower costs, improve efficiency, and reduce medical error, while providing better patient care and service. The chapter argues that utilizing health IT has the potential to enhance health care performance and reach strategic goals in global health care.

Chapter 18
Health Information System 308
Aman Tyagi, Dayalbagh Educational Institute, India
Preetvanti Singh, Dayalbagh Educational Institute, India

Information systems (IS) help in managing healthcare costs and in improving the quality of care. IS are uniquely positioned to capture, store, process, and communicate timely information to decision makers for better coordination of healthcare at both the individual and population levels. One of the most interesting aspects of HIS (Health Information System) is how to manage the relationship between healthcare providers and patients. The main focus of this Chapter is a brief overview of Health Information Systems and the description of the techniques that can be used to develop the health information systems. There are various emerging tools and technologies in creating and managing HIS like data mining and geographical information system. Developing HIS can improve access for geographically isolated communities; provide support for health care workers; aid in data sharing; provide visual tools linking population and environmental information with disease outbreaks.

Chapter 19
Smart Technology for Non Invasive Biomedical Sensors to Measure Physiological Parameters 318
K Rajasekaran, Karunya University, India
Anitha Mary Xavier, Karunya University, India
R Jegan, Karunya University, India

Communication and Information technologies are transforming our lifestyles, social interactions, and workplaces. One of the promising applications of the information and communication technology is healthcare and wellness management. Advancement in electronic health care and mobile have made doctors and patients to involve the modern healthcare system by extending the capabilities of physiological monitoring devices. Various biomedical sensors are being used to measure the physiological parameters like pulse rate, blood glucose level, blood pressure etc., Among various bio-sensor, Researchers from different field of science are particularly and increasingly interested in Photoplethysmography (PPG) signals. This chapter addresses the importance of bio sensors and its principle, significance of remote monitoring of PPG signal using Radio Frequency (RF) and design challenges in RF connectivity. Also this chapter presents a reliable low power wireless transmission mechanism of biomedical signals which works on narrow band RF frequencies.

Section 4
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Investigating Acceptance of Nursing Information Systems through UTAUT Lens 349
Lemai Nguyen, Deakin University, Australia
Nilmini Wickramasinghe, Epworth HealthCare, Australia & Deakin University, Australia
Mary Botti, Deakin/Epworth Clinical Nursing Research Centre, Australia
Bernice Redley, Deakin University, Australia & Monash Health Partner, Australia
Peter Haddad, Epworth HealthCare, Australia
Imran Muhammad, Epworth HealthCare, Australia

It is widely known that nurses are pivotal in coordinating and communicating patient care information in the complex network of healthcare professionals and service delivery. Yet, despite their pivotal role, information communication technologies have historically rarely been designed around nurses' operational needs. This could explain the poor integration of technologies into nursing work processes and consequent rejection by nursing professionals. The complex nature of acute care delivery in hospitals and the frequently interrupted patterns of nursing work suggest that nurses require flexible intelligent systems that can support and adapt to their variable workflow patterns. This study is designed to explore nurses' initial reactions to a new integrated point of care solution for acute healthcare contexts. We report on the first stage of a longitudinal project to use an innovative approach involving nurses in the development and refinement of this solution. Unified Theory of Acceptance and Use of Technology was used to evaluate acceptability of the proposed system by nurses.

Chapter 21
Social Forces that Influence Health IT Use Behavior of the Elderly 369
Karoly Bozan, Idaho State University, USA
Bill Davey, RMIT University, Australia
Kevin R Parker, Idaho State University, USA

The social forces that influence patient portal use behavior among the elderly are not well understood. Using both institutional theory and the Unified Theory of Acceptance and Use of Technology, the proposed model examines three social environmental factors – normative, mimetic, and coercive forces – within a Health Information Technology (HIT) context. An empirical study involving 117 subjects in the United States was used to test the proposed model. Using the partial least squares method, mimetic and coercive pressures were found to significantly influence patient portal use behavior. These findings indicate that older people follow not only their providers' advice, but also follow the behavior of respected, higher-status peers from their network. Normative pressure was not found to be significant, implying that older people do not follow the bandwagon effect.

Chapter 22
Active and Healthy Aging: Satisfaction with Health Services by Elderly Patients in Turkey 384
Emine Özmete, Ankara University, Turkey

This study aims to investigate the difficulties experienced by elderly persons in accessing healthcare services and their satisfaction with issues as regards the healthcare system. In this study, qualitative research was carried out to assess the difficulties regarding the healthcare delivery system and satisfaction

with the healthcare services. This qualitative research was performed through in-depth interviews with 6 men and 4 women aged 65+ years, in Ankara, the capital city of Turkey. It was discovered that elderly persons required the support of others to access a doctor, a health institution or hospital and the care and support of others for the regular intake of their drugs with increasing age. They were satisfied with the current family physician program. The most significant challenges experienced by elderly persons regarding the healthcare delivery system included crowded hospitals, difficulty walking, the unavailability of wheel chairs, and inadequate assistance from support staff.

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Effecting Superior Pain Management Strategies by Combining Technology with Tradition..... 407
CK Foo, Honorary Health Informatics, Australia

Today we are witnessing a significant rise in chronic diseases and chronic pain. Modern medicine appears not to be sufficient to relieve symptoms and reduce or eliminate discomfort. The following proffers the need to look at alternate strategies. In particular, it suggests that a solution might lie if we combine modern technology with ancient wisdom and traditional approaches. This chapter serves to highlight strategies for prudent pain management. “Pain is not just from physical disorders but also from combinations of physiological, pathological, emotional, psychological, cognitive, environmental, and social factors. The keys to successful pain control are the mechanisms that initiate and maintain pain.” “Now, the public and health professionals expect to control pain by using preventive and active strategies, including drugs and physical and psychosocial interventions.” (Holdcroft & Power, 2003).

Chapter 24

The Potential of Crowdsourcing in the Health Care Industry..... 418
Kaushik Ghosh, Lamar University, USA
Kabir C. Sen, Lamar University, USA

Crowdsourcing has immense potential in the health care industry as it can tap into a vast global pool of knowledge to solve a wide variety of health care problems. This chapter first categorizes the different problems in the health care industry. It then describes some existing health care services and also discusses the future challenges that a typical crowdsourcing service could face. The chapter emphasizes the potential of crowdsourcing to disrupt old ideas and introduce new ones as well as a make a significant improvement in the social quality for different population groups.

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Trends of Social Media Applications in Healthcare: A Managerial Perspective..... 428
Mohamed Gamal Aboelmaged, Al Ghurair University, UAE
Suja Sarah Thomas, Al Ghurair University, UAE
Samia Elsheikh, Al Ghurair University, UAE

The twenty-first century has witnessed social media taking firm root into business and economic activity. It can no longer be considered as a tool for ‘social’ activity alone. Even governments have taken to it in order to open up communication channels with citizens and provide more effective services. The healthcare sector is a unique field where information sources and uses need to be handled with utmost care, as the risks extend not only to the healthcare provider, but more so to the recipient and others such as prospective recipients, the broader community, and regulators. Therefore, responsible use of social media in healthcare is critical, whether it be with respect to ‘customer’ relationship, marketing,

education, recruitment or community building. This chapter scrutinizes relevant literature, which has been published in various disciplines, to provide significant insight into the question of how social media can improve healthcare administration. Practical implications and opportunities for further research are also highlighted.

Chapter 26
Preventing Occupational Stress in Railway Engine Pilots: Issues at a Glance 448
Devesh Kumar, Diesel Locomotive Works, Indian Railways, India
Poonam Singh Kharwar, Banaras Hindu University, India

Traffic volume and speed is going to be increased in Indian Railways successively leading to higher stress in train operations. The jobs of railway pilots come under the category of high strain jobs, necessitating a need to conduct study to unfold factors associated with occupational stress. OSI test, questionnaire of specific stressors and laboratory test battery were used as tools. Means of OSI of railway pilots was significantly higher than OSI of train operation staff. Mean of OSI of goods train pilots was higher to means to those of high speed and passenger train pilots. Study revealed positive correlation of speed perception and complex reaction time tests, and negative correlation of other constituent tests of laboratory test battery to OSI test. Highest stressor observed is role overload followed by role conflict. These findings provide evidence of higher occupational stress among railway pilots because of identified specific stressors. Significant correlation noticed between OSI and laboratory test results indicates its utility in preliminary psychological screening.

Chapter 27
Hospital Social Media Strategies: Patient or Organization Centric? 458
Fay Cobb Payton, North Carolina State University, USA
Natasha Pinto, North Carolina State University, USA

This chapter describes the role social media plays in patient communication at hospitals. The chapter explores how social media platforms are used by national and local hospitals to deliver higher quality healthcare and increase patient engagement. Using an in-depth literature review and semi-structured interviews at two local hospitals, the chapter assesses how hospitals approach traditional and social media strategies. The chapter identifies the importance of using both online and offline communication strategies for the most comprehensive and effective delivery of healthcare. The chapter also includes a discussion of how social media has the ability to influence health information seeking and the patient-physician relationship.

Section 5
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A Factor Analytical Study of Safety and Health Issues in Select Small and Medium Manufacturing Concerns 467
Meha Joshi, Delhi Technological University, India
Ritu Bajaj, JIM'S, India

Safety and health are the important issues which must be taken up by the organizations to ensure satisfaction of the employees and also to ensure productivity in the organization. Particularly in small and medium

enterprises, these issues demand more concern as due to small size of firm, they are often neglected. This chapter gives an overview of small and medium enterprises in India, their role in the development of economy. Moreover, this chapter focuses on the importance of Safety and Health in the organization, how they are taken up as major concerns of the organization by International Labor Organization in the form of providing various conventions and ratifications and what are the various provisions regarding the same in the Factories Act in India. The outcome of the chapter is the factors which are particularly relevant for ensuring safety and health of employees in small and medium enterprises. For determining the factors, Factor analysis was performed on the data collected from the respondents with the help of questionnaire comprising of statements on Likert scale.

Chapter 29
Promoting Health Literacy in Global Health Care 485
Kijpokin Kasemsap, Suan Sunandha Rajabhat University, Thailand

This chapter emphasizes the prospect of health literacy; the evaluation of health literacy level; health literacy and health communication; health literacy and health information; and the current issues of health literacy in global health care. Good health literacy is important because patients are living longer and experiencing a wider range of health issues. Health professionals must commit to promoting for improved health literacy in health care organizations and should establish the specific health care goals toward improving health literacy in strategic plans, performance plans, programs, and educational initiatives. Health professionals can utilize a broad range of health communication strategies to ensure patients understand their options and share their health care decisions. Through health education and training, effective health information can help promote patients' health literacy level in global health care.

Chapter 30
The Fundamentals of Health Literacy 507
Kijpokin Kasemsap, Suan Sunandha Rajabhat University, Thailand

This chapter describes the overview of health literacy; the characteristics of functional health literacy, interactive health literacy, and critical health literacy; and the significance of health literacy in global health care. Health literacy is about how patients understand health information about health and health care, and how they apply that health information to their daily lives, utilize it to make health-related decisions, and act on it. Being able to understand health information and make decisions from that information is vital to patients' well-being. Health literacy can help patients prevent their health problems and protect their health, as well as better manage those problems and unexpected situations that happen. Patients with good health literacy make effective health decisions because they can find, understand, and evaluate the health information in global health care.

Chapter 31
The Applicability of Currently Available Adults ADHD Treatment Tools 528
Bader Binhadyan, Ministry of Education, Saudi Arabia, & RMIT University, Australia
Nilmini Wickramasinghe, Epworth HealthCare, Australia & Deakin University, Australia

E-mental health services are able to provide tools and services to facilities treatment for many various mental disorders, such as Attentions Deficit Hyperactivity Disorder. ADHD is a neurodevelopmental disorder that affect approximately 5% of adults. This paper presents the findings of 12 interviews with psychologist who are specialized in treating adults with ADHD. The interviews emphasis on the use

of Information Technology (IT) by psychologists in their treatment of ADHD. The analysis shows that using IT is beneficial for psychologists and patients. However, there are some issues emerged from the findings that could limit the usability of IT.

Chapter 32

Health Policy Implementation: Moving Beyond Its Barriers in United States 541
Khadijeh Rouzbehani, University of Tehran, Iran

This research describes policy implementation components of a health system and explains how they affect outcomes. It argues that implemented policies affect various components of a health system in terms of service delivery, workforce, information, financing, medical products, technologies, leadership and governance. Using health system as framework of analysis, the paper explains that the outcome of health policy implementation determines the availability, quality and equitability of program service delivery. The paper goes on to argue that policy implementation barriers, such as demand-and supply-side barriers, market, insufficient resources, cultural barriers, imperfect communication, information, education, coordination, leadership and governance affect the poor and vulnerable groups in developed and developing countries from benefitting from public spending on public health policies and programs.

Chapter 33

Patient Privacy and Security in E-Health 553
Güney Gürsel, Gülhane Military Medical Academy (GATA), Turkey

In the digital era, undoubtedly, e-health is a major contributor for decision support, education, research and management activities in healthcare. It provides tremendous benefits by easy store and access to data. This easiness brings a big problem together with the benefits. Users have easy access to vast amount of sensitive health data about patients. This may give way to misuse and abuse. That is why the concepts of privacy and security becomes very popular and point of major concern. This chapter is a descriptive study aimed to give principles of these concepts and invoke awareness about.

Chapter 34

Accountable Care and Evidence-Based Decision Making 567
Nilmini Wickramasinghe, Epworth HealthCare, Australia & Deakin University, Australia
Steve L Goldberg, INET Intl. Inc., Canada

In today's cost challenged healthcare environment accountable care and evidence-based decision making have become important considerations. Contemporaneous to this is the fact that the superior management of diabetes has become a global priority especially given the exponential increase in the number of diabetes patients as well as the financial implications of treating this silent epidemic. Thus, this research focuses on trying to address these respective yet critical issues by examining the possibility of using a mobile web-based reporting system that taps into existing widely available resources to monitor and manage gestational diabetes. To test this solution, we adopted a randomized control trial with two-arm cross over applied to a not-for profit hospital in Victoria, Australia. From the perspective of practice, we have uncovered far reaching implications for hospital management's cost vs. quality care to patients. In particular, it appears that the adoption of smartphones to support many aspects of care and patient-clinician interactions is prudent.

Section 6
Theoretical Considerations

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Readiness as a Novel Construct of Readiness Acceptance Model (RAM) for the Wireless Handheld Technology 578
Abdul Hafeez-Baig, University of Southern Queensland, Australia
Raj Gururajan, University of Southern Queensland, Australia
Nilmini Wickramasinghe, Epworth HealthCare, Australia & Deakin University, Australia

In this conceptual chapter we have reviewed prominent theories or models in relation to the adoption of technology for wired devices. We have identified shortcomings in these leading models in predicting adoption behaviour associated with the wireless technology. The shortcomings are particularly acute in wireless handheld technology by comparison with desk top technology in which the adoption models have been extensively studied. Here we propose "Readiness Acceptance Model" (RAM) as new conceptual model for the adoption of ICT in conjunction with wireless handheld technology. Readiness is defined as user's ability to perceived readiness of the business in the context of organizational, technological, perceptional, behavioural, and environmental attributes for the acceptance of wireless handheld devices. In formulating the conceptual framework for RAM we incorporated variable characteristics from the nine prominent models reviewed here. We believe these considerations would allow RAM to be useful in wireless handheld technology ICT domains.

Chapter 36
A Taxonomy for mHealth 596
Ruwini Edirisinghe, RMIT University, Australia
Andrew Stranieri, Federation University, Australia
Nilmini Wickramasinghe, Epworth HealthCare, Australia & Deakin University, Australia

Recently, we are witnessing an exponential growth in remote monitoring and mobile applications for healthcare. These solutions are all designed to ultimately enable the consumer to enjoy better healthcare delivery and /or wellness. In order to understand this growing area, we believe it is necessary to develop a framework to analyse and evaluate these solutions. The purpose of this chapter then is to offer a suitable taxonomy to systematically analyse and evaluate the existing solutions based on number of dimensions including technological, clinical, social, and economic.

Chapter 37
A Guideline to Use Activity Theory for Collaborative Healthcare Information Systems Design..... 616
Carolin Durst, University of Bremen, Germany
Nilmini Wickramasinghe, Epworth HealthCare, Australia & Deakin University, Australia
Jana Riechert, University of Erlangen-Nuremberg, Germany

In healthcare, collaborative systems serve very different stakeholders: researchers, clinicians, nurses, patients, and administrators for instance. In order to design a collaborative healthcare information system that satisfies the stakeholders' needs, all individual requirements have to be mapped into the software. Traditional system design focuses at technical features and oftentimes ignores social requirements like human factors or organizational structures. Instead of integrating existing processes and working habits into a system, a technical-focused design approach tries to force new behaviors. As a result, stakeholders

could refuse to use collaborative healthcare information systems. In line with Kuutti (1991), we recommend activity theory as a rich framework to study and design collaborative information systems. We believe that activity theory analysis is particularly useful for healthcare settings where diverse stakeholders pursue very different goals. This book chapter offers a structured approach to analyze collaborative activities and to design the IT-support accordingly.

Chapter 38
Mathematical Programming and Heuristics for Patient Scheduling in Hospitals: A Survey 627
Daniel Gartner, Cardiff University, UK
Rema Padman, Carnegie Mellon University, USA

The effective and efficient treatment of individual patients subject to scarce hospital resources is an increasingly important and challenging problem for decision makers to address. A recent study by the U.S. Bureau of Labor Statistics listed Registered Nursing among the top occupations in terms of job growth until the year 2022 (American Association of Colleges of Nursing (2015)). This growing demand can be explained in part by the large number of aging baby boomers with multi-morbid health conditions who typically require more treatments and longer length of stay in a variety of healthcare delivery settings (Vetrano et al. (2014)). Given the projected demand growth and reduced mobility of elderly patients, efficient operational research methods have to be developed and deployed for optimizing the process of scheduling the treatment of individual patients in highly resource constrained environments. We will henceforth denote this process as 'patient scheduling' and provide a problem definition and a review of current approaches in the course of this chapter.

Chapter 39
Building an Ontological Framework for Healthcare: The Case of the Health Cluster 646
Keith KT Toh, RMIT University, Australia
Margaret E. Heffernan, RMIT University, Australia
Vass Karpathiou, Deakin University & RMIT University, Australia
Arkalgud Ramaprasad, UIC, USA
Nilmini Wickramasinghe, Epworth HealthCare, Australia & Deakin University, Australia

Health is a multidisciplinary domain which necessitates experts from diverse backgrounds coming together to effect optimal care delivery for patients. Such a context can benefit by being framed as a knowledge cluster. To illustrate, the case study of a health cluster research group is mapped in terms of ontology. In this way, key relationships and informational exchanges are captured and this in turn can enable more prudent use of critical knowledge assets within the cluster. This ontology is then proffered for the healthcare domain in general as the following discusses.

Chapter 40
Adoption of Mobile Devices in the Australian Healthcare: A Conceptual Framework Approach..... 662
Vasundhara Rani Sood, University of Southern Queensland, Australia
Raj Gururajan, University of Southern Queensland, Australia
Abdul Hafeez-Baig, University of Southern Queensland, Australia
Nilmini Wickramasinghe, Epworth HealthCare, Australia & Deakin University, Australia

In recent years, the potential use of mobile devices has significantly positively impacted healthcare globally. Despite global claims of widespread use of mobile devices in healthcare, its adoption in the

Australian healthcare context is slow. Limited research is available on slow adoption of mobile devices in the Australian healthcare context. Therefore, this chapter is designed to investigate the factors influencing adoption of mobile devices from healthcare professionals' perspective and develop a health specific conceptual framework. The influential factors for the adoption of mobile devices in the Australian health context may be intention, individual readiness, advantages, safety issues, features, self-efficacy, complexity, training, compatibility, social influences, age and gender.

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Foreword

It is a particular privilege to write the foreword for this important volume. To a certain extent the title of this Handbook belies its content. This is a book about health care solutions – an important contribution that provides tantalising demonstrations of some of the coming disruptors of healthcare. It should be read not just by health care administrators and managers but by clinicians, researchers and all those who are interested in collaborating with health professionals in managing their own health.

In most countries health care is the major call on the budget whether it be government funding or individual (private) funds. Health care is also a major employer of workers. Many governments are challenged by the projected rapid increases in health budgets as they struggle to keep pace with the demands of ageing and chronically diseased populations. The opportunities that technology provides to increase connectivity and productivity in health systems is still only dreamed of. The potential to link communities with health providers through telehealth, hand held devices and other monitoring tools will alter the way we deliver health service in ways we are only now appreciating. Uptake of this new M (mobile) health system is slow and hampered by the incredible reticence of health practitioners (particularly doctors) to embrace change.

This book provides a fascinating insight into the plethora of new devices that are becoming available to assist connectivity across the health system be they mobile phones, implantable devices, wearable devices or more. It also stresses the opportunities for rapid acquisition of large data bases on health information and the conversion of those data into 'intelligence.' This will then provide practical ways of informing health professionals and patients on things such as practice guidelines, clinical data bases and intelligent health systems to guide health professionals and patients in making those important decisions about treatment options. These databases could also be used for ranking Institutions and providers of care on clinical outcomes or a range of other parameters such as value for money etc.

The opportunities for research are extraordinary – linked geospatial data bases to help in epidemiologic research and disease surveillance, genomic input to disease predictability and the power of electronic health records and real record linkage. Research needs to also be promoted on the devices and databases themselves to ensure that the data we are now collecting is as accurate as it can be and is being interpreted appropriately. These are health interventions and should be tested as such in appropriately designed clinical trials. Issues such as privacy and the ethics around the data collection, interpretation and distribution of that data are also extremely important.

The papers are a mixture of up to date reviews of a wide range of topics and case studies demonstrating real world practical applications of these new health 'technologies' in a number of countries around the world from high income to emerging economies but all with the same message – these are the things we can do to improve productivity of health systems if we use these technologies and systems in an appropriate fashion.

If you are interested in any way in the future of the health system and how you might improve its productivity and connectivity, I suggest you read this book – you will find something of interest for you.

Peter Brooks
University of Melbourne, Australia

Preface

Healthcare is an important industry that touches most, if not all of us at some time in our lives. Healthcare is noted for using leading edge technologies and embracing new scientific discoveries to enable better cures for diseases and better means to enable early detection of most life threatening diseases. However, the healthcare industry globally, and in the US specifically, has been extremely slow to adopt technologies that focus on better practice management and administrative needs. Presently, healthcare is grappling with many challenges both nationally and globally, including escalating costs, a move to a preventative care environment and a technology savvy patient with high expectations. This in turn necessitates prudent healthcare administration and management in order to realise superior healthcare delivery. A critical aspect to facilitating optimal healthcare delivery is a focus on value.

Value of healthcare operations incorporates an examination of quality over cost, but this goal has distinct aspects depending upon one's perspective, and only some of these aspects are primarily monetary. To patients, the value proposition may be enhanced by reducing time spent in obtaining healthcare, lowering stress and worry and increasing satisfaction with the experience. To physicians and clinical support personnel, value may be enhanced by the ability to remotely access medical records and monitor prescribed regimens and patient symptoms. To managers and investors, value may be enhanced by lowering costs of delivering healthcare in ways that do not compromise access or quality. Because of the rapidly decreasing cost structure of hardware, IT is now able to provide many functions that were not previously available, such as connectivity through mobile devices. Thus, IT innovations hold great potential for enhancing the value of healthcare to patients and stakeholders. When we look at healthcare, we can see that in order to enhance value we must not simply focus on clinical care but also be cognizant of education, research, and administrative needs of this industry.

It is not possible in one volume to address all the factors that can facilitate healthcare value creation. This book presents a miscellany of initiatives written by leading international scholars and practitioners aimed at addressing various aspects of enhancing value in healthcare operations and thereby enabling superior healthcare practice to ensue and prudent healthcare administration and management to be realised. The chapters are arranged into the following broad categories which are not necessarily mutually exclusive but taken together do help to underscore key enablers to facilitating appropriate healthcare administration and management; including: *Section I* Data and Decision Making, *Section II* Healthcare Process Aspects, *Section III* Information Communication Technology Issues, *Section IV* Patient-Provider Interface, *Section V* Policy Implications and *Section VI* Theoretical Considerations.

The book is intended for students, scholars, practitioners, policy makers, healthcare advocates and everyone who is interested in providing a better healthcare experience. Enjoy reading and hopefully the following pages will serve to inspire readers to also work towards designing and developing better healthcare solutions.

The Editor,

Nilmini Wickramasinghe
Epworth HealthCare, Australia & Deakin University, Australia
May 2016

Section 1

Data and Decision Making

Chapter 1
Data Accuracy Considerations with mHealth

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ABSTRACT

With the plethora of mHealth solutions developed being digital, this necessitates the need for accurate data and information integrity. Lack of data accuracy and information integrity in mHealth can cause serious harm to patients and limit the benefits of such promising technology. Thus, this exploratory study investigates data accuracy and information integrity in mHealth by examining a mobile health solution for diabetes, with the aim of incorporating Machine Learning to detect sources of inaccurate data and deliver quality information.

INTRODUCTION

Reports from the World Health Organization (WHO) indicate that noncommunicable diseases are the leading cause of deaths worldwide, where the number of deaths from 2012 are projected to increase from 38 million to 52 million by 2030 (WHO, 2015). Noncommunicable diseases according to WHO, are chronic diseases such as cardiovascular diseases, cancers, respiratory diseases and diabetes. Chronic diseases along with change in demographics, increasing cost of medical services, ongoing quality and safety issues in healthcare, are all major challenges to the delivery of healthcare services (Armstrong et al., 2007).

A new and innovative way of dealing with these healthcare challenges is through the adoption of mobile health (mHealth) technology. mHealth is the use of portable devices such as smartphones and tablets to improve health (Hamel et al., 2014). This innovative technology has enabled people to play an active role in managing their health rather than being the passive object when seeking treatment during traditional methods (Niilo, Ilkka, & Elina, 2006). The advances in sensor technology such has heart

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rate, respiratory and blood pressure sensors, along with mobile phone devices, have allowed patients to self-monitor their health before conditions deteriorate and risk re-admission to hospital (Tarassenko & Clifton, 2011).

For mHealth to be effective in delivering safe and high quality health services, the technology must be free of errors. Errors in the medical field are defined as a preventable adverse outcome that results from improper medical management (a mistake of commission) rather than from the progression of an illness caused by lack of care (a mistake of omission) (Van Den Bos et al., 2011). Medical errors belong to a number of domains such as development and use of technologies, ergonomics, administration, management, politics and economics (Vincent, 2010). However, medical errors have progressed from human to technological errors. Jenicek (2010) defines technological errors in medicine as errors that relate to data and information recording, processing, and retrieval caused by information technology and its uses (Information technology inadequacy and failure). The use of mobile phone technology for managing health has its own set of challenges and complexities, such as accuracy, integrity, privacy, security and confidentiality.

Since the collected data in mHealth is in digital format, an information systems technique such as Machine Learning can be introduced to learn and detect medical errors by learning about the data. This study explores how Machine Learning can be used to address data inaccuracy in mHealth as opposed to the other studies where Machine Learning algorithms were used to detect diseases and classify them based on the training the algorithms have completed. This study is conducted using a qualitative approach whereby secondary de-identified medical data is extracted from a secondary database of a chronic disease for study. The expected outcome is a framework that covers accuracy aspects of health data in mHealth and a Machine Learning Algorithm that can best detect data inaccuracy.

BACKGROUND

This section explores mHealth technology and its role in connecting people to healthcare services. As well as what defines accurate data, effect of data inaccuracy on Information Integrity and the emergence of Machine Learning in the development of healthcare solutions and how it can be used to detect medical errors to enhance quality of mHealth.

mHealth

Smartphones are becoming both a necessity and an essential technology for people (Konschak & Jarell, 2010). This is reflected in the number of mobile phone subscriptions, where it is estimated to be 7 billion worldwide (International Telecommunication Union, 2015). The portability of smartphone devices and their ability in accessing the internet make them ideal for the collection and transfer of data (Medhanyie et al., 2015). Half of smartphone owners frequently browse for health information online and monitor their health using mobile health applications (Fox & Duggan, 2012). This has allowed for healthcare services to be developed and deployed on smartphones to deliver mHealth services. mHealth is a great opportunity and convenient way of tackling diseases and illness from both children to chronic diseases (Curioso & Mechael, 2010). Few examples that demonstrate the applicability of mHealth in treating diseases range from psychiatric assessments (Ben-Zeev et al., 2015) to more serious and life threaten-

ing diseases such as diabetes (Mallow et al., 2014) and cancer prevention (Purnell, Griffith, Eddens, & Kreuter, 2014).

This technology is growing fast and can help solve complex problems and diagnosis of diseases. The ability to solve complex problems and perform diagnosis is due to the new generation of smartphones having more advanced computing and communication (internet access, geo-locations) capabilities compared to older versions of mobile phones where they performed simple tasks and had limited capabilities (Boulos, Wheeler, Tavares, & Jones, 2011). These advancements in mobile phone technology provide patients with accessibility to healthcare services, which makes it convenient for people and patients to manage their health and drive long term commitment to one's well-being (Meyers & Barnes, 2011).

mHealth can play a role in all stages of care, including prevention (reminders, campaigns), diagnosis (remote access to patient information), decision, treatment (manage patient symptoms) and follow up (Nasi, Cucciniello, & Guerrazzi, 2015). The diversity in types of data collected through mHealth makes them an important asset for the treatment of patients and engagement of healthcare professionals when delivering healthcare services.

With collected data being a primary and key driver in the delivery of healthcare services using mHealth technology, data accuracy becomes an important factor in assuring the delivery of high quality services.

Data Accuracy

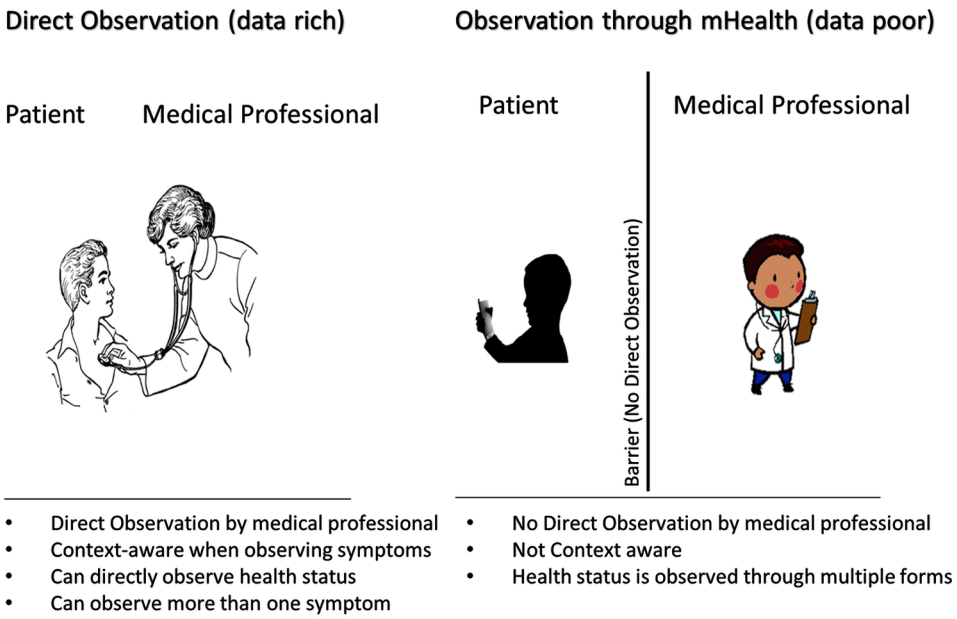
At the center of mHealth solution is data. The term data itself can be defined as information in the form of facts or figures obtained from experiments or surveys, and used as basis for making calculations or drawing conclusions, as defined by (Dumas, 2013). Accuracy of data according to WHO, is an element of data quality that is intended to achieve desirable objectives using legitimate means, and its accuracy is the original source of data (WHO, 2003). In health, the quality of the data helps evaluate health, assess effectiveness of interventions, monitor trends, inform health policy and set priorities (van Velthoven et al., 2013).

Accuracy of the data provided through mHealth solution helps convey a better picture of ones' health status. When data lacks accuracy, currency or certainty, it can have catastrophic results (Sadiq, 2013). For mHealth solution to be effective and safe, the data collected from mHealth devices, wearables and applications, must be accurate and secure (Mottl, 2014). Data accuracy is a foundational feature or dimension that contributes to data quality (Gregori & Berchialla, 2012) and it is still a major part of mobile health developments, as some of the traditional ways of assessing the patients, provide inaccurate data (Lin, 2013). The common standard for data collection in the medical field is direct observation. Direct observation is the observation of patients and the different patient characteristics at the clinic (Flocke & Stange, 2004). This allows for the collection of accurate data by directly observing the patients and their symptoms (Eisele et al., 2013). This common standard is missing in mHealth solutions as there's no direct observation of the patients by the medical professionals when data is collected. In comparison, the common method of data collection in mHealth is through data entry by users or automatic if it is a sensor based solution.

Figure 1 is an illustration of how observation through mHealth differs from the traditional direct observational method. This can introduce the risk of not conveying the full picture of a patient's health status.

The issues of data inaccuracy can be classified into four (4) categories. These categories are initial data entry, data decay, moving and restructuring, and using data (Olson, 2003).

Figure 1. Direct observation compared to observation through mHealth
Characters obtained using Microsoft Online Pictures.



1. **Initial Data Entry:** Mistakes, Data Entry Process, Deliberate, System Errors.
2. **Data Decay:** Accuracy of data when originally created over time.
3. **Moving and Restructuring:** Extracting, Cleansing, Transformation, Loading, Integration.
4. **Using:** Faulty Reporting, Lack of Understanding.

In addition to the four (4) categories described above, intentional and unintentional wrong data entry and the speed at which data is collected can be misleading. Misleading data results in misallocating resources or interventions when needed for the patients (Patnaik, Brunskill, & Thies, 2009). Inaccurate readings, insufficient amount of data, movement and physical activities also contribute to inaccurate data provided through the mHealth devices (Mena et al., 2013). Another factor that affects the quality of the data is security breaches, where unauthorized modification or alteration is made to patients' data that compromise their confidentiality and privacy (Mena et al., 2013).

Concerns associated with data accuracy and validity are persistent and can become a risk to patients' safety (Linda, 2012). mHealth solutions must deliver accurate data. For data to be accurate, it must always consist of completeness, consistency, currency, relevance and accuracy (Narman el al., 2011). In mHealth, these elements of data quality can be compromised as data goes through five (5) different stages. These are:

1. Collection,
2. Transmission,
3. Analysis,
4. Storage, and
5. Presentation (Klonoff, 2013).

This means data must be accurate and consistent over its entire life-cycle in order to conform to data integrity (Cucoranu et al., 2013).

Inaccurate data does not only affect integrity of the data, but also the information that are generated based on the collected data. This can compromise the integrity of the information and thus mislead patients and misguide treatments. This makes Information Integrity an equally important component of mHealth that must display high quality that conforms to the integrity expectation of the user.

Information Integrity

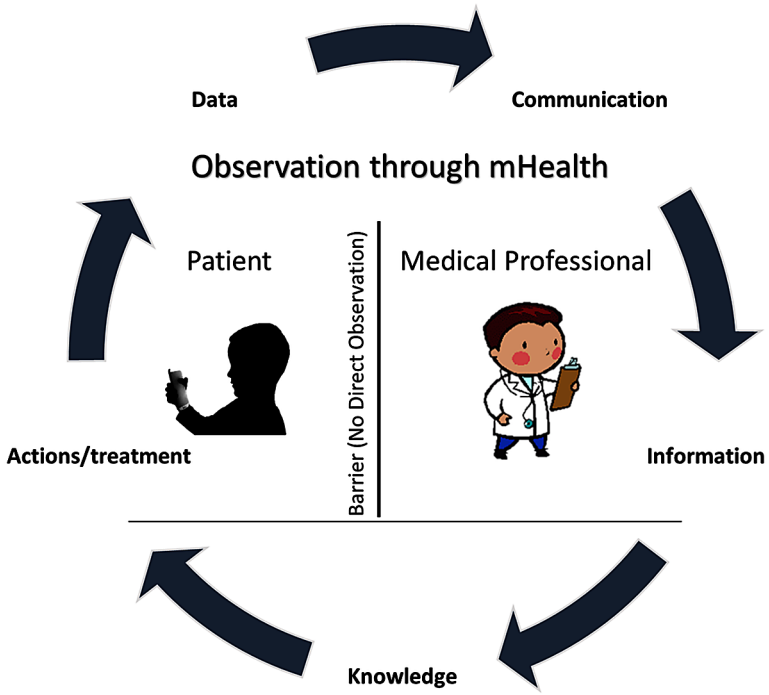
Information at the very basic level, is raw data that is processed and transformed into information, from which then knowledge is extracted (Dumas, 2012). In mHealth, information must conform to integrity. The integrity of information is about having the right properties of information including sensitivity in which information is used, as well as encompassing accuracy, consistency and reliability of the information content, process and system (Fadlalla & Wickramasinghe, 2004). mHealth can be used in a number of ways for the treatment of patients and delivery of healthcare services. It is vital that the information generated is accurate in order to avoid misdiagnosis, delayed care seeking, incorrect self-treatment, conflict over appropriate care or non-adherence to treatment plans and medication (Kahn, Yang, & Kahn, 2010).

The shift from clinician care towards patient centered model is encouraging patients to actively self-manage and make decisions concerning their health (Boulos et al., 2011). To sustain self-management using mHealth, patients must be provided with accurate information that are of high integrity. The integrity of information produced as a result of shift in the dynamics of technology has been getting more focus as the interaction has changed (Cunningham, 2012). What causes information to lack integrity is errors in healthcare system due to data loss, incorrect data entry, displayed or transmitted data (Bowman, 2013).

During the data collection stage, if the data is inaccurate, it continues through the data transformation cycle (See Figure 2). When data reaches the medical Professional, they apply their reasoning based on the provided data, from which then a recommended set of actions or treatment is suggested. If information that's circled during this process lacks integrity, the outcome of the treatment or suggested set of actions can unintentionally harm the patient.

To overcome the challenges of correctly treating patients using mHealth and ensure information integrity, then data governance, information workflow management, internal controls, confidentiality and data privacy processes must exist (Flowerday & Solms, 2010). These processes along with information technology can improve the quality of care by decreasing medical errors due to inaccurate and untimely information (Mahmood el al., 2012). Using a semantic tool when processing data and transforming it into information, can prove critical in detecting errors in data and ensuring information are of relevance to the patients and treatments. One of the most common and publicly available tool is the Omaha System. The Omaha System is 'a complex, multi-axial, hierarchical, relational standardized health services taxonomy' as explained by Monsen (el al., 2009). The Omaha System has been incorporated into software programs, being recognized by nursing associations, and is in agreement with the International Organization for Standardization (ISO) (Monsen el al., 2009). The three components of the Omaha System (see Figure 3) are the Problem Classification Scheme, the Intervention Scheme, and the Problem Rating Scale for Outcomes. The first component of the Omaha System enables healthcare professionals to collect assessment data such as signs and symptoms, Intervention scheme to design interventions and it is driven by the provider, and lastly is an outcome measurement scale for evaluating the intervention and the care process (Topaz, Golfenshtein, & Bowles, 2014).

Figure 2. Transformation of data into knowledge in order to provide treatment
Characters obtained using Microsoft Online Pictures.



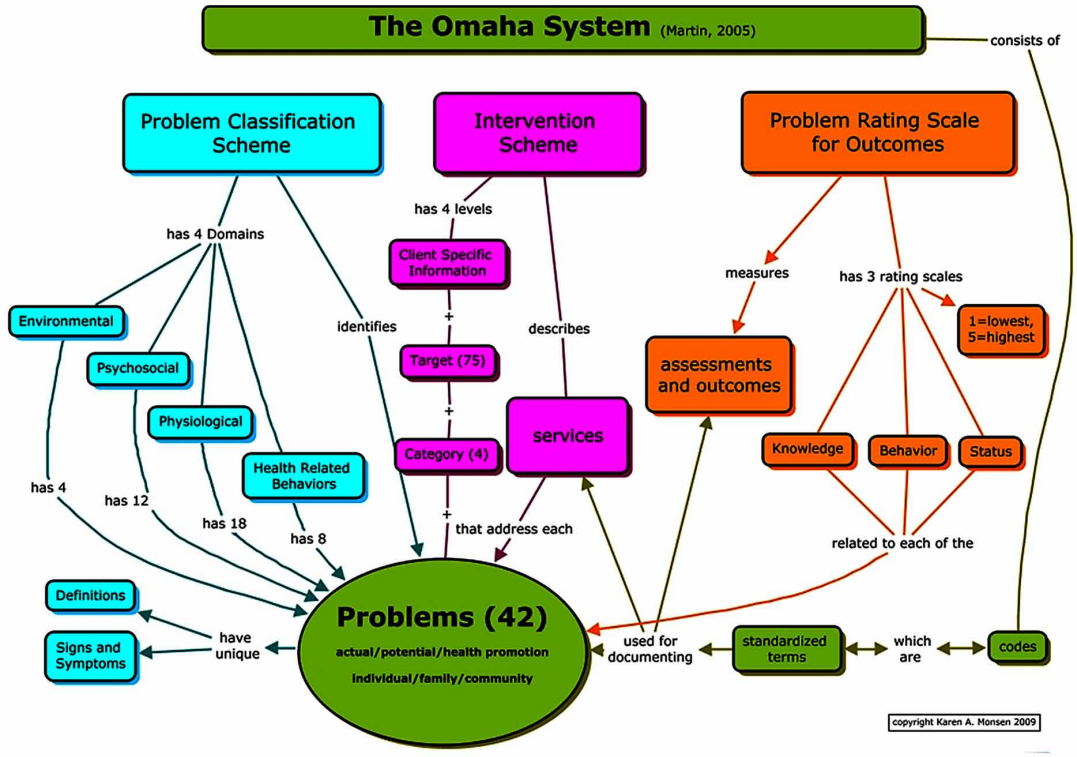
Using the Omaha System in an accurate and consistent way, it would establish an effective basis for documentation, communication, coordination of care and outcome measurement (Garvin el al., 2008). Incorporating the Omaha System in mHealth can potentially increase the accuracy of data and integrity of information by incorporating elements from the Omaha System into Machine Learning Algorithms. This offers a role for Machine Learning to be adapted in mHealth technology to improve the detection of inaccurate data using the standardized taxonomy that would enhance the quality and delivery of information.

Role of Machine Learning in Healthcare

Machine Learning has enabled smarter use of data in health by shifting from curing diseases to anticipating and preventing them before they occur through real time data analysis (Kumar et al., 2013). The prediction of diseases is the result of analyzing large quantity of data through different mHealth tools (See Figure 4).

mHealth can be used as a tool for different purposes such as the measurement of GPS locations and sensor readings, diagnosis, treatment and prevention, and access to global healthcare services. Despite the opportunities and benefits of mHealth brings, the risk of medical errors occurring in mHealth must be constrained. Varshney (2009) describes common medical errors as those found during investigation, diagnosis, treatment, communication and office administration errors. Constraining these errors during those stages can be achieved by learning about the collected data and applying analysis techniques to find sources of inaccurate data.

Figure 3. The Omaha System 2005 version
Adapted from The Omaha System Chart, 2015.



The analysis performed by Machine Learning, extracts new knowledge when there is great amount of data (Lamblin el al., 2013). The Machine Learning algorithms learn and improve outcomes through experience and observation (Oquendo el al., 2012). The concept of Machine Learning is – Learning that improves with experience at some task. That is (Bell, 2014):

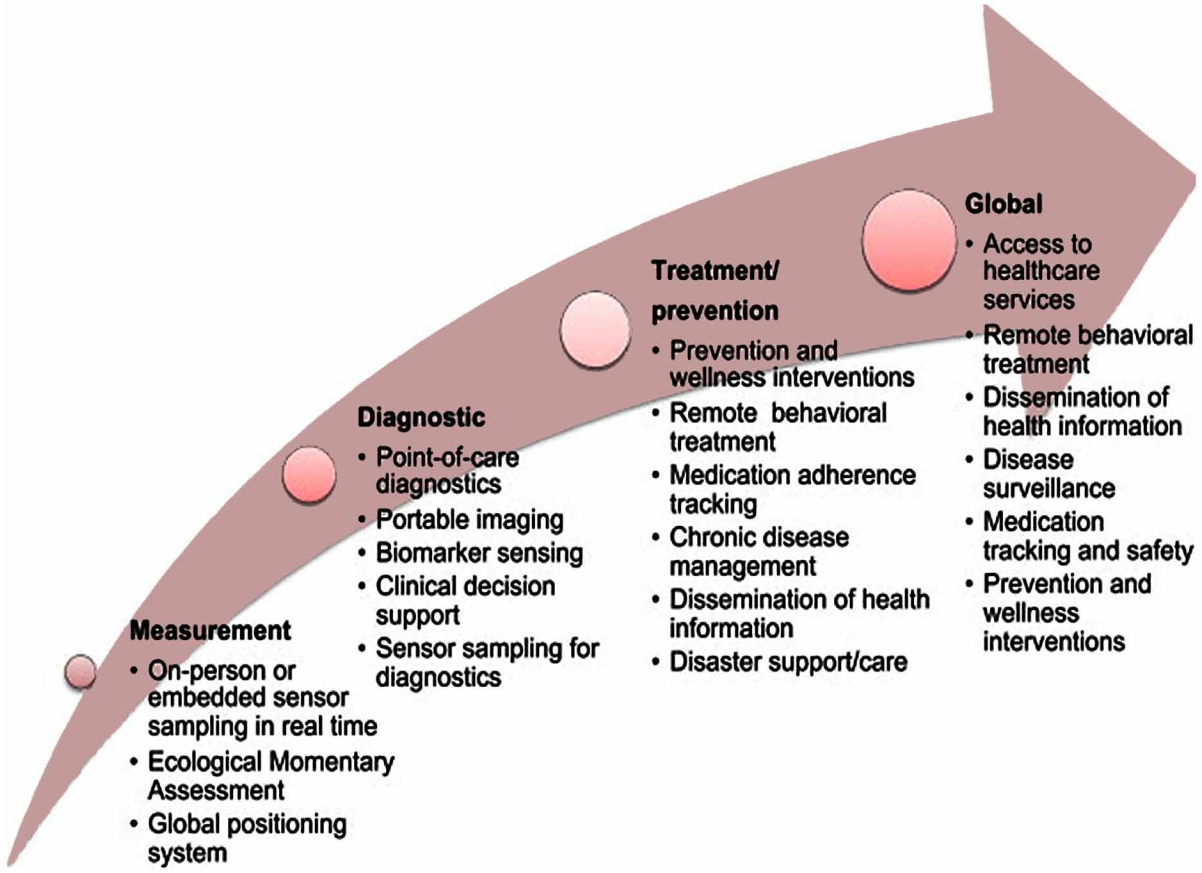
- Improve over task, T.
- With respect to performance measure, P.
- Based on experience, E.

Machine Learning algorithms can play a pivotal role in acquiring accurate data through pre-trained algorithms that can be deployed in mHealth solutions. This concept can be adopted in mHealth to detect errors by learning about the collected data and applying analysis techniques to detect inaccurate data before being transformed into information and disseminated to the stakeholders.

With Machine Learning having a role in the delivery of mHealth, the proposed study is to investigate data accuracy and information integrity in the context of mHealth solution by addressing the research question:

How can Machine Learning be applied in mHealth solutions to provide data accuracy and information integrity?

Figure 4. Continuum of mHealth tools
Adapted from Kumar et al., 2013.



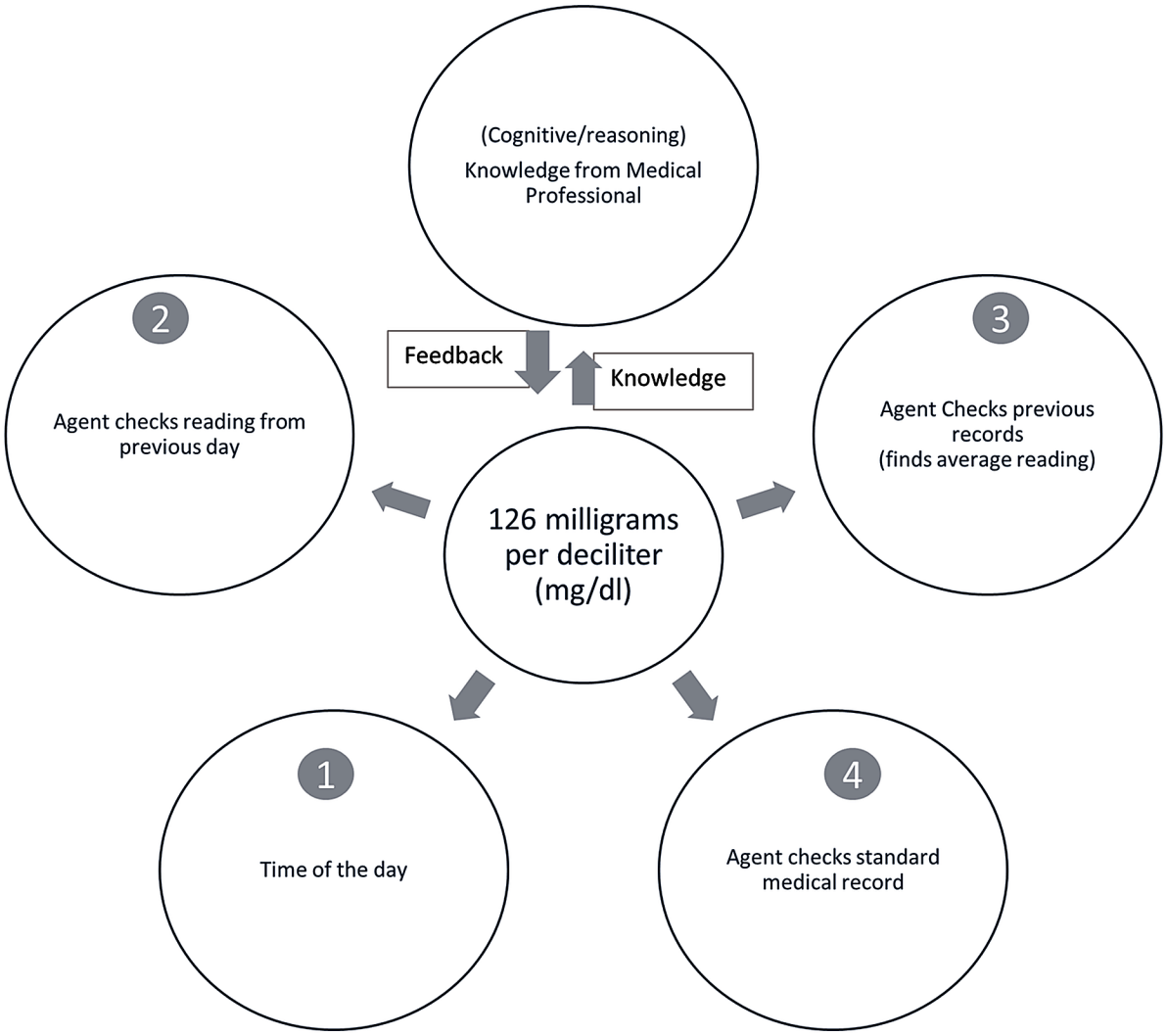
CONCEPTUAL MODEL

To help address the accuracy problem in mHealth, the conceptual model (See Figure 5) has been developed to facilitate the detection of data inaccuracy in mHealth and draws on providing high quality information using multiple agents. The conceptual model is built using the elements of data integrity that prove critical to generating high quality information that is free of errors.

The four (4) agents described in the conceptual model can perform smart functions which help detect and assess the accuracy of the value that is received from a patient during the use of mHealth:

1. **Time of the Day:** The function of this agent is to check for data decay, currency and timeliness, which makes the treatment and actions to be relevant and provide information in a timely manner. Thus ensuring no delay in seeking treatment and allows for monitoring of the patient to be more relevant.
2. **Reading from Previous Day:** The function of this agent can detect mistakes by comparing the current value against what was provided previously. Where there's a significant different, it will notify the medical professional such event to raise awareness about the change in the value.

Figure 5. Conceptual model consisting of agents that contextualize data



3. **Average Value from Previous Reading:** The advice given to a patient during mHealth treatment is often based on the current value and does not take into account the history of the patient. This agent performs calculations that finds the average value as well as providing a better insight of the patient's behavior by providing a trend suing the available historical data.
4. **Medical Standards:** This agent checks the current value against the standard acceptable medical reading that is of the right range and conforms to medical data definition related to the disease.

THE PROPOSED RESEARCH METHODOLOGY

In addressing this study's research question, a qualitative research method is applied using an exploratory case study. The following justifies the chosen research method, data collection, analysis and reporting.

Single Case Study

Yin (2014) defines case study as 'an empirical inquiry that investigates a contemporary phenomenon (the "case") in depth and within its real-world context, especially when the boundaries between the phenomenon and context may not be clearly evident'. Case studies are not considered a methodology but rather a choice of what is to be studied (Denzin and Lincoln, 2011), and they are for studying a single group, event or person (Donley, 2012). The selected case study is a mHealth solution for diabetes, with the case being patients' data. The selection of the case is guided by two principles. First is the form of question posed in this research where the form is 'How', requires no control over behavioural events (no control over how the data is produced) and focuses on contemporary events as the case (patients' data) is studied in its real-world context.

The second principle in selecting such case study is the single-case study rationale where the case is critical to the theory (Yin, 2014) and relevant to the research question. Treating patients via mHealth rather than at the clinic could allow a gap for errors. Accessing such case study, enables the research question to be addressed by examining patients' data and exploring the characteristics of the data, the intended meaning when data was produced and how it contributes towards the treatment of the patient.

Data Collection

The type of data collected for this study is qualitative secondary, de-identified data of patients with diabetes. Secondary, de-identified data is data that is used for research purposes and do not identify or represent a person (McGraw, 2012). The de-identified data will be of records of patients who have diabetes and contain information such as time and date of measurement, glucose reading and a description of the reading. The chosen method of data collection seeks data that presents a chronic disease that is relevant to the case study, it is produced by people in real world and is authentic.

Data Sampling

With the proposed method of data collection being Secondary data, the sampling technique employed in this study is convenience sampling. The selection of this sampling technique is due to the readily available and accessible secondary data that is used for this study, and conveniently recruited (Gideon, 2012) through two sources. The first sample is diabetes data from clinical solution for the treatment of diabetes, while the second source is data from mHealth solution. The sample represents one of the many developed mHealth solutions and the data characterize the type of data created when using mHealth.

Data Triangulation

The data is triangulated using triangulation of different data sources of information by separating the secondary data into different data sets to build coherent justification for themes (Creswell, 2009). The datasets will be numbered to represent different patients and for triangulation to confirm the accuracy of the findings.

Data Analysis

The data analysis is performed using Thematic and hermeneutics techniques. Thematic analysis is will be applied to aid in the interpretation of the texts by coding the data into organized segments of texts before bringing meaning to information (Creswell, 2009), and later underlining them for generating themes that describe passages in the data (Cohen, Steeves, & Kahn, 2000). In analysing the themes, Hermeneutics analysis is used to provide a detailed description of the text to capture and communicate the meaning of the lived experience (patients using mHealth) being studied (Cohen, Steeves, & Kahn, 2000). This is to seek interpretation of the mHealth data and understand the meaning of it, accuracy of the values and what the producers of the text initially intended it for (Flick, Kardorff, & Steinke, 2004).

ETHICS

This research has been cleared of any ethics requirement as it was exempted from review due to using secondary data that does not identify a person nor an entity.

LIMITATION

A key challenge for this research that requires mentioning is the use of secondary data. Using secondary data does not allow this research to observe the patients nor their behaviour during the use of the mHealth solution, specifically when the patient enters the data. Thus, this research does not take into consideration the human factors that can affect the accuracy of the data. Despite this difficulty, this is a major challenge in mHealth as there's no direct observation of the patient or their behaviour when the data is collected. Using the secondary data helps establish methods that can overcome this challenge and ensure data accuracy and information integrity in mHealth through the use of machine learning.

Another limitation is the study's focus on a single chronic disease, diabetes. Diabetes is one of the many chronic diseases listed by WHO. However, treatment of diabetes through mHealth is achieved through the transmission of text data that contain diabetes related information, which allows for the testing of Machine Learning algorithms to be done.

DISCUSSION AND CONCLUSION

The preceding serves to present a research in progress study that focuses on trying to optimize data assets for mHealth contexts. In particular, it focuses on critical considerations regarding data accuracy and information integrity. While still at an early stage, the research should provide important implications for theory and practice.

From the perspective of theory, as mHealth grows and the domain of consumer health informatics matures, we will see more and more mobile solutions being embraced to support health and wellness. Central to the success of these solutions is that they provide accurate data and information to consumers who in turn make decisions with far reaching implications and consequences based on the data and information received. The findings from this study will clearly be significant in ensuring optimal value

from such mHealth solution. Upon the completion of the study, it will contribute to the hermeneutics field in information systems, and a reference for researchers to use to analyse future empirical mHealth related studies and assist in the interpretation of their analysis.

Finally, given today's digital economy, findings from this study are relevant to not just for healthcare but transferable to other industries also concerned about accuracy of data input and information integrity.

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Chapter 2
GIS, Spatial Analysis, and Modeling: The Case of Breast Cancer Incidence in the US

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ABSTRACT

Breast cancer is a major health issue in all countries affecting thousands of women. Its causes are unknown and the national and international strategies to reduce its morbidity and mortality levels are based on early detection of cancer through screening and treatment according to clinical guidelines. Thus, knowledge of which women are at risk and why they are at risk is therefore essential component of disease prevention and screening. In 2015, an estimated 231,840 new cases of invasive breast cancer are expected to be diagnosed in women in the United States, along with 60,290 new cases of non-invasive (in situ) breast cancer. The purpose of this study is to provide a more detailed analysis of the breast cancer distribution in the United States by comparing the spatial distribution of breast cancer cases against physical environmental factors using Geographic Information System (GIS). Further, it gives background information to the GIS and its applications in health-related research.

INTRODUCTION

Breast cancer is a major health issue in all countries affecting thousands of women (Tazzite et al., 2013; Dube & Gupta, 2015). So far its causes are unknown and the national and international strategies to reduce its morbidity and mortality levels are based on early detection of cancer through screening and

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treatment according to clinical guidelines. Thus, knowledge of which women are at risk and why they are at risk is therefore essential component of disease prevention and screening. In 2015, an estimated 231,840 new cases of invasive breast cancer are expected to be diagnosed in women in the United States, along with 60,290 new cases of non-invasive (in situ) breast cancer (Siegel et al., 2015). However, all locations are not equal for breast cancer risk and thus support a major role of the geography in breast carcinogenesis (Akram & Nanna, 2003).

The purpose of this work is to provide a more detailed analysis of the breast cancer distribution in the United States by comparing the spatial distribution of breast cancer cases against physical environmental factors using Geographic Information System (GIS) (Figure 1). Further, it gives background information to the GIS and its applications in health-related research.

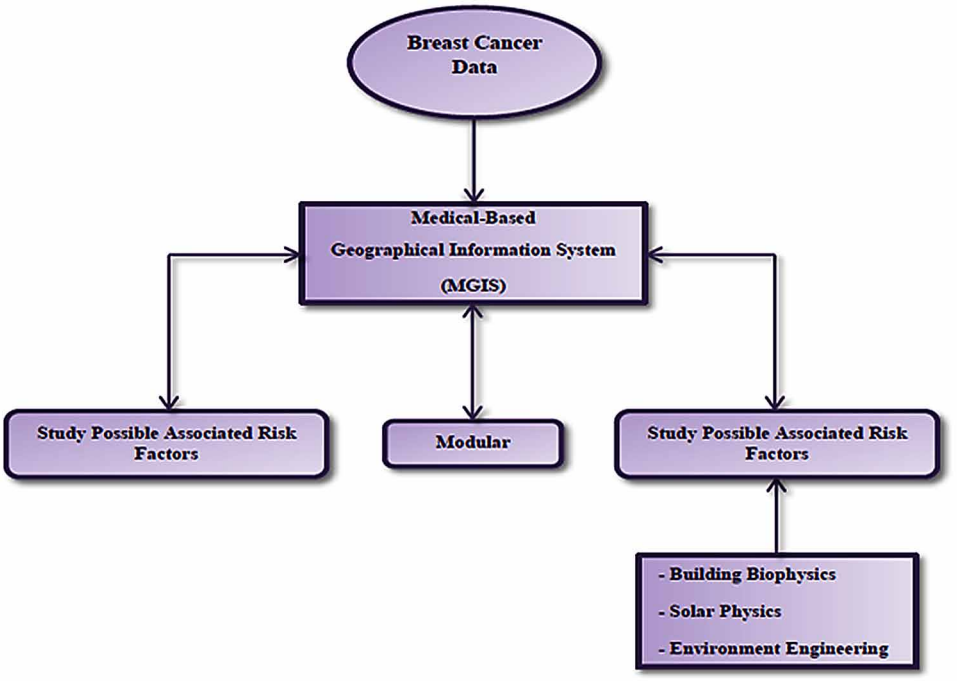
BACKGROUND

Breast Cancer Facts/Spatial-Based Patterns

Previous reports have shown that the Northeast United States has a 16% higher breast cancer mortality rate than the rest of the country (Kulldorff et al., 1997). The probability of breast cancer risk is not equal for all locations which indicate that geography plays a very important role in the etiology of breast cancer.

There are geographic patterns of high cases of breast cancer, and the analysis of these patterns is very important in the formulation of hypotheses about risks and focus investment more effectively in research and intervention on the most significant areas (Laden et al., 1997).

Figure 1. Medical-based GIS



In general, breast cancer incidence rates have continued to increase since 1980, although the rate of increase slowed down in the 1990s, compared to the 1980s (American Cancer Society, 2004). Furthermore, during the more recent time period, breast cancer incidence rates have increased only in those aged 50 and over. The mortality rates declined by around 1.4% per year during 1989-1995 and by 3.2% afterwards, with the largest decreases in younger women in both whites and African Americans. These decreases are probably due to the result of both earlier detection and improved treatment. Clearly, the ultimate cause of breast cancer is unknown (Roche, 1998), but several risk factors appear to play a role.

Previous literatures have shown that breast cancer mortality and incidence rates vary geographically according to the different regions of the United States (Devesa, et al., 1999; Joseph, et al., 2004). Generally, the disease is most common in North America and Western Europe, account for about one in four female cancers in these regions, while in the Far East (China and Japan) it is very much rare (Le, et al., 2002). Furthermore, the disease rates among Asian-Americans are lower than those of U.S. whites but considerably higher than rates prevailing in Asia. Thus, it is suspected that migration to the US brings about a change in endocrine function among Asian women, although reasons for this change remain obscure (Wu, et al., 1996). In fact, the geographic patterns of cancer around the world and within countries have provided important clues to the causes of cancer (Robert, 1996). The highest incidence rates of all are found in Hawaii, where a rate of 93.9 per 100,000 female populations has been reported, and in US white women. The incidence rises with age from about age 30. Moreover, there are ethnic variations, such as a high incidence in Israeli Jews compared with non-Jews in Israel. It is more common in single women, in higher social classes, and in urban rather than rural areas. On the other hand, about 1% of cases occur in males. Mortality has increased less rapidly than incidence, but breast cancer is most common cause of cancer death.

What Is Geographic Information System (GIS)?

Maps are well-known to be one of the most used visual tools in our life today. They have very long tradition and they have been used from ancient time. They are very useful tools to visually show a place and its features. However, maps, at least in their traditional form, have limited capabilities in the amount and type of information they can depict. In addition to this, the capability of human processing of huge information is limited. Gathering information from different sources, integrate, analysis, and interpret them is a complex and time-consuming task.

Data visualization is one of the areas that have been improvement due to the adoption of new technology and visualization frameworks and systems. Advancement in information technologies has affected each aspect of our daily life. Data integration, processing and visualization are no exception. Today, intelligent computerized tools are available to help users enter and process information effectively and efficiently. The capability of computer systems in processing and make sense of data is importing dramatically in the last few years. Data visualization is the branch of information processing that deals with finding ways and methods to present data using various visualization techniques in order to make it easy for the users to interpret and make sense of the data.

One the general and most comprehensive definitions of GIS is the one provided by ESRI (Environmental System Research Institute), in which GIS is described as “an integrated collection of computer software and data used to view and manage information about geographic places, analyze spatial relationships, and model spatial processes. A GIS provides a framework for gathering and organizing spatial data and

related information so that it can be displayed and analyzed."This definition stresses the fact that GIS is more than just the technology behind this system, but it is actually a comprehensive framework to support decision making by the integration of spatial data and other factors using visualization techniques.(GIS) can be defined as "a collection of science and technology tools used to manage geographic relationships and integrate information. GIS helps us analyze spatially-referenced data and make well-informed decisions based on the association between the data and the geography".

Applications of GIS in Health Science

Applications of GIS in health science have increased dramatically in the last few years with many innovative approaches have emerged. Understating the relationship between health and contextual factors, such as sociodemographic, environmental and political variables, can be complex. GIS can facilitate the integration and presentation of these contextual variables to gain insight into their influence on health. This section reviews the research related to the use of GIS to improve health care.

A previous study conducted a review that focuses on the applications of GIS in public health and health promotion (Nykiforuk & Flaman, 2011). The final review was composed of 621 journal articles and book chapters reporting health-related applications of GIS. According to the review, GIS applications in public health can be classified into four main themes: disease surveillance, risk analysis, health access and planning, and community health profiling. Moreover, some other reviewed literature on the applications of GIS in health science research (Lyseen, et al., 2014), and present a conceptual framework that can be used to better categorize and understand research in this area, and thus put emphasis on areas that need further research. The sample size of the study consists of a total of 865 articles pulled out from the research databases Scopus and Web of Science. By applying ground-theory data analysis method, the study presents a framework that comprises four conceptual domains to represent GIS applications in health science. These domains are spatial analysis of diseases, spatial analysis of health service planning, public health, and health technology.

Disease Surveillance

One of the most well-known applications of using GIS in public research is for disease surveillance, which is the integration and tracking of data related to the incidence, prevalence, and the spread of the disease in the community. Epidemiology seek to answer basic questions such as when and where are cases of an infectious disease currently occupying, can we predict the next occurrence of the disease, and how can we prevent the spread of the disease? GIS can help increase the speed and occurrence of finding answers to epidemiology these questions by integrating spatial information on the disease with other types of geographic information to track and map the spread of the disease (Eisen & Eisen, 2014).

Research in this area can be classified into two interrelated categories: disease mapping and disease modeling. Disease modeling is the extension of GIS capabilities to support the decision making process. It can be applied to the data to:

1. Predict the outbreak of a disease,
2. Identify Planning of Healthcare Services Literature reported different ways of applying GIS technology to support decision making in the planning and distribution of healthcare service.

Strategic planning is required to achieve optimal and demand-based distribution of healthcare centers. An example, GIS was used to assess hospital distributions in Seoul, the capital of South Korea (Lee & Moon, 2014). The study proved that GIS can be used to identify and examine the factors that influence health service distribution.

In developing countries, planning and delivery of healthcare services can be critical. Brijnath and De Souza (Brijnath & De Souza, 2012) discussed different ways in which GIS can be utilized to enhance health service planning and delivery for infectious diseases in low-income countries. according to the paper GIS be used to:

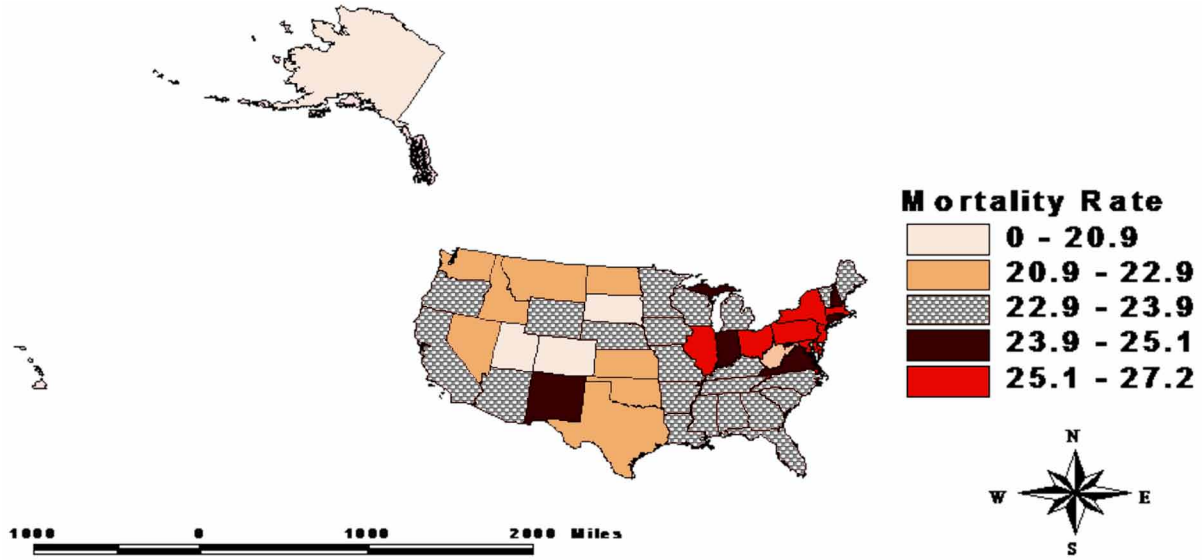
1. Get insight into the optimized locations for distribution healthcare centers,
2. Provide real-time surveillance system for the control of diseases,
3. Serve as an evidence-based accountability tool between funding agencies and healthcare provides, and
4. Transform data into accessible format to make it easy for stakeholders to make informed decisions.

METHODOLOGY

In this research we obtained mortality estimates (Figure 2) in 50 states of the United States from the National Center of Health Statistics (NCHS) for the years 1994-98. Those states for which the corresponding data was not available were excluded.

The environmental factors used in the analysis were limited to seven spatial environmental factors collected from NSTATE, LLC. In this work Regression analysis have been used to detect and evaluate the statistical significance between the mortality rates and the spatial environmental factors.

Figure 2. Female breast cancer mortality (1994-98) rate by state



Preliminary results show an inverse relationship between the death rates and mean elevation (T = -6.25; p = 0.000) and positive relationship with the average temperature (T = 3.07; p = 0.004). The high F-value 21.71 and low p-value indicate there is a statistically significant difference between mortality rates and the selected spatial environmental factors. The differences are certified as statistically significant and are probably not due to sampling variability only. All the relevant finding related to the explanatory power of the independent variables, in the goodness of fit of all possible models can be enhanced by looking at the best-fit models with the significant (at the 5% level, $p \leq 0.05$) explanatory underlying variables, for each of the mortality/incidence pattern groups according to the spatial environmental factors (Table 1 and 2).

RESULTS AND DISCUSSION

Effect of Average Temperature on Breast Cancer

Temperatures cause a variety of physiological changes, e.g. of blood composition, blood pressure (Stout & Crawford, 1991) and circadian rhythms (Reiter, 1991), which in turn are believed to contribute to an increased mortality/incidence of breast cancer (Kliukiene, et al., 2001). Furthermore, published laboratory studies have reported that melatonin might have cancer-preventive activities (Coleman & Reiter, 1992). Moreover, melatonin has been observed to exert potent inhibition on cancer growth by acting as natural anti-angiogenic molecule, with a following opposition or angiogenesis-dependent cancer pro-

Table 1. Stepwise multiple regression, explanatory variables best-fit model according to mortality rates, 1991-95, 1992-96, 1993-97 and 1994-98

Step	1	2	3	4
Constant	21.14	21.10	21.39	25.27
Ave. Temp	0.048	0.069	0.067	0.069
T-Value	3.42	6.20	6.09	6.27
P-Value	0.001	0.000	0.000	0.000
Elevation		-0.00080	-0.00075	-0.00067
T-Value		-11.24	-10.29	-8.14
P-Value		0.000	0.000	0.000
Land Area			-0.00000	-0.00000
T-Value			-2.53	-3.00
P-Value			0.012	0.003
Low Ave. Temp				-0.046
T-Value				-2.06
P-Value				0.041
S	2.13	1.65	1.63	1.61
R-Sq	5.81	43.54	45.40	46.61
R-Sq (adj)	5.32	42.95	44.53	45.47

Table 2. Stepwise multiple regression, explanatory variables best-fit model ($p \leq 0.05$) according to incidence rates, 1990-94, 1991-95, 1993-97 and 1994-98

Step	1	2	3	4
Constant	105.2	182.8	185.2	182.7
Ave. Temp	0.026	0.055	0.130	0.171
T-Value	0.40	1.00	2.34	3.07
P-Value	0.690	0.317	0.020	0.003
Elevation	-0.00128	0.00033	0.00050	0.00073
T-Value	-3.29	0.84	1.34	1.98
P-Value	0.001	0.402	0.183	0.050
Low Ave. Temp		-0.93	-1.04	-1.05
T-Value		-7.86	-8.94	-9.30
P-Value		0.000	0.000	0.000
Water/Land Ratio			13.7	27.2
T-Value			3.98	4.88
P-Value			0.000	0.000
Water Area				-0.00014
T-Value				-3.03
P-Value				0.003
S	8.75	7.37	7.03	6.84
R-Sq	6.79	34.25	40.64	44.15
R-Sq (adj)	5.53	32.92	39.02	42.24

liferation (Lissoni, et al., 2001). This has been demonstrated in certain human breast cancer cell lines such as MCF-7, with additional in-vivo effects on breast oncogenesis in various rat models. Melatonin (N-acetyl-5-methoxytryptamine) is a hormone secreted by the pineal gland of vertebrates, which controls several physiological functions associated with circadian rhythm (Becker-Andre, et al., 1994). Temperature is a major regulator of circadian rhythms. Circadian rhythms control many physiological activities. Synchronization of biological clocks to environmental time is adaptive and important for physiological homeostasis and for the proper timing of species-specific behaviors. A number of investigations have been conducted to examine the effects of temperature and light on melatonin rhythms (Underwood & Calaban, 1987). Based on our analysis, we proposed a second order equation ($y = a + bx + cx^2$) to describe the correlation between the average temperature and mortality rates as this model seems to be the one that best describes the relationship between the two parameters. Hence, based on this model, the estimated temperature (Te) values at which the mortality rates are low is in the range $49 < T_e < 11^oC$.

To further examine the idea that temperature can influence breast cancer rates, we tested the relationship (if any) between mortality rates and geographic coordinates: latitude and longitude.

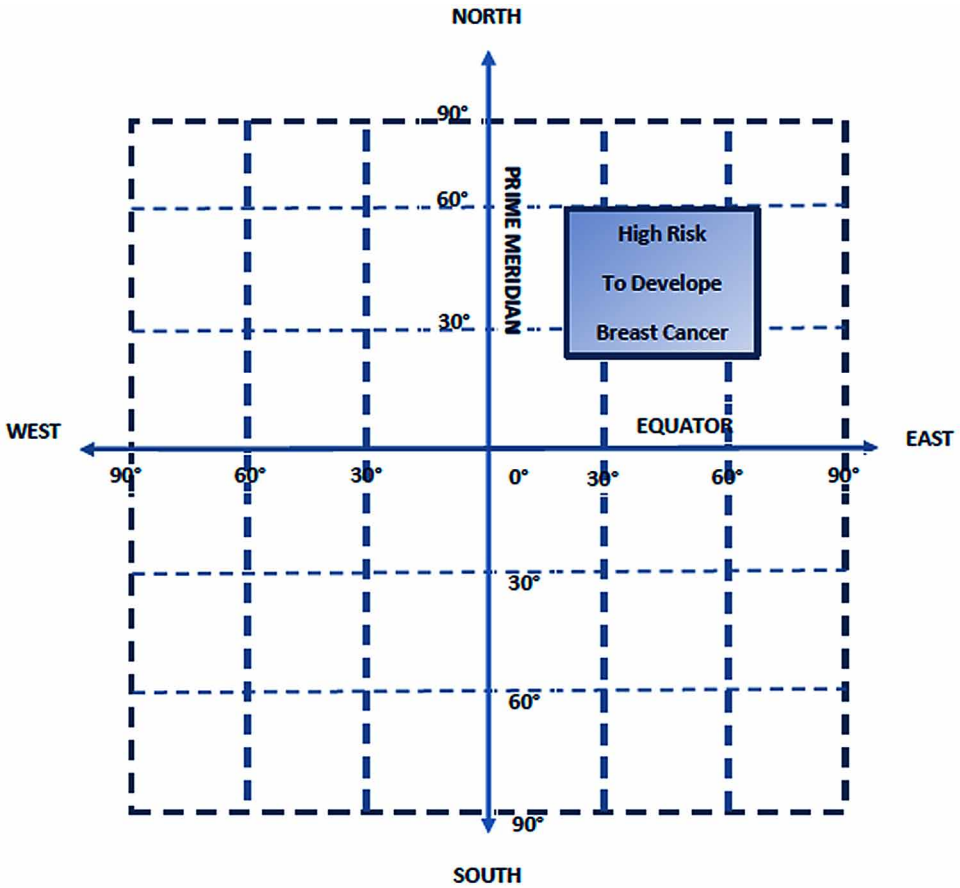
Clearly, the principal controls of temperature variations are latitude and elevation (altitude). The latitude for a given point on the earth has an effect on temperature; the farther away from the Equator (0°) a point is the cooler average temperature that point is likely to have. We obtained worldwide breast

cancer mortality statistics from WHO Cancer Mortality Database. Then, we investigated the possible correlation between the geographic coordinates of the countries and the age-specific rates (ASR) of breast mortality. The result revealed that there is existing negative relationship between latitude and mortality rates, i.e. by increasing latitude the death rate increases. Variations in latitude lead to variations in the temperature and sunlight intensity and hence for disturbance of melatonin rhythms. A previous report, investigators showed evidence for a link between cosmic ray intensity and cancer due to variations in the latitude (Juckett & Rosenberg, 1997). Moreover, it was demonstrated that light-induced melatonin suppression in humans is sensitive to short wavelength light (420 – 480 nm; λ_{max} @ 460 nm) (Skene, 2003).

Jet Lag and Circadian Rhythm

Investigators reported that "Jet Lag" is caused from air travel through changing time zones, and hence leading to disturbance of melatonin rhythms (Samel & Wegmann, 1997). The main but not only cause of jet lag is crossing time zones. Usually going east is worse than going west (Delagrange & Guardiola-Lemaitre, 1997). Finally, the obtained negative relationship between mortality data and elevation is clear in the sense that reduced temperature occur at higher elevation where there is less water vapor to trap and hold heat (Figure 3).

Figure 3. Influence of "jet lag" on breast cancer development



Further, we found a large, significant relationship between women at ages 30-74 and the geographic latitude. For women aged 65 years and older, breast cancer mortality is 26% higher in New England than in the south, while incidence is only 3% higher. Mortality rates from breast cancer are approximately 25% higher for women in the northeastern United States than for women in the South or West. This can be depicted by the correlation with the geographic longitude, see Figure 3. Investigators reported that "Jet Lag" is caused from air travel through changing time zones, and hence leading to disturbance of melatonin rhythms.

The exposure to some spatial environmental factors seems likely to have a major impact on the overall trends in breast cancer rates. The possibility to develop cancer is existing naturally through the environment factors. Unbalanced in these nature factors and/or other existing risk factors, e.g. socioeconomic conditions will increase the chance for cancer development (Figure 4).

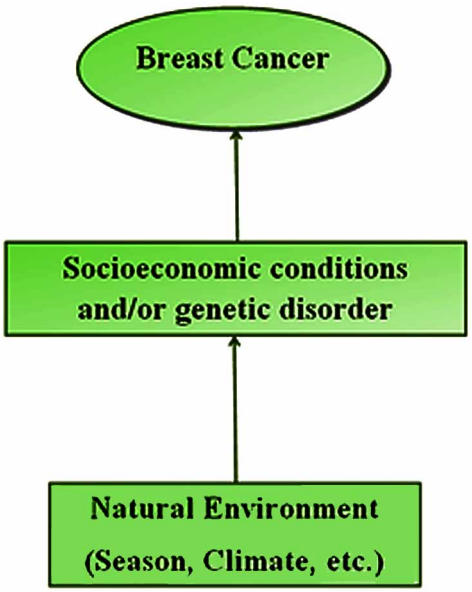
CONCLUSION

We have combined data and techniques from the areas of environmental physics and cancer epidemiology to explore the hypothesis that spatial environmental factors can induce changes in melatonin rhythms, which can lead to increases in breast cancer rates. The results are interpreted as evidence that temperatures can modulate cancer via changes induced in melatonin rhythms.

Results show that the exposure to some spatial environmental factors seems likely to have a major impact on the overall trends in breast cancer rates. Moreover, the possibility to develop cancer is existing naturally through the environment factors.

Furthermore, this study provides valuable reference information for clinicians and health administrators, as well as baseline for statistics will lead to a better understanding of health/environment interaction.

Figure 4. Role of spatial environmental factors in breast cancer development



By utilizing geographical information system technology we can enhance our ability to manage, estimate and predict breast cancer distribution.

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KEY TERMS AND DEFINITIONS

Breast Cancer: Tumor growth that starts in the cells of the breast. The disease occurs almost entirely in women, and it can affect men as well.

Circadian Rhythm: A description of physiological and behavioral patterns altered within 24 hours.

Geographic Information System (GIS): It is defined as computer- established information system that is particularly designed to view and manage information about geographic places, analyze spatial relationships, and model spatial processes.

Incidence and Mortality Rates: Are defined as how many people get and die from breast cancer respectively.

Jet Lag: A medical condition which results as consequence of alterations to circadian rhythms due to long hours of travel.

Medical-Based Geographic Information System (m GIS): GIS applications and the related medical data for monitoring and analyzing medical risk factors associated with the spatial environmental factors.

Regression Analysis: A statistical tool for estimating the relationships between variables.

Chapter 3
Data-Driven Approaches for Developing Clinical Practice Guidelines

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ABSTRACT

This chapter discusses clinical practice guidelines (CPGs) and their incorporation into healthcare IT (HIT) applications. CPGs provide guidance on treatment options based on evidence. This chapter provides a brief background on challenges in CPG development and adherence, and offers examples of data-driven approaches to improve usability of CPGs and their applications in HIT. A focus is given to clinical pathways, which translate CPG recommendations into actionable plans for patient management in community practices. Approaches for developing data-driven clinical pathways from electronic health record data are presented, including statistical, process mining, and machine learning algorithms. Further, efforts on using CPGs for decision support through visual analytics, and deployments of CPGs into mobile applications are described. Data-driven approaches can facilitate incorporation of practice-based evidence into CPG development after validation by clinical experts, potentially bridging the gap between available CPGs and changing clinical needs and workflow management.

INTRODUCTION

Clinical practice guidelines (CPGs) are "systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances" (Field & Lohr, 1990; Steinberg, Greenfield, Mancher, Wolman & Graham, 2011). CPGs are known as the best sources of available medical evidence, and their usage is expected to improve health outcomes, avoid unnecessary treatment variations, and reduce overall costs of care (Rotter et al., 2012; Saint, Hofer, Rose, Kaufman, & McMahon, 2003). Hence, recommendations from CPGs can play a crucial role in shaping the way

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healthcare providers care for patients. In the United States, the National Guideline Clearinghouse (NGC), maintained by the Agency for Healthcare Research and Quality (AHRQ) of the Department of Health and Human Services, is a publicly available repository of evidence-based clinical practice guidelines created by professional healthcare organizations ("Guideline Index," 2015). For example, the National Kidney Foundation (NKF) produces CPGs through the NKF Kidney Disease Outcomes Quality Initiative (KDOQI) to provide evidence-based guidelines for the diagnosis and management of chronic kidney disease (CKD) and associated complications (Levin & Rocco, 2007). In the United Kingdom, the National Institute for Health and Care Excellence (NICE) publishes clinical, public health, social care, safe staffing and medication practice guidelines ("Find guidance," 2014). NICE guidelines cover 23 broad clinical conditions, each of which further extends to sub-conditions ("Conditions," 2014).

Typically, CPGs are text-based, and contain very detailed, contextualized recommendations about various clinical circumstances that may arise during the diagnosis and management of health conditions. Accessing CPGs during patient care imposes significant cognitive workload due to their length and detailed content (Zhang et al., 2015; Zhang, Padman & Patel, 2015; Zhang & Padman, 2015). As information technology (IT) gains widespread adoption in healthcare, researchers have developed languages and systems to incorporate CPGs into healthcare IT (HIT) applications with the objective of guiding more efficient healthcare practice (Peleg, 2013). This chapter summarizes the current state of CPG usage by clinicians and presents an overview of data-driven methodologies that can be incorporated into HIT systems to address some of the challenges in CPG deployment and usage. We further delve into data-driven clinical pathway learning, visual analytics, and mobile healthcare applications that are key components to facilitate the incorporation of CPGs into current best practices. Finally, we discuss CPG-based clinical decision support (CDS) that integrates these components into an effective tool for encouraging adherence and facilitating decision support at the point of care (Lobach & Hammond, 1997) to improve the quality and efficiency of modern healthcare delivery.

BACKGROUND

As of 2015, the number of CPGs in the US National Guideline Clearinghouse is 2,382 ("Guideline Index," 2015). On the other hand, the number of diagnostic codes in ICD-10 is 69,823 ("Classification," 2015). There is a clear shortage of CPGs, given the number of clinical conditions that exist. In addition, CPGs across clinical areas contain recommendations with differing *strengths of evidence*. *Strength of evidence* is categorized into 3 levels:

1. Consistent and good quality patient-oriented evidence,
2. Inconsistent or limited quality patient oriented evidence,
3. Consensus by experts (Ebell et al., 2004).

Most clinical practice guidelines and pathways are designed with the 'average patient' in mind (Geleris & Boudoulas, 2011; Rosoff, 2001), and its development process is driven by evidence from randomized clinical trials (RCTs) in some areas and by consensus opinions of experts in others (Uhlig, Balk, Lau, & Levey, 2006). For instance, while recommendations made in CPGs for conditions such as hypertension are frequently based on consistent, good quality, patient-oriented evidence ("Rating," 2014), strength of evidence in nephrology is known to be of lower quality (Uhlig et al., 2006). Even evidence from

RCTs is not always generalizable to a broader population, as most RCTs have strict patient recruitment criteria that exclude patients with multiple comorbidities, and can be biased by the method of trial execution and interpretation (Hampton, 2003). Hence, there are limited evidence-based guidelines on the appropriate treatment processes for multi-morbid and high-risk patients who incur a large proportion of current healthcare spending (Stewart, Shah, Selna, Paulus, & Walker, 2007). Moreover, RCTs have no guarantees of significant findings, despite high costs and long execution times, making it an expensive choice for evidence-generation for CPGs.

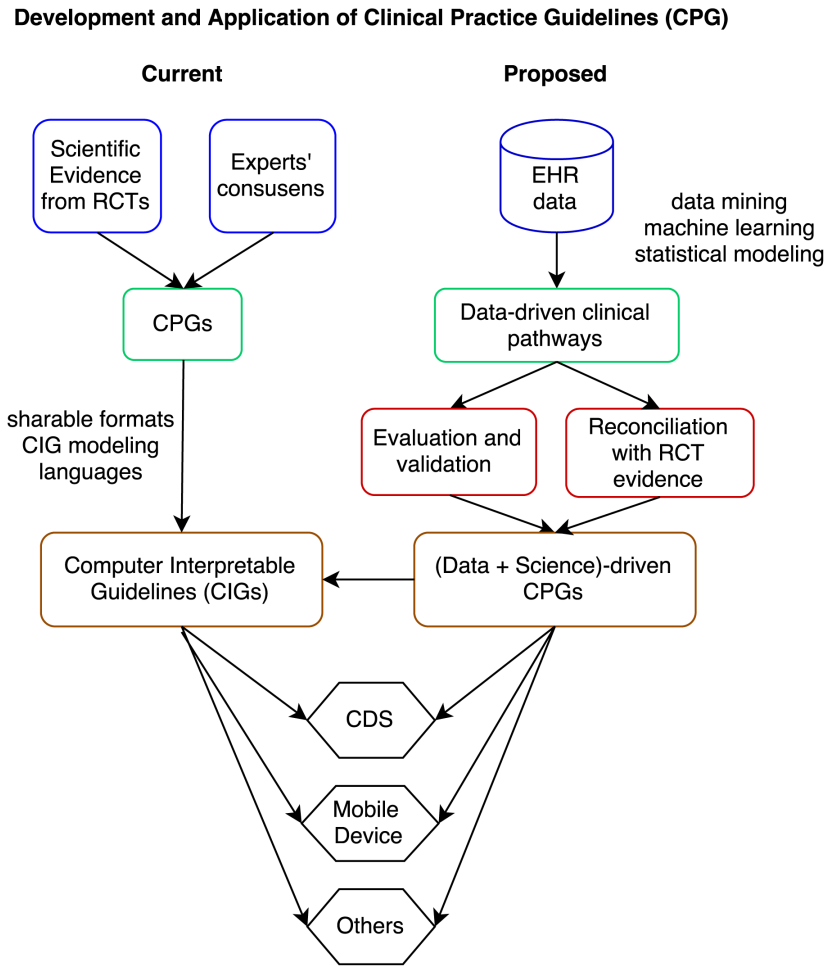
MAIN FOCUS OF THE ARTICLE

Previous studies have investigated clinicians' CPG adherence across clinical areas and facility settings (Ho, Caughey, & Shakib, 2014; Lee et al., 2015; So et al., 2014). Ho et al. examined clinicians' adherence with Australian CPGs for congestive heart failure (CHF), atrial fibrillation, diabetes mellitus and ischemic heart disease (Ho, Caughey, & Shakib, 2014). They found that clinicians' adherence was high, ranging from 86% for lipid lowering therapy to 98% anti-platelet agents. So et al. evaluated interventions for improving antibiotic prophylaxis (AP) guideline adherence to prevent surgical site infections in a pediatric hospital in Canada. They found that a multifaceted intervention, including trainee orientation, HIT functions such as antibiotic verification, computerized alerts, and follow-up emails, improved CPG adherence, significantly increasing appropriate antibiotic use from pre-intervention to follow-up (So et al., 2014). On the other hand, a widely cited study by Cabana et al. reports that lack of awareness, familiarity, agreement, self-efficacy and outcome expectancy are among the primary barriers to physician adherence to CPGs (Cabana et al., 1999). A study by Hall et al. also finds that across 9 Ontario cancer treatment centers, a CPG on concurrent chemotherapy with radiation therapy was observed on 55% of the patients, and recommends that CPG development should take the expected level of adherence into account (Hall, Irish, Gregg, Groome, & Rohland, 2015). While lack of adherence may be due to simplistic treatment needs (Fauman, 2006), it may also be an indication of mismatch between the guidance and access to critical information that is desired and provided (Hasan, Duncan, Neill & Padman, 2011). The difference in level of adherence also may be a result of the differing strengths of evidence across clinical conditions. Lack of CPG adherence could be a great loss to healthcare quality, because effective use of CPGs can facilitate caregivers to provide accurate and confident decisions at the point of care (Cook, Enders, Linderbaum, Zwart, & Lloyd, 2014), and avoid cognitive errors in the assessment of probabilities (Tversky & Kahneman, 1974).

As shown in Figure 1, a commonly used approach for healthcare providers to access CPGs are through electronic health record (EHR) interfaces, such as AskMayoExpert developed at the Mayo Clinic (Cook et al., 2014). CPGs are integrated with EHRs as computer-interpretable guidelines (CIGs) (Peleg, 2013). Sharable formats for translating text-based CPGs into CIGs have been widely explored in the literature over the last two decades (de Clercq, Hasman, Blom, & Korsten, 2001a, 2001b; Wang et al., 2003; Shahar et al., 2004; Wang et al., 2004; Moskovitch et al., 2006; Mulyar, van der Aalst, & Peleg, 2007; Young et al., 2007, Moskovitch & Shahar, 2009; Zheng, Padman, Johnson & Hasan, 2010). The main topics associated with CIGs include modeling languages, knowledge acquisition and specification methodologies, integration with workflows, validation, execution engines, exception handling, maintenance, and sharing guidelines (Zheng, Padman, Johnson & Hasan, 2010; Peleg, 2013). Well known ontologies for processing CPGs include Arden Syntax (Pryor & Hripcsak, 1993), EON (Musen, Tu, Das, & Shahar,

1996), Asbru (Shahar, Miksch, & Johnson, 1998), GEM (Shiffman et al., 2000), PROforma (Sutton & Fox, 2003) and GLIF3 (Boxwala et al., 2004; Wang et al., 2004). Some recent work takes a more patient-centered approach to CPG incorporation (Gonzalez-Ferrer, ten Teije, Fdez-Olivares, & Milian, 2013). In Gonzalez-Ferrer et al. (2013), CPGs developed for Hodgkins' disease were translated into CIG, and then further translated into a hierarchical task network (HTN), enabling the automated generation of patient-centric, time- and resource-based care pathways. These approaches take existing CPGs as input, and therefore inherit the limitations of the CPGs as well. This chapter summarizes some innovative, data-driven approaches as a potential strategy to overcome the limitations faced by current CPGs by learning practice-based evidence from the vast amounts of EHR data collected as part of routine care. Applying novel statistical modeling techniques and machine learning methods to represent and learn data-driven insights presents a new opportunity for meeting evidence-based care delivery objectives in CPG development.

Figure 1. Comparison of text-based and data-driven CPGs



SOLUTIONS AND RECOMMENDATIONS

As care delivery focus on evidence-based and patient-centered healthcare intensifies, continuous quality improvement and efficient service innovation has become increasingly important. Traditionally, the best available source of evidence has been CPGs (Steinberg, Greenfield, Mancher, Wolman & Graham, 2011). However, provider organizations are accumulating tremendous amount of data in their electronic health records (EHR) systems that provide an alternative, and more practice-based, source of evidence that they can rely on via the data warehouse. Today, nearly every task performed by healthcare providers for patient treatment can be logged in the EHR (Jarvis et al., 2013). In addition, there is a growing trend to link EHR data with claims data from health insurance providers, laboratory values, behavioral data, and even genomic as well as patient-generated data, to obtain a comprehensive view of patients' health status and history. The availability of such rich data sources has motivated attempts to replicate RCT evidence from observational studies by extraction of care delivery patterns and associated outcomes from groups of matched patients (Johnson, Crown, Martin, Dormuth, & Siebert, 2009; Wallace, Shah, Dennen, Bleicher, & Crown, 2014). For example, organizations such as Intermountain Healthcare have developed evidence-based CPGs, to be applied as part of their clinical workflow such as order sets and checklists. They also regularly cross-reference their actual practices to update CPG contents with an aim to reduce treatment variation and costs (James & Savitz, 2011). This practice, called "shared baselines," has been shown to contribute to effective care management and significant cost reduction (James & Savitz, 2011).

One example of data-enabled approaches is the development of data-driven clinical pathways. Data-driven clinical pathways are based on patterns of care that result in differential outcomes, learned from EHR data (Zhang, Padman, & Patel, 2015). Since they reflect the actual practices in specific care delivery settings, data-driven clinical pathways have the potential to be consistent with each organization's workflow, up-to-date with the current best practices, and capable of being incorporated efficiently into CDS as an extension of current clinical information systems. Clinical pathways, traditionally developed manually by clinical experts, translate CPG recommendations into actionable plans for patient management, taking into account local workflows and IT systems (Rotter et al., 2010). As opposed to CPGs, which provide detailed, text-based recommendations, clinical pathways are easier to read and understand by frontline healthcare providers (Rotter et al., 2010). For example, NICE pathways summarize NICE guidelines to assist healthcare providers navigate through lengthy and detailed topics ("Find guidance,"2014). Clinical pathways are known to reduce in-hospital complications and lead to potential reduction in length of stay and medical expenses (James & Savitz, 2011; Rotter et al., 2010). In the US, more than 80% of all hospitals use clinical pathways for at least one intervention (Saint et al., 2003).

- **Statistical Methods:** Since the 1990s, studies have explored ways to learn clinical pathways and care patterns from EHR using methods from statistics, process mining, and machine learning (Aalst, Weijters, & Maruster, 2004; Z. Huang et al., 2014; Z. Huang, Lu, & Duan, 2012; Lakshmanan, Rozsnyai, & Wang, 2013; F. Lin, Chou, Pan, & Chen, 2001; F.-R. Lin, Hsieh, & Pan, 2005; Poelmans et al., 2010; Zhang, Wasserman, & Padman, 2014; Zhang & Padman, 2015; Zhang, Padman, & Patel, 2015; Zhang et al., 2015). For example, Lin, Hsieh, and Pan (2005) and Poelmans et al. (2010) modeled clinical pathways as a hidden Markov model (HMM), a stochastic model for randomly changing processes. An HMM is defined by 5 elements: sequence of hidden states, sequence of observations, state transition probability distribution, observation probability distribution, and initial state distribution (Rabiner & Juang, 1986). In an HMM, the sequence of

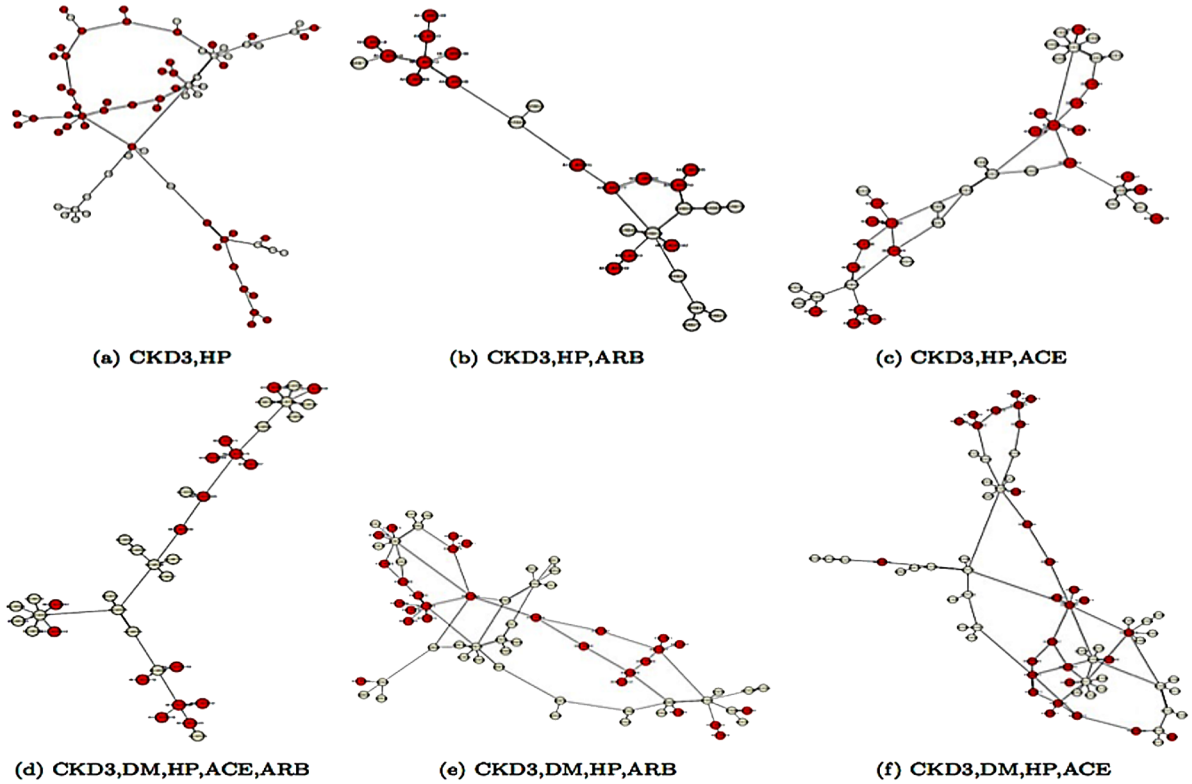
observations is visible, and each observation is dependent on its corresponding hidden state in the sequence of hidden states. In Lin et al. (2005) and Poelmans et al. (2010) it is assumed that hidden states in the HMM are states in the clinical pathway to be learned, and observations are actual interventions that occurred in practice. These two studies applied HMM on newborn delivery and breast cancer surgery, respectively, both of which are processes whose events have clear temporal relationships. Some recent studies by Zhang, Padman, and Wasserman (2014), Zhang et al (2015), and Zhang, Padman, and Patel (2015) used time homogeneous Markov chains to model clinical pathways, where each state in the pathway is a transition of clinic visits with specific durations in between the visits. Markov chains are sequences of states that follow the Markov property, which states that current state is dependent only on the previous state (Norris, 1999). This study applied clinical pathway learning methods to chronic kidney disease, whose management is based on repeated clinic visits and monitoring of patients' comorbidities over time. Unlike the applications in previous studies, in the management of chronic conditions, it is typical for multiple interventions to have the same timestamps, so considerable effort was applied to develop accurate representation of the EHR data (Zhang, Padman, & Patel, 2015). A growing number of organizations, such as the Accountable Care Organization (ACO) in the US, are incentivizing healthcare providers from different disciplines to provide coordinated care to groups of patients via bundled payments. Exploring clinical pathways that describe the trajectory and interactions of multiple clinical activities, and the outcomes and expenses associated with them, have the potential to provide significant insights on cost effectiveness of treatments ("Patient Protection and Affordable Care Act," 2010), and hence is an important research topic to pursue further (Zhang & Padman, 2015).

- **Process Mining and Machine Learning:** There is also some literature on data-driven clinical pathways using process mining approaches. Process mining is about learning a workflow model from tasks and their time of execution recorded in EHRs (Yang & Su, 2014, Zheng et al., 2009). Many of the process mining approaches, such as Heuristic Miner (Weijters, Aalst, & Medeiros, 2006) and Fuzzy Miner (Günther & Aalst, 2007), have been applied to clinical settings, although they disregard noise in the data and assume that event logs contain sufficient information. Since diversity is innate to most health data, and is one of its most challenging characteristics, this assumption may lead to spaghetti-like workflow models that are very difficult to interpret (Aalst et al., 2004). Using process mining approaches, Huang et al. presented several algorithms for clinical pathway patterns using methods such as dynamic programming and topic modeling (Huang et al., 2014; Huang et al., 2012). Machine learning techniques such as clustering and sequential pattern mining are used in recent studies. These techniques provide a potential solution to the spaghetti-like workflows by segmenting patients into relatively homogeneous groups before learning the workflow model. For example, Zhang et al. and Greco et al. used hierarchical clustering to cluster patients' sequences of visits (Gianluigi Greco, Antonella Guzzo, & Pontieri, 2005; Zhang, Padman, & Patel, 2015), and Lakshmanan et al. segmented patients by their outcomes, followed by further clustering using DBScan and frequent pattern mining using SPAM (Lakshmanan et al., 2013). The main focus in these studies is to extract not only the process structures but also latent patient subgroups from data. Associating processes and subgroups with outcomes will be a valuable next step in eliciting further insights.
- **Visualization of Pathways:** Visualization techniques allow healthcare providers to make effective use of their large amount of health information, and can be even more powerful when coupled with advanced analytical methods such as clinical pathway learning algorithms. The combination

of visualization and analytics is therefore called visual analytics (Caban & Gotz, 2015, Keim, Mansmann, Oelke, & Ziegler, 2008). Although visual analytics have been explored widely in computer science and engineering, its application in healthcare is still in the early stages of application and adoption (West, Borland, & Hammond, 2015, Harle et al., 2012). A promising role of visualization in the context of CPG is to compare CPGs and actual practices. For example, EBCPG (Yang & Chiang, 2006) uses radial basis tree explorer and a knowledge map to assist clinical decision making according to the visualized CPG at the point of care (Boxwala et al., 2004; Wang et al., 2004). Figure 2 is a visualization of the different pathways found using methods from Zhang, Padman, and Patel (2015), and shows the most common data-driven clinical pathways for subgroups of patients with specific diagnoses and medications. Close examinations of these pathways may identify practices that are consistent, or inconsistent with CPG recommendations, and more importantly, patients' subsequent clinical status.

In addition, Vita-Lab derives its medical concepts from CPGs using a knowledge acquisition tool Gesher (Hatsek et al., 2010), and its visualization interface has a function that allows users to assess the outcomes from CPG-adherent treatments (Klimov, Shknevsky, & Shahar, 2015). These techniques to visualize temporal and granular nuances in the EHR data, as well as those to compare against CPGs, have the potential to better aid healthcare providers and researchers to identify discrepancies between actual practice and CPGs, hence prompting timely maintenance and updates of CPG, and even hypoth-

Figure 2. Visualization of pathways across patient subgroups



esis generation for future RCTs (Hirsch et al., 2015; Huang et al., 2015; Klimov, Shknevsky, & Shahar, 2015; Zhang, Padman, & Patel, 2015).

FUTURE RESEARCH DIRECTIONS

- **Mobile Applications:** In recent years, there has been an increased adoption of mobile applications by healthcare providers (Junglas, Abraham, & Ives, 2009; Mosa, Yoo, & Sheets, 2012; Ventola, 2014). More than 4,000 Apple iOS medical applications have been developed by both commercial and academic institutions to target usage by healthcare providers (Seabrook et al., 2014). For example, mobile applications such as Epocrates includes medication recommendations from CPGs for treating various diseases as well as other decision support functions, with one in two physicians using its services (Epocrates, 2015). Literature that evaluates these healthcare mobile applications has also been increasing. In 2014, Andrus et al. reviewed 1,529 medication records from outpatient family medicine or pediatric clinics at a teaching hospital, and found that Epocrates provided accurate formulary information for 89.4% of the medications (Andrus, Forrester, Germain, & Eiland, 2015), with 2,730 covered diseases (Epocrates, 2015). Other studies have compared recommendations from a number of mobile applications to those from CPGs, with mixed results across different clinical areas (Chomutare, Fernandez-Luque, Arsand, & Hartvigsen, 2011; Dubey et al., 2014; Miller, Beattie, & Butt, 2003; O'Neill, Holmer, Greenberg, & Meara, 2013; Zaki & Drazin, 2014). Nevertheless, as clinicians increasingly continue to rely on mobile technology for relevant information at the point of decision making (Ventola, 2014), there is still a substantial lack of understanding and evaluation of the mechanism of CPG incorporation into mobile applications. Mobile applications' impacts on healthcare providers' performance, care quality and clinical outcomes, especially given limited space for knowledge display as well as different pricing options, may be topics to be explored in the future.
- **Workflow Management:** An understanding of healthcare providers' workflows and the needs and demands of their patients is essential, although not sufficient, for successful application of CPGs in practice. In healthcare service delivery setting, front-line employees are the physicians and nurses caring for the patients, who incur both physical and cognitive costs associated with their management (Zhang, Padman, & Levin, 2014). To improve quality of healthcare services, there is a need to understand how these clinicians organize care provisioning, what they refer to during interactions with patients and for decision making, and, when they decide to disagree with recommended practices, the reasons behind such decisions. Answers to these questions were difficult to collect and systematically quantify until the accumulation of vast amounts of data was made possible via advances in healthcare IT. EHR data contains valuable information on care delivery patterns of clinicians, allowing healthcare organizations to compare them against CPGs (van de Klundert, Gorissen, & Zeemering, 2010), identify treatment and workflow variations (Zhang, Padman, & Levin, 2014; Lin & Padman, 2013), build IT components such as CDS and health portals (Jung & Padman, 2014), and examine the risks incurred and their management resulting from the incorporation of CPGs into workflows (Bai et al, 2013). Future work needs to explore innovative use of EHR data to address these challenges and can contribute further to service innovation and evidence generation in a timely manner and is aligned with cognitively-guided, optimized workflows.

- **Validation:** It is important to recognize that data-driven algorithms and their outputs may be biased due to data quality and size, and more importantly the practice culture and individual provider's habits. Therefore, we need systematic ways of assessing the association between knowledge learned from data, such as data-driven clinical pathways, with known scientific knowledge, patient outcomes, and medical expenses. Inputs from clinical professionals are crucial in validating knowledge from data, identifying biases, and suggesting efficient routes to translate data-driven knowledge into actionable plans.

CONCLUSION

Innovative use of data-driven approaches has the potential to facilitate more efficient development and use of CPGs, leading to better care for patients (Lobach & Hammond, 1997). Some of these concepts have been explored over the last few decades, especially with the development of CIGs (de Clercq, Blom, Korsten, & Hasman, 2004), and this chapter provides a brief overview of selected research on this topic. For the future, data-driven approaches in developing and visualizing CPGs offer even more promise in patient care that are tailored to different organizations, patient populations, and the vast number of health conditions for which CPGs do not yet exist. For example, data-driven clinical pathways can be learned from patient data collected from within and outside the clinical setting via EHR that potentially provides actionable insights on outcomes and costs based on patients' treatment history, biochemical measurements, genomic and patient-generated data. It is expected that each clinical pathway will contain rich temporal information on how individuals may respond to different interventions depending on demographic, behavioral, and genomic characteristics, making it a valuable method that contributes to the Precision Medicine Initiative (Collins & Varmus, 2015). For instance, studies have explored methods to use historical pathways and trajectories to predict a new patient's future status, such that appropriate interventions can be taken to mitigate potential risks (Ebadollahi et al., 2010; Zhang & Padman, 2015). Future studies that advance further development and appropriate use of these data-driven CPGs in the context of decision support-enabled care delivery are critically needed to help healthcare organizations achieve continuous quality improvement (Kayyali, Knott, & Kuiken, 2013), better patient outcomes, and reduced costs.

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Chapter 4
Opportunities and Challenges of Big Data in Healthcare

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ABSTRACT

Healthcare big data streams from multiple information sources at an alarming volume, velocity, and variety. The challenge that faces the healthcare industry is extracting meaningful value from such sources. This chapter investigates the diversity and forms of data in the healthcare sector, reviews the methods used to search and analyze these data throughout the past years, and the use of machine learning and data mining techniques to mine useful knowledge from such data. The chapter will also highlight innovations of particular systems and tools which spot the fine approaches for different healthcare data, raise the standard of care and recap the tools and data collection methods. The authors emphasize some of ethical issues regarding processing these records and some data privacy issues.

INTRODUCTION

We live in the age of Big Data, where every single data entry to any computer at home or office is being recorded in data centers and processed later in order to get valuable information or knowledge. IDC (International Data Corporation) defines Big Data technologies as a new generation of technologies and architectures, designed to extract economical *value* from very large *volumes* of a wide *variety* of data produced every day, by enabling high *velocity* capture, discovery, and/or analysis (Gantz & Reinsel, 2011). Other institutes and companies such as SAS, IBM and Oracle have other dimensions for Big Data, but they all address same concepts.

Several organizations create very large databases, such as consumer data and transaction histories of sales records, patient records, images at hospitals, fingerprints and DNA samples at crime scenes, and data acquired via satellites or surveillance cameras. It is apparent that there is a huge gap between the amount of available information and its corresponding knowledge, which gives an opportunity for extracting hidden knowledge.

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Healthcare can be considered a major sector for producing big data. Healthcare data have many dimensions such as personal information regarding dates of birth, nationality, sex, location and other information about income and education plus other specific data about history of the patient with medical centers and/or disease. It is generated by everything around us at all times in intensive care units and in surgical operation room, inwardfrom every digital process in systems or sensors.

The aim of this chapter is to discuss the notion of big data when applied to the healthcare sector. The next section reveals how and why big data are represented in health care. Big Data's Vs will be emphasized for healthcare data in the third section. The fourth section highlights different techniques that are well suited for intelligent data analysis. Section five illustrates the challenges facing Big Data and the opportunities available for valuing analysis, and some ethical, legal and social concerns about manipulating healthcare data specifically. Some implications are contending in the future directions showing how they can play an important role in the overall improvement of the healthcare industry.

BACKGROUND

Medical data are at once the most rewarding and challenging of all biological data. For decades everyone was infatuated by the liability of keeping every record and collecting any possible information about everything in their life. The healthcare industry has also experienced these practices about generating and keeping large amounts of data driven by record keeping at physicians' clinics, which is referred to as patient records. This includes forms filled by the patient regarding his/her personal information and oral examination recorded by physicians during visits. Other forms of checkups, different laboratory examinations, and CT scan as well as X-ray images are also kept in hospital's emergency room when examining patients. Moreover, data about compliance & regulatory requirements, and patient care is also evolving from national and international organizations that monitor and administer the healthcare industry.

Electronic health records have experienced several studies. Drug safety study (Trifirò et al., 2009) investigated adverse drug reactions with other diseases, in (Jensen, Jensen, & Brunak, 2012), they combined the HER with the genetic data to reveal gene-disease association, (Almodaifer, Hafez, & Mathkour, 2011) discovered the interesting and concise medical rules for prediction purpose to assist the medical decision makers.

Medical diagnosis researches have proven a great success, because the data about the disease and the patient under examination is always available. In fact the medical diagnostic knowledge can be automatically derived from the description of cases solved in the past. (Kumar, Sathyadevi, & Sivanesh, 2011) proposed using an intelligent clinical decision support system to assist physicians in diagnosing. An automatic diagnosis system was presented in (Karabatak & Ince, 2009b). Soni & Ansari, 2011; Kharya, 2012; Huang, Chen, & Lee, 2007; (Ha, 2011) (Kononenko, 2001) summarized several machine learning techniques used for classifying diseases such as naïve Bayesian and neural networks, his work also highlighted the specific requirements for good performing machine learning algorithms in solving medical diagnostic tasks.

Image parameterization observed in medical records is very useful in quality control, identification, image grouping, surveillance, image storage and retrieval, and image querying. Texture classification is closely related to diagnostic process to diagnose coronary artery disease (Kukar, Kononenko, & Grošelj, 2011).

Big Data V's

The V's that characterizes Big Data (volume, variety, velocity, and value) will be identified with exceptional respect to healthcare sector.

Volume

The volume of generated and stored data is extremely expanding every year, and there is an evolution amongst the country level, in digitizing all transactions. Electronic health records (EHR) are stored in databases since the eighties of the past century. These records are generated when a patient gets medication service at a physician clinic, hospital or even from the pharmacy. In the past there was no collaboration between these different entities which resulted in duplication and inconsistence of patient records. According to data.worldbank.org the world population is about 7 billion, where about 15% lived in developed countries. EHRs types, which vary from any, basic to fully functional, were adopted in these developing countries, and there are plans to establish health systems in other urban areas, which describe the volume of records in anticipation of processing. Moreover, data also is generated during laboratory examinations of blood and other fluids, images of different types and are all kept recently in electronic formats. These records are kept not only for living people, but also for the people who died several years ago. Data about drug specifications, formulations, interaction, side effects and safety are all kept as pharmaceutical documentary records. Billing, financial transactions and insurance claims are also archived over years.

Variety

The variability and complexity of healthcare data come from different resources that provide the data in different formats. Patient records by themselves can have different forms, since some clinics or hospitals can adopt a similar format, although some private clinics may not. Some records may contain images with different size and dimensions like X-Ray, CT Scan or MRI which increase the complexity of handling these data. Laboratory tests may also differ between clinics and hospitals. The prescription advised by the physician can be kept as text or scanned image. In the operation or intensive care units, nurses and doctors may keep observatory text notes and examination checks.

Survey information on population health, such as causes of deaths, community health, and health care systems are collected in Population health metrics. National health organizations control enrollment into health insurance plans in order to administer health care delivery. Huge statistics on public health databases and registries concerning births, deaths, disease incidence, health event case reports, demographics and more are available at United Nations organizations.(HealthData.gov, 2014)

Velocity

Medical databases are constantly updated in critical health conditions. Dealing with data from intensive care units (ICUs) and operating rooms (ORs) are a challenge in hospitals. Continuous and high priority monitoring add new records and tests in every second. There is a necessity to update the databases since doctors and nurses write progress notes. Drug prescription and delivery is changed and charted several times a day. Monitors generate large amounts of data on a continuous basis, as well as therapeutic de-

vices such as mechanical ventilators, syringe- and infusion pumps for drug and fluid administration, or renal replacement therapy machines. Blood samples for ICU occupants are drawn for laboratory analysis several times a day, and microbiology sampling occurs several times a week (Meyfroidt, Güiza, Ramon, & Bruynooghe, 2009). At Home monitoring systems for critical disease patients through sensing devices such as heart monitors, ventilators, cell phones accelerometer or wearable devices provide real-time data.

Value

It is, however, the value, veracity, or 'data assurance' that should generate an improvement in the healthcare industry. In order to benefit from the mass of collected data; researchers, practitioners and policy makers should analyze these data and get implication which will strengthen decision making and improve healthcare management. Organizations should be able to analyze health problems through investigating health claims, get a more complete view of health processes and their interactions by analyzing patients' records, evaluating a greater number of scenarios quicker and more cheaply to best achieve operational efficiency at ICU units and operation rooms, employees satisfaction, and risk reduction for healthcare organizations across the nation. Drug safety researchers need to get new experiences into medication drug collaborations that have not been completely comprehended or anticipated during clinical trials, this can be achieved by association analysis at the pharmacology level and public health researchers. (Silvia & Claps, 2013)

The healthcare industry is moving from reporting truths to disclosure of experiences, getting to be information driven. Converting data and information into actionable insights by several procedures of data analytics to prevent inefficiencies and adapt workflows for improved healthcare outcomes across the end-to-end patient journey will be paramount. It will empower better joint effort among clinical experts, engaging general health authorities to supervise the individualized gathering anticipation movement, and providers to implement new industry models, pushing performance by reward could set scales for financing healthcare services, making it available extensively for people. (Silvia & Claps, 2013)

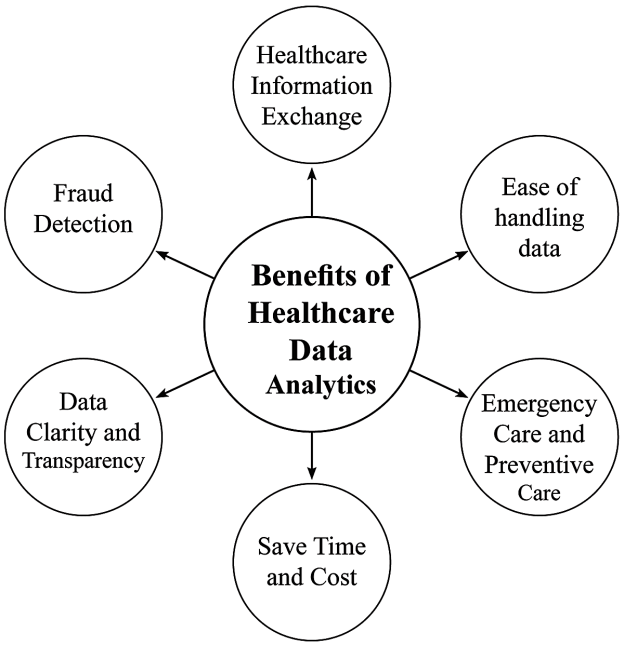
Eventually, it is the value that will make Big Data a genuine power of progress in healthcare, ensuring value while preserving quality.

HEALTHCARE DATA ANALYSIS

In addition to the high volume and velocity, the complexity and variety of big data, Gartner IT dictionary has added that big data also demand cost-effective, innovative forms of information processing for enhanced insight and decision making (Gandomi & Haider, 2015). Data can be described as big if the growth of data far exceeds the efforts done to understand it.

Healthcare data analysis can be advantageous in building predictive modeling that can lower attrition and results in fine procedures in clinical operations and drugs safety. For public health improvement, analysis of largely produced medical data can help in finding disease patterns and tracking epidemic diseases, turn data into actionable evidence to improve services and prevent fraud and crises (Raghupathi & Raghupathi, 2014). Figure 1 illustrates that different employees in the healthcare sector will aggravate better choices concerning strategy making, inventing new instruments to capture data, new strategies for diagnosing and prognosis, developing patient engagement, optimizing operations, putting off fraud as well as threats, and profiting by introducing a new supply of income.

Figure 1. Benefits of healthcare data analytics
Dergurahian, 2011.



Due to the variety of data, which holds images, forms, databases and surveys, analysis techniques that deals especially with large amount of data is adopted. Machine learning algorithms and data mining techniques proved to be the best practices which aids and supports the process of decision making.

Machine Learning

Statistics for decades was the best analytical tool for medical students and researchers. It was used for survey analysis, generating reports and representing charts, comparative studies about different health care distribution and disease/drug relationship. Due to the fast evolution in computation and computers, machine learning became the new solution. A major subfield of artificial intelligence based on statistical foundation, machine learning is a multidisciplinary field involving information theory, philosophy, neurobiology and other fields.

The fast growth of databases and the lack of knowledge mining, challenged researchers to benefit from the low-priced computation power. Big Data investigation requires enormous programming effort, which can be simplified using intelligent systems that support learning making it simple and comprehensible, a program can be automatically driven. Machine learning algorithms are probably the most valuable candidates for health care data analytics because they can deal with different and large amounts of data integrated from different sources and they also rely explicitly on previous domain knowledge or experience in the analysis, providing several programs for intelligent data analysis.

Supervised learning algorithms discover automatically a knowledge model as a result of the learning process that provides a description of the data explored. Support Vector Machine (SVM), Decision Tree (DT), Artificial Neural Networks (ANNs), Regression, K-nearest neighborhood (KNN), Bayesian

Networks (BN) and many more algorithms were considered for machine learning to classify and organize big data easily. The aim of the knowledge model is to predict the value of the target attribute for new unseen patterns.

Another type of learning is unsupervised learning, which analyzes the information or data with unknown target variable, building the model which solely describes the data analyzed. The goal of the process is to build a model that describes interesting regularities in the data.

These learning techniques are mostly used in medical diagnosis, and classifying patients accordingly to different attributes available in their medical records (Hariz, Adnan, Husain, Aini, & Rashid, 2012; Kononenko, 2001; Meyfroidt et al., 2009; Yang & Wu, 2006), Lots of researches regarding machine learning in medical data and bioinformatics are available in (Larrañaga et al., 2006; Prompramote, Chen, & Chen, 2005; Lavrac, 1999; Lavrač, 1999).

Data Mining

As the gap between produced data its understanding is widening, it is high time to look for potentially useful information which lies hidden in all these hypes of data or information. Data mining or Knowledge Discovery from Databases (KDD) helps extracting such patterns (Witten, Frank, & Hall, 2011). Data mining has been used earlier in market analysis, financial data analysis, business management, space exploration and proved to be the best solution for various domains especially medical data analysis (Tomar & Agarwal, 2013).

Healthcare industry can benefit from using data mining techniques to take considerable actions regarding: (Tomar & Agarwal, 2013)

1. Effective management of Hospital resource,
2. Hospital Ranking,
3. Better Customer Relation,
4. Hospital Infection Contro,
5. Smarter Treatment Techniques,
6. Improved Patient care,
7. Decrease Insurance Fraud,
8. Recognize High-Risk Patients,
9. Health Policy Planning.

The nature, complexity and growth of the data in healthcare sector, brings medical data mining to the edge of new technologies, proposing a powerful tool for analyzing and extracting important knowledge.

The knowledge can help building models that might support prediction of diseases or recommend drug, understanding the nature or describe associations of the data been collected. Applying data mining concepts, such as prediction, description, summarization and visualization to the healthcare big data improved the industry, saving time, money and life (Jacob, 2012).

Medical data may take tabular form or standard format *m.n* array where *m* represents the size of the data in rows and *n* represents the features or attributes in which data is described. Classification techniques, built across supervised learning techniques, dominates other data mining techniques because it is can assist in the future prediction by building a model of a classifier. Practitioners may seek for quantitative

or qualitative description of the data, grouping patients with similar features or having similar disease type, using association analysis and clustering techniques.

Natural language processing and text mining can be applied for medical records or drug prescription, applying different techniques for classification, clustering or even discover new associations. Images can undergo digital image processing and then apply image mining to extract useful and hidden patterns.

Medical diagnosis systems can be developed using mining techniques, investigate symptoms and patient medical history to detect certain disease, classify image as malignant or benign for tumer detection, find explanation for causes of diseases through descriptive analysis such as association analysis, clustering and sequential pattern mining. Data mining patterns could be analyzed to prevent developing of diabetes or high blood pressure for example.

Challenges and Solutions

The significance and value of Big data lies in the storage facilities, functioning processes and procedures used for sharing and capturing data and tools used to analyze and search very large data sets.

The first challenge that faces medical data mining is the lack of a standardized clinical vocabulary (Jacob, 2012). The mass of healthcare data is buried in heterogeneous databases scattered throughout many institution, tied in with a lot of missing, distorted, conflicting, and non-homogenous data in different formats in diverse data sources, thus most probably might be ignored during analysis. The stored information becomes less useful if it is not available in an easily comprehensible format. Nevertheless, large portion of this gathered data will be unprocessed, for instance, video streaming data are deleted after a week, instead some sort of archiving should be adopted every period and some arrangement of knowledge extraction, such as using it for performance auditing (Raghupathi & Raghupathi, 2014).

Bio/medical big data has major challenges, computation power and data analysis. Computation cost while analyzing the biological data especially after using the next generation sequencing technology that produces large size of data. Bio/medical cloud services have developed integrated tools and biological databases to formulate complex systems (Chae et al., 2013).

Data Mining Tools

Powerful automated tools to analye, visualize and interpret useful information from different data sources will be benificial. Many manufacturers support such tools to discover patterns involving methods using the artificial intelligence, machine learning and statistical analysis. KD nuggets offered many Analytics and Data Mining Suites, supporting classification, clustering, data preparation, visualization, and other tasks, it also provides a list of specific healthcare analytics solutions (Kdnuggets, 2015). Microsoft developed the SQL Server Analysis Services platform to build high performance multidimensional and tabular analytical models for interactive data analysis, reporting, and visualization (Russo, Ferrari, & Webb, 2012). DB2® Intelligent Miner(TM), was developed at IBM to provide Intelligent Miner analytics such as modeling, scoring and visualization (Ibm, 2014). DB2® was integrated with Clementine data mining workbench since 2004 (Ibm, 2007). SAS and Intel provide an analytical solution as well, SAS® Enterprise Miner™, that can handle accurately large amounts of data and produce predictive and descriptive models (Sas, 2014). Oracle Data Miner deploy data mining models inside the relational database environment (Tamayo, 2005). There are also open source tools for data mining, and the six powerful and mostly used are RapidMiner, Weka, R, Orange, Knime and Natural Language Toolkit(NLTK) (Goopta, 2013).

Novel Frameworks

Practitioners need systems and tools in order to capture and store this information, researchers need optimal processing power, analytics capabilities and skills to search and share the information. Big Data organizations start investing in the development of new infrastructures for running operational, real-time applications that can cope with the enormous and various amounts of information produced.

Yahoo after working with Nutch and Google released Hadoop as an open-source project for reliable, scalable and distributed computing in 2008, but it is now supported by Apache Software Foundation (ASF), it can perform two tasks: data storage and processing (Sas.com, 2014). The Hadoop platform comprise of three main components;

- **Hadoop Distributed File System (HDFS):** A Java based distributed file system that provides high-throughput access to application data that can store all kinds of data without prior organization.
- **Hadoop YARN:** A resource management framework for job scheduling, handling resource requests from distributed applications and cluster resource management.
- **Hadoop MapReduce:** A software programming model for parallel processing of large data sets. It is also accompanied by some other products for handling scalable data bases, warehousing, machine learning, data mining and many more(Apache.org, 2015).

Traditional relational databases can no longer handle and get value from healthcare big data, JustOneDB is a new high performance NoSql relational databases suitable for Big Data storage, load, and fast retrieval of queries and predictive analytics for healthcare industry (JustOneDB, 2015).

Recently bio/medical cloud services have begun evolving from simple and primitive applications to offering integrated and complex systems. The bioinformatics cloud service provides systems such as Galaxy, DNAnexus, Crossbow, SoapSNP and many others, not only without worrying about the manual system installation and data integration processes, but also with reduced data uploading/transferring time. (Chae et al., 2013)

High speed transfer of large volumes of data is achieved byAspera and Intel. Aspera's patented fasp* transport technology is designed and implemented to have no theoretical throughput limit on Intel® Xeon® processor E5-2600 product family in Virtualized Environments (Intel, 2013).

Ethical, Legal, and Social Issues

Medical data contains sensitive, private and confidential information about patients, accordingly the public may fear of data misuse, abuse and disclosure. Data ownership is an open question, since data is collected at different healthcare position, processed mainly by third party. Patient might hesitant against the release of information, although data analysts need to combine various records sometimes from another society. Records are shared and linked more widely nowadays than before while working on the open internet platforms. Security of patient's data during electronical transfer through the internet should be handled within ownership. Furthermore, medical data mining can drive the fear of lawsuits directed against healthcare providers. Patients may raise claims about unnecessary tests performed, confident questions asked and particular conclusion derived unconsciously.

RECOMMENDATIONS AND FUTURE RESEARCH DIRECTIONS

Healthcare Big Data by its different dimensions provide big opportunities for researchers and healthcare practitioners. Everyday activities are moving online, shared and linked to medical transactions or others. Data gathered during any medical transaction should be secured, encrypted or anonymized. Easily accessed and explored data storage facilities will have made it easy to govern and direct plans and strategies to provide the best quality healthcare services. Medical data mining can practice new algorithms for real time data analysis.

Healthcare records have to be standardized to avoid the future data cleansing and inconvenient data. Control over medical data ownership will minimize legal suits against health institutes. Improving care quality consequently will produce value to identify modern approaches for healthcare administration.

CONCLUSION

The chapter went through the advent of Big Data in Healthcare industry and emphasized its four dimensions. The critical manner of processing such data which are of various forms in big volumes and rushing in high velocity in time is clarified. Extracting knowledge or value is a need using new methods and technologies available. Some of the new storage and transfer platforms as well as high performance computing, on the cloud were mentioned. Privacy and confidentiality issues were discussed when trying to merge or analyze such data.

Big data in the health industry is still promising, offering new opportunities for new data storage, transfer and analysis frameworks, and try to get from the exploding information gathered.

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KEY TERMS AND DEFINITIONS

Big Data: Large amount of data, in many different formats, that flows rapidly in real time. This data should undergo some sort of analysis in order to extract useful information or knowledge.

Cloud Computing: High performance computing service which does not require location setting, but instead use a grid of computers over the internet.

Data Mining: The process of extracting new, useful, understandable and previously unknown knowledge from information that might help in decision making.

Electronic Health (Medical) Record: The narrative record written by the nurse or the physician during patient examination.

Hadoop: Hadoop is an open-source software framework from IBM, capable for storing and processing big data in a distributed fashion on large clusters.

Machine Learning: The subfield of artificial intelligence that uses learning algorithms in handling problems.

Medical Diagnosis: Investigating the symptoms and causes of certain disease, either by oral examination or laboratory tests.

Chapter 5
Leveraging Key Aspects of Collaborative Techniques to Assist Clinical Decisions

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ABSTRACT

Employing collaborative systems in healthcare contexts is an important approach towards designing and developing intelligent computer solutions. The objective of this study is to develop a real-time collaborative system using the Intelligent Risk Detection Model (IRD) to improve decision efficiency for the care of patients undergoing hip and knee arthroplasty (THA, TKA). Expected benefits include increasing awareness, supporting communication, improving decision making processes and also improving information sharing between surgeons, patients, families and consultants as key collaborative parties. The research question under investigation is: How can key information technologies be designed, developed and adopted to support clinical decision making in the context of THA and TKA? This research in progress has identified the value and benefit of developing a systematic and technology supported tool to facilitate the identification of various risks associated with THA and TKA.

INTRODUCTION

Leading healthcare organizations are recognizing the need to incorporate the power of a decision efficiency approach, driven by intelligent solutions (Wickramasinghe, Bali, Gibbons, Choi, & Schaffer, 2008). The primary drivers for this include the time pressures faced by healthcare professionals coupled with the need to process voluminous and growing amounts of disparate data and information in shorter

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and shorter time frames and yet make accurate and suitable treatment decisions which have a critical impact on successful healthcare outcomes and far reaching implications for the lives of their patients (Gibbons, Bali, & Wickramasinghe, 2010; Wickramasinghe et al., 2008).

This paper directly examines the benefits of an Intelligent Risk Detection (IRD) Model (Moghimi, Wickramasinghe, & Zadeh, 2011; Moghimi, Zadeh, Schaffer, & Wickramasinghe, 2012) to support and facilitate superior decision making in the context of Hip and Knee Arthroplasty. An important, unique feature of the IRD Model is the integration of the three well established IT [information technology] solutions [Knowledge Discovery, Decision Support Systems and Risk Detection], which have proved to be very successful in providing collaborative decision support in complex, high risk decision making scenarios in various business contexts (Pulakkazhy & Balan, 2013).

The aim of this paper is to present the initial outcomes of the study conducted in one of the biggest private hospitals in Melbourne, Australia to develop and then investigate the benefits of using the IRD Model to design a collaborative system for supporting surgical decision making in the context of Hip and Knee Arthroplasty. The research question is:

How can key tools and technologies of today's information age be designed, developed, and adopted to support clinical decision making in the context of hip/knee Arthroplasty?

The four key objectives of the study include:

- **Reducing the Burden of Hip and Knee Arthroplasty:** This will be achieved by supporting the prediction of the surgery results to identify patients at risk during surgery and thereby, enabling better planning and appropriate measures to be taken in the design of an appropriate treatment protocol.
- **Improving the Treatment and Management of Hip and Knee Arthroplasty:** This will be achieved by supporting better, informed collaborative decision making which will in turn allow for more appropriate/successful treatment choices to be made.
- **Gaining an Even Better Understanding of the Consequences of Hip and Knee Arthroplasty:** This will be achieved by developing an initial repository for analysis and to discover and extract hidden knowledge (patterns and relationships) associated with surgeries and other treatments from historical data to detect important surgery risk factors which will not only lead to a better understanding of critical and potentially confounding aspects to recovery but also facilitate more tailored and appropriate treatment regimens in the specific context.
- **Developing Preventative Measures to Reduce Side Effects of Hip and Knee Arthroplasty:** This will be achieved by developing important KPIs (key performance indicators) as a set of metrics and then using these to design and develop more suitable protocols and recommendations which when applied can result in measures to reduce side effects.

To answer the research question and thereby achieve the stated aims a Design Science Research Methodology (DSRM) is adopted to design and develop a prototype of the IRD Model in the chosen research case. This paper focuses on identifying the problem and specific motivations in the case of Hip and Knee Arthroplasty and then identifying requirements towards design and develops the IRD application by using on-line survey and an expert focus group.

BACKGROUND

Clinical Decision Support Systems (CDSS) are computer driven technology solutions, developed to provide support to physicians, nurses and patients using medical knowledge and patient-specific information (De Backere, De Turck, Colpaert, & Decruyenaere, 2012). Decision Support systems can be found in widely divergent functional areas. However, in e-health contexts because of the importance of real time outcomes and the multi-spectral nature of care teams (Wickramasinghe, Bali, Kirn and Sumoi 2012), the following key features become most essential:

- Intelligent timing,
- Multidimensional views of data,
- Calculation-intensive capabilities.

Hence, these systems will give advice and support rather than decision making replacing that of clinical staff. Studies have already proved that CDSS enhance quality, safety and effectiveness of medical decisions through providing higher performance of the medical staff and patient care as well as more effective clinical services (Garg, Adhikari, McDonald, Rosas-Arellano, Devereaux, Beyene, & Haynes, 2005; Fichman, Kohli, & Krishnan, 2011; Restuccia, Cohen, Horwitt, & Shwartz, 2012). A variety of CDSS programs designed to assist clinical staff with drug dosing, health maintenance, diagnosis, and other clinically relevant healthcare decisions have been developed for the medical workplace (Haug, Rocha, & Rocha, 2007). On the other hand, patients' demand for participation in medical decisions has been increasing (Kuhn, Wurst, Bott, & Giuse, 2006). Therefore, to be respectful of patients and parents'/guardians' participation and decisions, shared decision-making (SDM) between health care professionals, patients, parents and guardians is widely recommended today (Lai 2012). SDM is defined as the active participation of both clinicians and families in treatment decisions, the exchange of information, discussion of preferences, and a joint determination of the treatment plan (Makoul & Clayman 2006; Légaré, Stacey et al. 2011; Barry & Edgman-Levitan, 2012).

Although SDM is supported in many disease management domains, some concerns and issues still remain regarding the adoption of SDM solutions such as a perception among some practitioners that the ultimate responsibility for treatment should remain under their authority (Schauer, Everett, Vecchio, & Anderson, 2007; Edwards & Elwyn 2009). Moreover, client capacity to participate in decisions (O'Brien, Crickard, Rapp, Holmes, & McDonald, 2011), identifying the SDM components (Sheridan, Harris & Woolf, 2004; Van der Weijden, Van Veenendaal, Drenthen, Versluijs, Stalmeier, Loon, & Timmermans, 2011) as well as SDM user acceptance (Scholl, Loon, Sepucha, Elwyn, Légaré, Härter, & Dirmaier, 2011) are main issues to promote this type of CDCS in the healthcare contexts.

On the other hand, SDM has also some limitations for example SDM is appropriate for situations in which two or more medically reasonable choices exist (O'Connor, Bennett, Stacey, Barry, Col, Eden, & Rovner, 2009), regardless of whether the degree of risk is high or low (Whitney, McGuire, & McCullough, 2004). Therefore, SDM is not appropriate in these cases while still patients or their families would like to have participation in the care process. Hence, more studies are needed to deepen the understanding of interactions between patient decision aid use and the patterns of patient-practitioner communication as well as format issues such as web-based delivery of patient decision aids. (O'connor, Bennett et al. 2009; Flight, Wilson, Zajac, Hart & McGillivray 2012; Parsons, Harding, Breen, Foster, Pincus, Vogel,

& Underwood, 2012). Research on shared decision making is under way (Deegan & Drake, 2006; Barry & Edgman-Levitan, 2012), but much more is needed in this area.

Moreover, Medical decisions always have to be made in a tradeoff between benefit and risk. Unfortunately, many decisions are based upon an incorrect knowledge of risk (Weijden et al 2007). Also different viewpoints concerning risks can result in different optimal choices because of different perspectives (Horn et al 1985; Kuntz & Goldie, 2002).

Therefore, the following suggest that an Intelligent Risk Detection (IRD) model which attempts to facilitate and provide decision support for clinicians and patients regarding the treatment risk factors might be beneficial. In developing such a solution, it is necessary to combine three key areas of business analytics, risk detection and decision support systems. This is an important contribution to both theory and practice in healthcare since, to date real time use of risk detection, while prevalent in many industries such as finance, has rarely if at all been incorporated into healthcare settings.

This in turn makes a real time intelligent risk detection framework the preferred choice. Thus, our study proposes an intelligent application for high-level surgery risk detection and outcome prediction to support surgical decisions. The model is designed based on two steps of the decision making process (surgical and personal) and, includes a decision support system which is suitable for high concentration prediction. Continual model updates inherent in the proposed system results in adaptive and more accurate risk detection and outcome prediction capabilities as compared to a fixed model.

MAIN FOCUS

We note that while data mining is being utilized in various healthcare contexts including applications of text mining and secondary uses for data (Safran, Bloomrosen, Hammond, LAbkoff, Markel-Fox, Tang, & Detmer, 2012), infection control (Iakovidis, Tsevas, Savelonas, & Papamichalis, 2012), physician order entry and electronic health records (Wright & Sitting, 2006; Botsis, HArtvisen, Chen, & Weng, 2010; Batal & Hauskrecht, 2010) and even in the identification of high risk patients (Marschollek, Gövercin, Rust, Gietzelt, Schulze, Wolf & Steinhagen-Thiessen, 2012) the application of data mining and BI for risk detection is at a nascent state.

However, the lack of interaction between healthcare industry practitioners and academic researchers makes it hard to discover surgical risks, and limits opportunities for the application of BI techniques, and hence weakens the value that knowledge discovery and data mining methods may bring to healthcare risk detection.

In the context of surgical risk detection many dimensions and perspectives (Haga, Ikejiri, Takeuchi, Ikenaga, & Wada, 2012) are of importance and these mainly focus on pathological process, physiological variables, some general health perceptions, social paradigm and also quality of life (Rizzo & Kintner 2012). Naturally, detecting the risk factors in all of these dimensions is not easy or trivial but based on two approaches to assess the risks, with contribution of clinical experts; this research aims to cover these main dimensions. The expected outcomes include:

- Early identification of risk factors.
- Providing superior decision support.
- Developing key performance indicators to detect the surgery risk factors.
- Predicting surgical results to identify patients at risk during surgery.

- Standardizing clinical risk assessment and management processes to facilitate superior health outcomes.
- Developing a risk profile for patients.
- Improving risk information sharing.
- Developing a true picture of surgical risk categories and factors.
- Creating a "Risk Aware" alarm to control the risk factors.
- Monitoring the risk factors by using dashboards.

RESEARCH DESIGN AND METHODOLOGY

A design science approach is recommended to be used quantitatively, where improving an existing solution is desired or needed, or qualitatively, where there is a need for a solution to address specific unsolved problem (Hevner, March, Park, & Ram, 2004). Based on this and on other studies on using design science in IS research, Peffers et al. (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007) developed their Design Science Research Methodology (DSRM) as a process model to carry out researches on designing artifacts to serve in IS. Today DSRM is widely used in IS research to create new solutions or to improve existing ones.

In this research we use DSRM to carry out our research toward designing a decision making support system in the context of Hip and Knee total Arthroplasty. Table 1 maps the application of DSRM to the proposed decision-support solution.

SOLUTIONS AND RECOMMENDATIONS

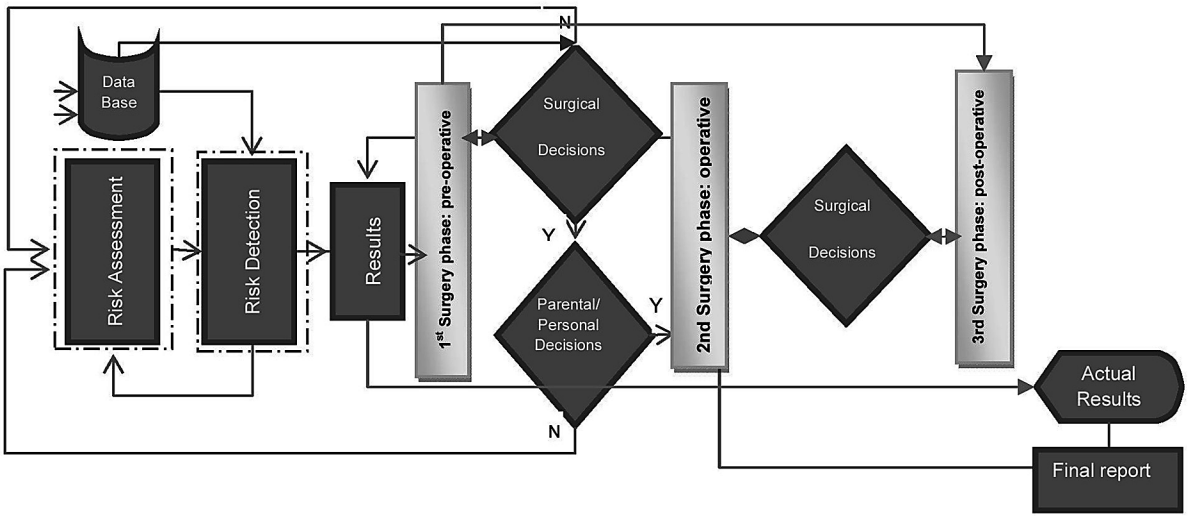
To capture the inherent complexities of surgery interventions, the conceptual model (figure 1) has been developed. Integral to this model are the two steps of decision making defined over the three key phases of the decision making process for the surgery. The first type of decision making is called "surgical decision making" and is primarily associated with the surgeons while the second type is called "personal decision making" as it is primarily associated with the patients or their family.

In the first phase, or pre-operative phase, the surgeon, having received information about the patient and his/her medical condition, needs to make decisions relating to whether surgery is the best medical option. Once this decision is made but before the surgery, the parents/patients must then decide whether to accept or reject the surgeon's decision in consideration of the predicted outcomes. Thus, already at

Table 1. Results on device related risk factors

Risk Factor	Percentage of Respondents Said Yes	Estimate Risk Level (Out of 5)
Type of prosthesis	86.2%	2 (44%)
Correct sizing of components	72.4%	2 - 4 (28.6%)
Femoral head size in THR	65.5%	3 (42.1%)
Cementless as a method of fixation	55.2%	3 (50%)
Cemented as a method of fixation	55.2%	1 (37.5%)

Figure 1. The conceptual model
Source: Moghimi et al. 2011.



stage one of the decision making process already two, key decisions must be made. Once parents/patients and surgeons have agreed to proceed, in phase two (pre-operative phase), critical decisions pertaining to the unique situations that may arise during the surgery must be addressed. Finally, at the post-operative phase, or phase three, decision making is primarily done at two levels:

1. Strategies to ensure a sustained successful result for the patient during aftercare and beyond, and
2. A record of lessons learnt for use by clinicians in future similar cases.

Detecting risk factors based on a risk assessment process using BI tools is a useful way to assess improvements in surgery (Larrazabal, Jenkins et al. 2007). Therefore, after first identifying important risk factors in the literature, we will seek expert input at two distinct stages to address this subject. The specific stages involved in the risk assessment process include the following:

In the first stage, the specialists in an expert group of clinicians and surgeons are presented with risk factors identified from the literature. The experts will then nominate (or introduce) some main riskscategories or dimensions as well as risk factors to be used in the surgical decision making process. In the next stage, the expert group is asked to assess the risk factors and also evaluate the effects of these factors in surgery outcomes. It is also important to document the surgeons' and specialists' recommendations and advice in order to improve the model.

Design Data Collection and Analysis

After identifying the research problem and the objective of the planned artifact, collecting required data launched to start Activity 3: Design and Development. To do so, an online survey was designed to target 58 active and busy surgeons at one of the biggest private hospitals in Melbourne in the context of THR

and TKR. The response rate was 76%. The survey had 6 main sets of questions; the first asked whether, or not, the respondent agrees with the suggested grouping of the risk factor in the survey, and the other five sets of questions related directly to five categories of risk factors as follow:

1. Device related risk factors,
2. Surgeons' factors,
3. Patient factors,
4. Co-morbidities,
5. Process issues.

The online survey was left open for three weeks, during which on-parallel analysis was taking place and preparing for the second round of data collection by organizing a focus group to gain in-depth evaluation of the responses. This focus group was performed two weeks after closing the online survey and during which we met four senior surgeons in the context of THA and TKA to continue gaining better understanding of the results.

For data analysis, we used IBM SPSS Statistics 21 to deal with collected data from the online survey and the integrated data analysis tool within Survey Gizmo, the used online survey software in this study. For data coding resulted from the focus group we used the qualitative data analysis software NVivo.

In the following section we present the results from the online survey and the summary of discussions about each result during the focus group, as this is expected to help design and develop the prototype of the computerized decision support solution.

Results

The first set of questions is to categorize risk factors into broad groupings. Ideally, these groupings must be mutually exclusive, collectively exhaustive. The following was the suggested grouping: 1) Device related (example: type of prosthesis, method of fixation such as cemented or cementless). 2) Surgeon's factors (Type of approach THR, experience of surgeon, and volume of cases at the case study). 3) Patient's factors (demographics, BMI, ASA). 4) Co-morbidities. 5) Process Issues (time out, antibiotics, DVT prophylaxis, theatre where operation performed). The respondents were asked to say if they agree or disagree with this grouping. 96.6% of the respondents agreed with this and 3.3% disagreed. During the focus group, the participants agreed with that and suggested replacing the heading "process Issues" by "Process Logistics" to cover all aspects of the process.

Device Related Risk Factors

Device related risk factors are identified as one of these major risk categories affecting surgery outcomes. Thus, the respondents were asked to agree or disagree with the proposed device related risk factors and to estimate risk level for each of them. Table 1 shows the results.

Discussing these results during the focus group led to collapsing cementless and cemented in one group: Fixation Femoral Stem: Cemented and Cementless and breaking that into two distinct groups: THA and TKA rather than being generic.

Table 2. Results on surgeon's related risk factors

Risk Factor	Percentage	Estimate Risk Level (Out of 5)
Volume of cases	75%	3 (52.3%)
Experience of the surgeon	71.4%	3 (40%)
Type of Approach in THR	55.2%	Lateral: 2 (37.5%); Posterior: 2 (50%); Anterior: 3 (31.3%)

Surgeons' Factors

Surgeons' related risk factors are identified as one of the major risk categories affecting surgery outcomes. Accordingly, the respondents were asked to state whether or not they agree with the proposed risk factors and to estimate the risk level of each of them. The results from the online survey are in Table 2.

These results initiated deep discussions between the surgeons during the focus group. In summary, the participants suggested keeping "volume of case" as is, changing "Experience of the surgeon" to more measurable quantity as "Years of Experience": Less than 5 years, 5 - 15, 15 - 35 based on the contextual conditions of the case study. A number of issues were raised during the focus group, like physical and mental health for surgeons, bias in theatre settings (left-handed vs. right-handed surgeons), and assigning different weighting for different risk factors based on their individual risk levels.

Patient's Factors and Co-Morbidities

Patient factors are also identified as one of the major risk categories affecting surgery outcomes, so are co-morbidities. The respondents were asked to state whether or not they agree with the proposed risk factors and to estimate the risk level of each of them. Patient's Factors and Co-morbidities were two groups in the online survey. The discussions during the focus group, however, suggested merging them together and expanding the co-morbidities more. The results from the online survey are in Table 3 and Table 4.

Table 3. Results on patient's related risk factors

Risk Factor	Percentage	Estimate Risk Level (Out of 5)
Age	71.4%	3 (35%)
Gender	46.4%	3 (38.5%)
Ethnicity	28.4%	1-2 (37.5%)

Table 4. Results on comorbidities

Risk Factor	Percentage	Estimate Risk Level (Out of 5)
Obesity	75%	4 (57.1%)
Diabetes	75%	3 (47.6%)
Cardiac conditions	67.9%	4 (36.8%)
Blood thinning medications	67.9%	3 (31.6%)

During the focus group, the longer discussions were about these two groups. "Ethnicity" as a patient's factor was recommended to be replaced with "Culture" and the impact of that on patients' expectations from the surgical team. All agreed that obesity and diabetes represent major risk factors. Psychological health of patients was raised as an issue during the discussions, and the surgeons suggested capturing that by analyzing the drugs or medications the patient takes. A number of suggested risk factors in this broad group were emerged from both the online survey and the focus group, like compensation status (who pays what for the operation), patient expectations and understanding of the treatment, and prior surgery (THA or TKA).

Process Issues

Process issues are also identified as the other major risk categories affecting surgery outcomes. Table 5 shows the responses from the online survey, including the percentage of surgeons agreed with the proposed grouping and estimated risk levels.

During the focus group, the title "Process Issues" was recommended to be changed to "Process Logistics" and to be extended to cover: theatre temperature, single-bed vs. dual-bed theatre, discharge status (whether the patient is going to a ward, rehabilitation, home, etc.).

Based on the previous results, and aligning with DSRM abovementioned, the next step is to develop 20-40 subcategories of risk factors and entering that to the system. Once that is done, the prototype would be built and then surgeons in the context of THA and TKA will be invited to participate in Activity4: Demonstration, where this research intends to try this software to solve the problem of lack of decision support system in this context. Case study will continue to be used in this stage and sufficient proof will be sought after to move to Activity5: Evaluation.

FUTURE RESEARCH DIRECTIONS

Based on an extensive review of the extant literature and initial data analysis there is evidence to support the benefits of such an intelligent application for healthcare contexts; however, many issues remain to be examined regarding its implementation into specific healthcare contexts such as hip/knee interventions. Therefore, the next phase for this research is to trial the model in the selected clinical.

The major contributions of this study to practice are emphasizing the importance of knowledge sharing between clinicians as well as between clinicians and patients, the importance of clinicians' involvement during systems development, the acceptability and capability of the system and the high demand of outcome predictions to improve collaborative decision making efficiency in the research case study.

Table 5. Results on process issues

Risk Factor	Percentage	Estimate Risk Level (Out of 5)
Appropriate administration and timing of antibiotics	67.9%	3 (26.3%)
DVT prophylaxis	67.9%	2-3 (31.6%)
Theatre where operation performed	64.3%	2 (55.6%)
Time out being documented	64.3%	1-2 (30.8%)

Furthermore, this study has contributed to theory and the body of knowledge by proving the importance of Design Science Research Methodology in developing the IRD prototype in the context of Hip and Knee Arthroplasty. Also, this study contributes to emphasize the importance of knowledge discovery, clinical decision support systems, and risk detection in developing and designing a collaborative decision support solution for healthcare contexts.

Of the hospital clinicians who were participants in the study on-line survey and focus group, all had a positive intention to use the IRD to detect surgical risk factors and to predict surgical outcomes more accurately. The participants also commented and believed that the IRD can be useful in improving collaboration and knowledge sharing between clinicians.

Although risk groups, risk factors and levels were captured through the survey, experts in the focus group had some argues about them. "Patient's Factors and Co-morbidities" was the most discussing risk groups between participants. For example, one of participants raised the issue of mental health of patients, as an important risk factors, to be placed in the "Patient's Factors and Co-morbidities" group. In this regards, the other participants mentioned capturing psychological issues is not easy; however, it might be possible by looking at drugs list that the patient takes. Hence, we inserted the "psychological health", as a risk factor as well. Moreover, "Prior Hip and Knee Surgery" also was the other proposed risk factor in this group.

"Process Issues" was the other discussing risk group in the expert focus group. Surgeons proposed the name of "Process Logistics" for this risk group and they also stated that discharge status, designing the operating theatre (single bed, double bed) and also duration of operation are the other important risk factors under "Process Logistics" that should be addressed in the prototype.

Through a rich discussion in the focus group between surgeons, list of risk group and risk factors finalized, as follows:

- **Group 1:** Device related risk factors.
  - Type of prosthesis.
  - Correct sizing of components.
  - Femoral head size in THR.
  - HIP: Fixation Femoral Stem: cemented and Cementless, hybrid.
  - Knee: cemented, Cementless, hybrid.
- **Group 2:** Surgeons' factors.
  - Years in Practice (less than 5, 5-15, 15-35).
  - Type of Approach in THR.
- **Group 3:** Patient's Factors and Co-morbidities.
  - Age.
  - Gender.
  - Country of Birth.
  - Obesity.
  - Diabetes.
  - Cardiac conditions.
  - Blood thinning medications.
  - Psychological Health.
  - Prior Surgery.

- **Group 4:** Process Logistics.
  - Appropriate administration and timing of antibiotics.
  - DVT prophylaxis.
  - Theatre where operation performed.
  - Time out being documented.
  - Discharge status (sub categories).
  - Designing the operating Theatre (single bed, double bed...).
  - Duration of Operation.

Therefore, the IRD prototype will be designed based on these captured risk groups and risk factors.

Discovering and capturing surgical risk factors is quite difficult due to the lack of interaction between healthcare industry practitioners and academic researchers. Hence, this research also captured three limitations pertaining to the case study as follows:

- The study investigators acknowledge the difficulty associated with attempting to capture all risk factors.
- The study showed that there was no access to longitudinal data sets.
- Relatively homogeneous population of patients in this study needs to be tested on a more diverse population.

CONCLUSION

This study has outlined an exploratory research study aimed at trying to examine the potential benefits of combining a real time intelligent risk detection solution with decision support in a healthcare context.

The management of long term clinical conditions in pre and post-operative process normally requires close collaboration between care providers. The IRD solution supports such collaboration by providing immediate access to the patient's record to detect surgical risk factors, as well allowing the user to add any new identified risk factors and actual operation results into the system. Hence, this study is conducted to answer this question that "How can key tools and technologies of today's information age (such as IRD solution) be designed, developed, and adopted to support clinical decision making in the context of Hip/Knee Arthroplasty?".

In this study, clinicians, expert in Hip and Knee Arthroplasty, agreed this is important, relevant study in the health care context and would be very useful and beneficial for them to make better decisions and thereby enjoy better patient outcomes.

This paper, presents outcomes of the on-line survey and expert focus group to identify requirements and problems to design and develop a prototype of the IRD system in the case of Hip and Knee Arthroplasty. Thus, in the next step, once the prototype is designed and developed, then it will be tested using de-identified patient data obtained from data bases as well as focus group with an expert group. On the completion of testing and validation the final IRD solution will be complete.

In closing, the study researchers contend that real time intelligent collaborative decision making between clinical professionals and patients or their families appears to be critical for many areas in healthcare where complex and high risk decisions must be made.

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KEY TERMS AND DEFINITIONS

Business Analytics (BA): A comprehensive package of new IT techniques which taken together are able to make robust solutions taking into account industry/companies specific requirements.

Data Mining (DM): An IT technique to discover hidden knowledge or patters through historical data through even huge data bases.

Decision Support Systems (DSS): A computer based systems or applications to facilitate complex decision making processes to improve processing outcomes.

Intelligent Risk Detection (IRD): A proposed IT solution to improve surgical decision efficiency in healthcare contexts by (Moghimi & Wickramasinghe, 2011).

Real Time Intelligent Solution: IT solutions capable to make ad-hoc services smartly while their outputs would be accessible on-line.

Risk Detection: Capturing risk factors by using computer based solutions.

Chapter 6
Data Mining Approach for Predicting the Likelihood of Infertility in Nigerian Women

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ABSTRACT

According to WHO, there are 60 - 80 million infertile couples worldwide with the highest incidence in some regions of Sub-Saharan Africa. The social stigma of infertility weighs especially heavily on women, who bear the sole blame for barren marriages in many developing countries and may face divorce as a result. Interviews were conducted with gynecologists at one of the Teaching Hospitals in Nigeria in order to identify likelihood variables for infertility. 14 risk factors were identified and data collected from 39 patients from the hospital was pre-processed and the variables used to formulate the predictive model for the likelihood of infertility in women using three different decision trees algorithms. The predictive model was simulated using WEKA environment. The results revealed that C4.5 algorithm had the highest accuracy of 74.4% while the least performance was for the random tree algorithm with a value of 53.8%. This chapter presents a predictive model which can assist gynecologists in making more objective decisions concerning infertility likelihood.

INTRODUCTION

The goal of data mining is to learn from data and the strategy used may vary as per the requirement (Yap et al., 2007). Data mining is an interdisciplinary field and is gaining popularity because of exploring Database technology, Information Science, Machine Learning and Neural Networks along with Statistical techniques. This study aims at applying data mining techniques to clinical data in order to predict the likelihood of infertility in Nigerian women.

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Infertility is defined as one year of frequent, unprotected intercourse during which pregnancy has not occurred (Zegers-Hochschild et al., 2009). In another definition, infertility is the inability of a sexually active woman who is not practicing contraception to have a live birth (American Society for Reproductive Medicine (American Society for Reproductive Medicine (ASRM), 2008). Infertility can be attributed to any abnormality in the female or male reproductive system (European IVF-Monitoring Consortium, 2008). The etiology is mostly distributed fairly equally among the male and female with factors ranging from ovarian dysfunction, tubal factors amongst others. A smaller percentage of cases are attributed to endometriosis, uterine or cervical factors, or other causes. In approximately, one fourth of couples, the cause is uncertain and is referred to as unexplained infertility, while etiology is multifactorial for some couples (Puscheck & Woodad, 2009). Developed and developing societies tend to differ in prevailing assumptions about childlessness while in developed societies, voluntary childlessness is viewed as a more viable and legitimate option and women without children are often presumed to be voluntarily childfree (ASRM, 2006).

Infertility is a worldwide problem, affecting 8% – 15% of the couples in their reproductive age (Puscheck & Woodad, 2009; Boivin et al., 2009; Audu et al., 2003). WHO estimates that there are 60 - 80 million infertile couples worldwide with the highest incidence in some regions of Sub-Saharan Africa which is said to have an infertility belt warped around its center as infertility rate may reach 50% compared to 20% in Eastern Mediterranean Region and 11% in the developed world (Okonofua, 1996). In some parts of this belt, infertility is said to constitute up to 65% of gynecological consultations (Idrisa, 2005). Early exposures (e.g. in utero or in childhood) could permanently reprogram men and women for fecundity or biologic capacity (e.g. gynecologic and urologic health or gravid health during pregnancy) and fertility outcomes (e.g. multiple births or gestational age at delivery) which could affect adults later on set diseases (Skakkebaek et al., 2001). Thus, infertility could have public health implications beyond simply the inability to have children.

In general, an infertility evaluation is initiated after 12 months of unprotected intercourse during which pregnancy has not been achieved. Earlier investigation may be considered when historical factors, such as previous pelvic inflammatory disease or amenorrhea suggest infertility, although physicians should be aware that earlier evaluation may lead to unnecessary testing and treatment in some cases. Evaluation can be initiated earlier if the female partner is older than 35 years, because fertility rates decrease and spontaneous miscarriage and chromosomal abnormality rates increase with advancing maternal age (Puscheck & Woodad, 2009). Partners can be evaluated together or separately which can be due to the fact that each person may want to reveal information which their partner may be unaware of, such as previous pregnancy or sexually transmitted disease.

The risk factors for infertility can be classified into: genital, endocrinal, developmental and general factors. Pelvic inflame ematory disease (PID) due to sexually transmitted diseases, unsafe abortion, or puerperal infection are the main causes of tubal infertility caused mainly by chlamydial infection. Polycystic ovarian syndrome (PCOS) is thought to be the commonest cause of an ovulatory infertility. Several lifestyle factors may affect reproduction, including habits of diet, clothing, exercise, and the use of alcohol, tobacco and recreational drugs. Exposure to textile dyes, lead, mercury and cadmium, volatile organic solvents and pesticides has been also associated with infertility. Estimates of the proportion of infertility cases attributable to male or female specific factors in developed countries were derived in the 1980s by the WHO: 8% of infertility cases were attributable to male factors, 37% to female factors, 35% to both the male and female, and 5% to an unknown cause (the remaining 15% became pregnant) (Zegers-Hochschild et al., 2009).

Data mining is the process of extracting patterns from data; these patterns may be discovered depending on the data mining tasks that are applied on the dataset (Gupta et al., 2011). Discovering knowledge in medical systems and health care scenarios is a herculean yet critical task (Bennett & Duob, 2010). Knowledge discovery (Cabena et al., 1997; Zhu & Davidson, 2007) describes the process of automatically searching large volumes of data for patterns that can be considered additional knowledge about the data (Mishra et al., 2010). The knowledge obtained through the process may become additional data that can be used for further manipulation and discovery (Desikan & Hsu, 2011). Clinical data mining is the application of data mining techniques using clinical data. It involves the conceptualization, extraction, analysis, and interpretation of available clinical data for practical knowledge-building, clinical decision-making and practitioner reflection (Gupta et al., 2011). The main objective of clinical data mining is to haul new and previously unknown clinical solutions and patterns to aid the clinicians in diagnosis, prognosis and therapy (Tan et al., 2005).

The basis for any data mining framework involves preliminary learning phase during which the problem is modeled followed by the test phase that validates the constructed model. The learning process can be accomplished either in a Supervised or Unsupervised manner (Vanneschi et al., 2011). Supervised learning (Idowu et al., 2015) requires the training data to be accompanied by class labels and the test data is classified based on the training set, whereas in unsupervised learning, the class label is unknown and the aim is to establish the existence of clusters or classes in the data. The models required to mine data are classified into Predictive and Descriptive models. Clusters, Feature Selection and Association rules are descriptive while classification and regression models are predictive models.

Predictive research aims at predicting future events or outcomes based on patterns within a set of variables and have gained popularity in medical research (Toll et al., 2008). Accurate predictive models can inform patients and physicians about the future course of an illness or the risk of developing an illness and thereby help guide decisions on screening and/or treatment. There are several important differences between traditional explanatory research and prediction research. Explanatory research typically applies statistical methods to test causal hypothesis using priori theoretical constructs (Singal et al., 2013a; Singal et al., 2012). In contrast, prediction research applies statistical methods and/or data mining techniques, without preconceived theoretical constructs to predict future outcomes (Singal et al., 2013b; Moons et al., 2009). A number of different techniques to develop predictive algorithms exist, using a variety of predictive tools/software (Waijee & Wiggins, 2010; Siegel et al., 2011); some examples include artificial neural networks, support vector machines, decision trees, naïve bayes, etc.

An efficient predictive model for predicting the likelihood of infertility in Nigerian women based on identified relevant causal variables using decision trees algorithm has been proposed in this paper. In addition, simple rules were induced from the decision tree structure proposed in order to assist the gynecologist in easily identifying infertility likelihood.

Related Work

There exist a number of literatures in the application of machine learning algorithms to the development of prediction models in the area of infertility and sterility related research. Related work has been discovered to be limited to the area of In-Vitro Fertilization (IVF) studies, sperm motility and likelihood of pregnancy etc. A number of the related work reviewed is as follows.

Girija & Shashidhara (2012), developed a predictive model for the classification of women health disease (fibroid) using decision trees algorithm. Data was collected from three (3) classes of people

(no fibroid, mild condition and sever condition) and eight (8) features were used in developing the proposed predictive model. The results showed that the C4.5 decision trees algorithm implemented as J48 on WEKA was able to select two (2) important features as predictive for fibroid in women; the features selected were: the age of the patient and signs of heavy bleeding. The evaluation of the performance of the predictive model had a value of 56%.

Durairaj & Thamilselvan (2013), applied artificial neural networks for In Vitro Fertilization (IVF) data analysis and prediction with the aim of detecting the success rate of IVF. Data collected from patients (couples) containing information about the endometriosis, tubal factors and follicles in the ovaries, body mass index, sperm concentration, duration of infertility, embryos transferred and the physiological factors such as stress levels were used to develop the predictive model needed for the prediction of the success rate of IVF. The results showed that the prediction model developed using the identified variables had a correlation coefficient (r) of 0.498 with an accuracy of 75%.

Girela et al. (2013) applied artificial intelligence using machine learning algorithms to predict semen characteristics resulting from environmental factors, life habits and health status in order to develop a decision support system that can help in the study of male fertility potential. Semen samples collected from 123 young, healthy volunteers were analyzed and information regarding their life habits and health status was collected using a questionnaire. Sperm concentration and percentage of motile sperm were related to socio-demographic data, environmental factors, health status, and life habits in order to determine the predictive accuracy of the multi-layer perceptron network model developed. The results showed that the most important semen parameter is the sperm concentration with an accuracy of 90%, sensitivity of 95.45% and specificity of 50%.

Uyar et al. (2014) developed a predictive model for the outcome of implantation in an In Vitro Fertilization (IVF) setting using machine learning methods. The paper was aimed at predicting the outcome of implantation of an individual embryo in an IVF cycle in order to provide decision support on the number of embryos transferred. Electronic health records from 2453 embryos transferred at day 2 or day 3 after intracytoplasmic sperm injection (ICSI). Each embryo was identified using eighteen (18) clinical features and a class label (indicating positive and negative implantation outcomes). Naïve Bayes' classifier was used to train the predictive model using 66.7% for training and the rest for testing over 10 runs and the evaluation of the performance showed a value of 80.4% for accuracy, 63.7% for sensitivity (true positive (TP) rate) and 17.6% for the false positive (FP) rate (1 – specificity).

Idowu et al. (2015) developed a predictive model for the likelihood of infertility in Nigerian women using the multi-layer perceptron (MLP) architecture of artificial neural network using three sets of clinical variables: personal profiles, medical and surgical history and gynecological history. Using a filter-based feature selection algorithm (consistency subset evaluator), six (6) relevant features were identified out of the fourteen (14) identified variables selected. A comparison of the performance of the predictive model developed was done using all fourteen (14) variables and the selected six (6) relevant variables – three different training methods was used: full dataset, percentage proportion (66% for training and 37% for testing) and 10-fold cross validation. The results of the comparison showed that using the full training set over-fitted the predictive model developed while the performance of the predictive model developed was shown to improve using the reduced feature set compared to using the whole 14 features. The accuracy of the developed model was observed to be 74.36% before and after feature selection using the 10-fold cross validation training method but improved from 69.23% (before feature selection) to 76.92% (after feature selection) using the percentage proportion training method.

Table 1. Identified variables for determining infertility

S/N	Class of Risk	Risk Factors/Considered Parameters (Points)	Labels (Points)
1.	Personal Profiles	Age of Menarche	≤15 yrs or >15 yrs
2.		Age of Marriage	≤30 yrs or >30 yrs
3.		Family History of infertility	Yes or No
4.		Menstrual cycle	Regular or Irregular
5.	Medical and Surgical history	Diabetes Mellitus	Yes or No
6.		Hypertension	Yes or No
7.		Thyroid	Yes or No
8.		Pelvi-abdominal operation had	Yes or No
9.	Gynecological history	Endometriosis	No or Yes
10.		Fibroid	No or Yes
11.		Polycystic Ovary	No or Yes
12.		Genital Infection	No or Yes
13.		Sexually transmitted Infection (STI)	No or Yes
14.		Previous termination of pregnancy	No or Yes

METHODS

Data Collection

For the purpose of this study, it was necessary to identify and collect the data needed for identifying infertility in women from gynecologist located at a University Teaching Hospital in south-western Nigeria. The variables identified include: age of menarche, age of marriage, family history of infertility, menstrual cycle, diabetes mellitus, hypertension, thyroid disease, pelvi-abdominal operation, endometriosis, fibroid disease, polycystic ovary, genital infection, previous termination of pregnancy, Sexually Transmitted Infection (STI) and the likelihood of infertility (identified using the labels: Likely, Unlikely and Probably) (Table 1). Data was collected from a total of 39 patients with a description of the variables in the dataset stated as follows:

1. **Age of Menarche:** Is the identification of the age of the patient at first menstruation; it is recorded as a nominal value which determines the age category in years identified as *equal or less than 15 years and greater than 15 years*.
2. **Age of Marriage:** Is the identification of the patient's age of marriage; it is recorded as a nominal value *less than or equal to 30 years* and *greater than 30 years*.
3. **Menstrual Cycle:** Is the identification of the regularity of the patient's menstrual cycle; it is a nominal value identified as *Regular* or *Irregular*.
4. **Family History of Infertility:** Is the identification of an existing history of infertility in the family; it is a nominal value identified as either *Yes or No*.
5. **Diabetes Mellitus:** Is the identification of the existence of diabetes disease in the patient; it is a nominal value identified as either *Yes* or *No*.

6. **Hypertension:** Is the identification of if the patient has hypertension before or presently or not; it is a nominal value identified as either *Yes* or *No.*
7. **Thyroid Disease:** Is the identification of the existence of thyroid disease in the patient; it is a nominal value identified as either *Yes* or *No*.
8. **Pelvi-Abdominal Operation Had:** Is the identification of the existence of pelvi-abdominal operation on the patient; it is a nominal value identified as either *Yes* or *No*.
9. **Endometriosis:** Is the identification of the existence of Endometriosis in the patient; it is a nominal value identified as either *Yes* or *No*.
10. **Fibroid Disease:** Is the identification of the existence of fibroid disease in the patient; it is a nominal value identified as either *Yes* or *No*.
11. **Polycystic Ovary:** Is the identification of the patient having a polycystic ovary; it is a nominal value identified as either *Yes* or *No*.
12. **Genital Infection:** Is the identification of a genital infection in the patient; it is a nominal value identified as either *Yes* or *No*.
13. **Previous Termination of Pregnancy:** Is the identification of the patient having a previous termination of pregnancy; it is a nominal value identified as either *Yes* or *No*.

Data-Preprocessing

Following the collection of data from the required respondents; 39 patients with their respective attributes (14 infertility risk indicators) alongside the likelihood of infertility was identified. In addition, the task of data cleaning for noise removal (errors, misspellings etc.) and missing data were performed on the information collected from the health records. Following this process, all data cells describing the attributes (fields) of each patient were found to be filled. No missing data were found in the repository and all misspellings were corrected.

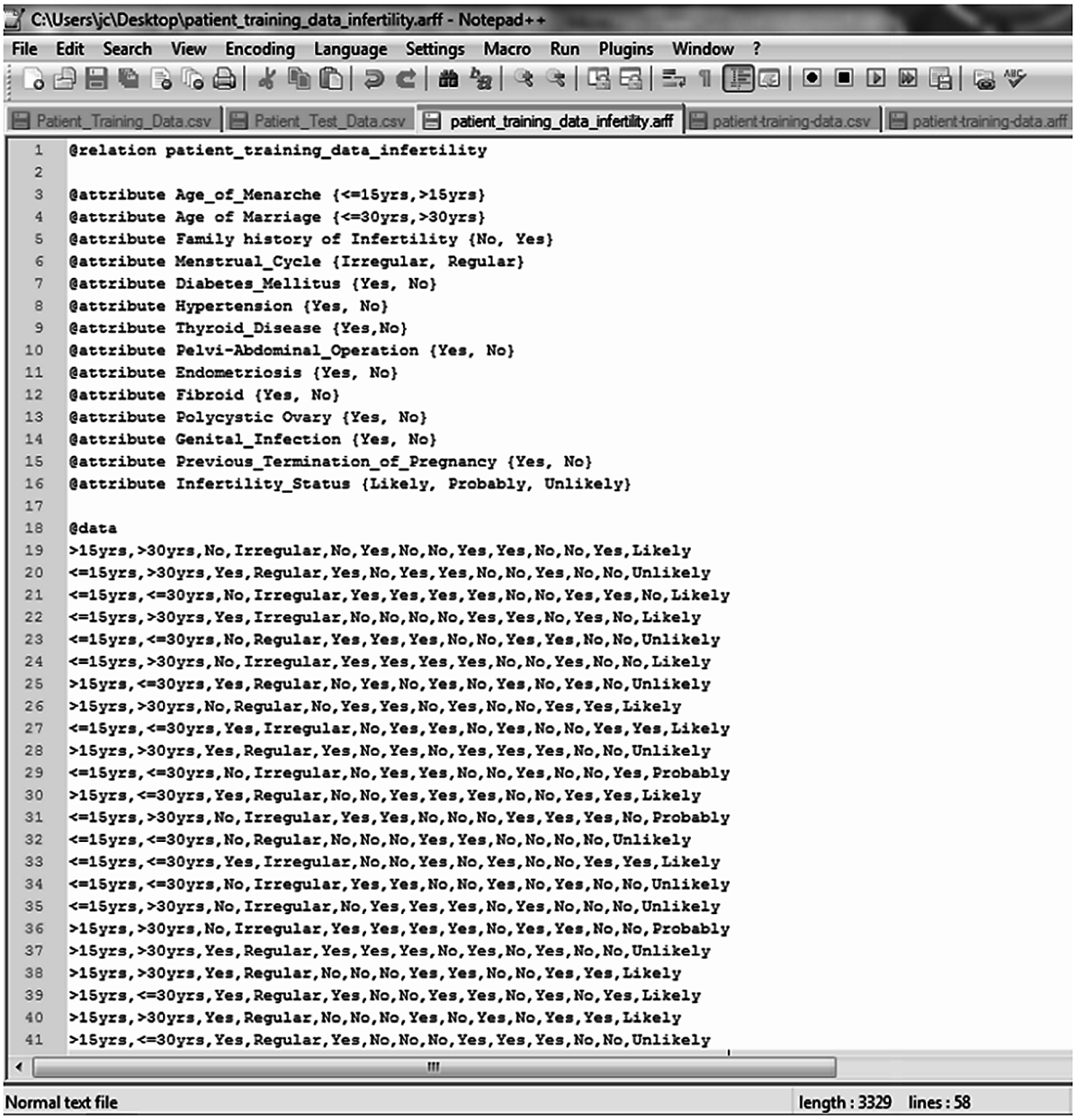
In order for the dataset collected to be fit for the simulation environment; the dataset was converted to a more compactible data storage format. This would make the dataset fit for all the necessary machine learning operations performed by the simulation environment. Important to the study is the ability of the machine learning techniques to identify the most important combination of features that are more likely to improve the predicting the likelihood of infertility.

The dataset collected was converted to the required format needed for simulation; the Waikato Environment for Knowledge Analysis (WEKA) called the attribute relation file format (.arff) – a light-weight java application with a number of supervised and unsupervised machine learning tools. This format allows for the formal identification of the file name, attribute names and labels alongside the dataset that correspond to each attribute expressed using their respective labels. Figure 1 shows the format of the .arff file format chosen for the formal representation of the dataset using the 39 patient data collected.

Model Formulation

Systems that construct classifiers are one of the commonly used tools in data mining. Such systems take as input a collection of cases, each belonging to one of a small number of classes and described by its values for a fixed set of attributes, and output a classifier that can accurately predict the class to which a new case belongs. Supervised machine learning algorithms make it possible to assign a set of records (infertility risk indicators) to a target classes – the risk of infertility (Unlikely, Likely and Benign).

Figure 1. .arff file containing identified attributes



Supervised machine learning algorithms are Black-boxed models, thus it is not possible to give an exact description of the mathematical relationship existing among the independent variables (input variables) with respect to the target variable (output variable – risk of infertility). Cost functions are used by supervised machine learning algorithms to estimate the error in prediction during the training of data for model development. Gradient decent and other related algorithms are used to reduce the error by estimating cost function parameters.

The theory of a decision tree has the following parts: a root node is the starting point of the tree; branches connect nodes showing the flow from question to answer. Nodes that have child nodes are called interior nodes. Leaf or terminal nodes are nodes that do not have child nodes and represent a possible value of target variable given the variables represented by the path from the root. The rules are inducted by definition from each respective node to branch to leaf (Chaurasia et al., 2012).

The basic idea of decision tree analysis is to split the given data set into subsets by recursive portioning of the parent node into child node based on the homogeneity of within – node instances or separation of between-node instances with respect to target variables. For each node, attributes are examined and the splitter is chosen to be the attribute such that after dividing the nodes into child nodes according to the value of the attribute variable, the target variable is differentiated to the best using algorithm. Because of this, there is the need to distinguish between important attributes, and attributes which contribute little to overall decision process. Splitting points attribute variables and values of chosen variables are chosen based on Gini impurity and Gini gain as expressed below by (Chaurasia et al., 2012):

$$i(t) = 1 - \sum_{i=1}^{m} f(t,i)^2 = \sum_{i \neq j} f(t,i) f(t,j)$$

$$I(u_1, u_2, u_3) = -\sum_{i=1}^{3} \frac{u_i}{u_1 + u_2 + u_3} \log_2 \frac{u_i}{u_1 + u_2 + u_3}$$

where $f\left(t,i\right)$ is the probability of getting i in node t, and the target variable takes values in {1, 2, 3… m}. P_L is the proportion of cases in node t divided to the left child node and P_R is the proportion of cases in t sent to the right child node. If the target variable is continuous, the split criterion is used with the Least Squares Deviation (LSD) as impurity measure. If there is no Gini gain or the preset stopping rule are satisfied, the splitting process stops. Given a set S of cases, C4.5 first grows an initial tree using the divide-and-conquer algorithm as follows:

- If all the cases in S belong to the same class or S is small, the tree is a leaf labeled with the most frequent class in S.
- Otherwise, choose a test based on a single attribute with two or more outcomes. Make this test the root of the tree with one branch for each outcome of the test, partition S into corresponding subsetsS1, S2, ... according to the outcome for each case, and apply the same procedure recursively to each subset.

The pseudo-code for the decision tree Induction is shown as follows:

```
START
DTree(examples, features) returns a tree
If all examples are in one category then return a leaf node with that category
label.
Else if the set of features is empty then return a leaf node with the category
label that is the most common in examples
```

```
Else pick a feature F and create a node R for it
For each possible value v_i of F:
Let examples_i be the subset of examples that have value v_i for F
Add an out-going edge E to node R labeled with the value v_i
If examples_i is empty then attach a leaf node to edge E labeled with the cat-
egory that is the most common in examples.
Else call DTree(examples_i, features – {F}) and attach the resulting tree as the
sub-tree under edge E.
Return the sub-tree rooted at R.
END
```

ID3 Decision Trees Algorithm

ID3 (Iterative Dichotomiser 3) developed by Quinlian (1993) is a classification tree used in the concept of information entropy. This provides a method to measure the number of bits each attribute can provide, and the attribute that yields the most information gain becomes the most important attribute and it should go at the top of the tree. Repeat this procedure until all the instances in the node are in the same category.

In this study, there are three outcomes, namely: Likely (u_1), Unlikely (u_2) and probably (u_3) in the root node T of target variable. Let u_1, u_2 and u_3 denote the number of probable, unlikely and likely records, respectively. The initial information entropy is given by as:

$$EI(X) = \sum_{j=1}^{N} \frac{u_{1j} + u_{2j} + u_{3j}}{u_1 + u_2 + u_3} \cdot I(u_1, u_2, u_3)$$

If attribute X (a risk indicator of infertility) with values {x_1 and x_2} is chosen to be the split predictor and partition the initial node into {T1, T2, T3… TN}, and u_1, u_2 and u_3 denote the number of probable, unlikely and likely records in the child node j. The expected information EI(X) and information gain G(X) are given by and:

$$EI(X) = \sum_{j=1}^{N} \frac{u_{1j} + u_{2j} + u_{3j}}{u_1 + u_2 + u_3} \cdot I(u_1, u_2, u_3)$$

and information gain is defined as:

$$G(X) = I(u_1, u_2, u_3) - EI(X).$$

C4.5 Decision Trees Algorithm

In 1993, Ross Quinlan made several improvements to ID.3 and extended it to C4.5 (Quinlan, 1993). Unlike ID.3 which deals with discrete attributes, C4.5 handles both continuous and discrete attributes

by creating a threshold to split the attribute into two groups, those above the threshold and those that are up to and including the threshold. C4.5 also deals with records that have unknown attribute values. C4.5 algorithm used normalized information gain or gain ratio as a modified splitting criterion of information gain which is the ratio of information gain divided by the information due to the split of a node on the basis of the value of a specific attribute. The reason of this modification is that the information gain tends to favor attributes that have a large number of values.

The best approach in selecting the attribute for a specific node is to choose the one that maximize the given ratio. Stopping rule of C4.5 needs to be pre-specified and it initiated a pruning procedures by replacing branches that do not help with leaf nodes after they are created to decrease overall tree size and the estimated error of the tree. A rule set can be derived from the decision tree constructed by writing a rule for each path from the root node to the leaf node. After C4.5, Quinlan (1996) created C5.0 as an extended commercial version of C4.5 featuring a number of improvements including smaller decision trees, weighting different attributes and misclassification types, reducing noise, speed and memory efficiency, support for boosting which gives the trees more accuracy.

According to Wu et al. (2008) there are usually many tests that could be chosen in this last step. C4.5 uses two heuristic criteria to rank possible tests: information gain, which minimizes the total entropy of the subsets $\{S_i$ - the risk factors of infertility$\}$ (but is heavily biased towards tests with numerous outcomes), and the default gain ratio that divides information gain by the information provided by the test outcomes. Attributes can be either numeric or nominal and this determines the format of the test outcomes. For a numeric attribute A they are $\{A \leq h, A > h\}$ where the threshold h is found by sorting S on the values of A and choosing the split between successive values that maximizes the criterion above. An attribute A with discrete values has by default one outcome for each value, but an option allows the values to be grouped into two or more subsets with one outcome for each subset.

The initial tree was then pruned to avoid over-fitting. The pruning algorithm was based on a pessimistic estimate of the error rate associated with a set of N cases, E of which do not belong to the most frequent class. Instead of E/N, C4.5 determines the upper limit of the binomial probability when E events have been observed in N trials, using a user-specified confidence whose default value is 0.25.

Pruning was carried out from the leaves to the root. The estimated error at a leaf with N cases and E errors is N times the pessimistic error rate as above. For a sub-tree, C4.5 adds the estimated errors of the branches and compares this to the estimated error if the sub-tree is replaced by a leaf; if the latter is no higher than the former, the sub-tree is pruned. Similarly,

C4.5 checks the estimated error if the sub-tree is replaced by one of its branches and when this appears beneficial the tree is modified accordingly. The pruning process was then completed in one pass through the tree.

Random Tree Algorithm

Random Tree is a supervised Classifier; it is an ensemble learning algorithm that generates many individual learners. It employs a bagging idea to produce a random set of data for constructing a decision tree. In standard tree each node is split using the best split among all variables. In a random forest, each node was split using the best among the subset of predicators (risk factors of infertility) randomly chosen at that node. Random trees were introduced by Leo Breiman and Adele Cutler. The algorithm could deal with both classification and regression problems. A random tree is a collection (ensemble) of tree predictors that is called forest. The classification works as follows: the random trees classifier takes the

input feature vector, classifies it with every tree in the forest, and outputs the class label that received the majority of votes. In case of a regression, the classifier response is the average of the responses over all the trees in the forest. This study used the earlier described method since a classification of infertility model problem.

Random Trees are essentially the combination of two existing algorithms in Machine Learning: single model trees are combined with Random Forest ideas. Model trees are decision trees where every single leaf holds a linear model which is optimized for the local subspace described by this leaf. Random Forests have shown to improve the performance of single decision trees considerably: tree diversity is generated by two ways of randomization. First the training data was sampled with replacement for each single tree like in Bagging. Secondly, when growing a tree, instead of always computing the best possible split for each node only a random subset of all attributes is considered at every node, and the best split for that subset was computed.

Simulation of Prediction Model

In order to develop the predictive model needed for predicting infertility in Nigerian women, the dataset collected from a University Teaching Hospital in south-western Nigeria was used as the historical dataset for training and testing the prediction model using the selected decision trees algorithms. The WEKA simulation environment supports three different training methods, namely:

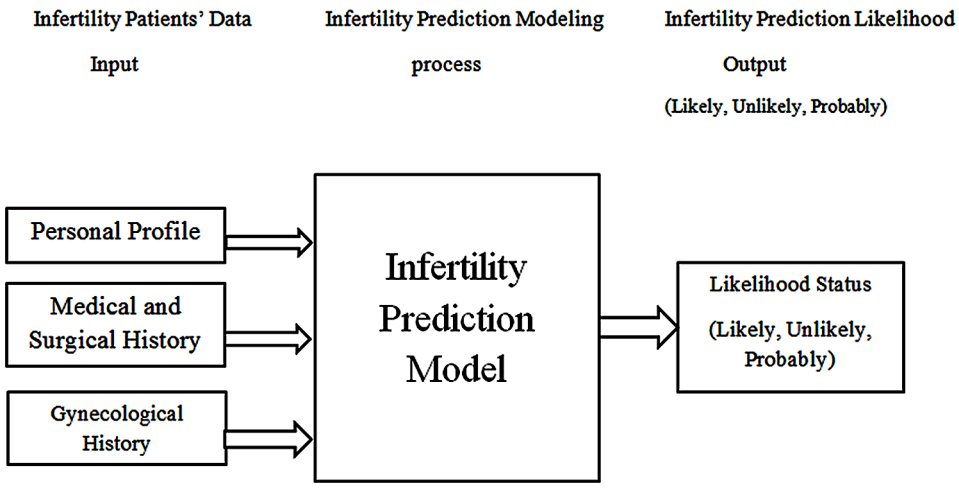
1. **Using the Entire Training Data:** This method allows the whole 39 dataset to be used in developing the predictive model using the decision trees algorithm while the same 39 dataset was later used to test the performance of the developed model. This method is usually believed to cause an over-fitting of the dataset;
2. **Using the 10-Fold Cross Validation Method:** This method allows the whole dataset to be split into 10 parts such that, 9 parts are used for training with the remaining one part used for testing. This is done by picking each individual one-part for testing while using the remaining 9 parts for training for every tenth of the dataset. The advantage is the ability to allow a portion of the whole dataset to be used for testing and training until all other portions have been covered; and
3. **Using the Proportion Method:** This method allows for the use of a percentage split of the historical dataset which is 66% for the training set and 34% for the testing set. The issue with this method is the fact that only a portion of the dataset is used for training while the remaining part is used for testing the developed model.

For this study, the full training dataset and the 10-fold cross validation techniques were used as the training technique for model development using the historical dataset containing 39 patient records using the identified 14 attributes (risk indicators for infertility likelihood). The framework used in developing the predictive model needed is shown in Figure 2.

Performance Evaluation of Model Evaluation

Following the development of the predictive model using all the proposed methods, the performance of the model was evaluated using the confusion matrix to determine the value of the performance metric

Figure 2. Infertility prediction modeling framework



chosen for this study. A confusion matrix contains information about actual and predicted classification done by a classification system and its performance is commonly evaluated using the data in the matrix. Also, correctly classified cases are placed in the true cells (positive and negative) while incorrect classifications are placed in the false cells (positive and negative) and this has generated the rule 1 to 4, below:

1. True positives are correctly classified positive cases (likely cases predicted as likely);
2. False positives are incorrectly classified positive cases (unlike and probable cases predicted as likely);
3. True negatives are correctly classified negative cases (probable or unlikely cases predicted as probable and unlikely respectively); and
4. False negatives are incorrectly classified negative cases.

In order to capture the performance of the decision trees algorithm used to classify breast cancer risk, there is the need to plot the results of the classification on a confusion matrix. A confusion matrix is a square which shows the actual classification along the vertical and the predicted along the vertical. All correct classifications lie along the diagonal from the north-west corner to the south-east corner also called True Positives (TP) and True Negatives (TN) while other cells are called the False Positives (FP) and False Negatives (FN). In this study, the likely cases are considered as the positive case while the unlikely and probable cases are the negative cases.

The confusion matrix shown in Figure 3 above assumes that the unlikely breast cancer case is the positive class; either way the performance will be evaluated considering each breast cancer case (Unlikely, Likely and Benign) as the positive class. The performance evaluation criteria allow the measurement of the accuracy of the models developed using the training dataset. The results of the classification recorded on a confusion matrix are used to determine the following performance evaluation criteria.

1. **Precision:** Is the fraction of classifications that are relevant (or correctly classified), see–for example, patients classified as benign who are actually benign etc.;

2. **TP Rate (Recall/Specificity):** Is the fraction of relevant classifications that were retrieved, see – for example, fraction of benign patients classified as benign etc.;
3. **FP Rate (False Alarm/1-Specificity):** Is the fraction of irrelevant classifications that were incorrectly retrieved, see – for example, classification of risks as benign when they were actually unlikely/likely etc.;
4. **Accuracy:** The fraction of correctly classified instances of the total data, see ; and

F-Measure: The harmonic mean of the precision and recall, see.

$$precision = \frac{TP}{TP + FP}$$

$$TP_rate(recall\ /\ sensitivity) = \frac{TP}{TP + TN}$$

$$FP_rate(false_alarm\ /\ 1 - specificity) = \frac{FP}{FP + TN}$$

$$Accuracy = \frac{TP + TN}{TP + FP + TN + FN}$$

$$F - measure = \frac{2TP}{2TP + FP + FN}$$

Figure 3. Confusion matrix of classification results

A	B	C	<-----	Classified as
TP	FP	FP		A = Likely
FN	TN	FN		B = Probable
FN	FN	TN		C = Unlikely

RESULTS

Data Description

The data containing information about the attributes and the respective infertility status for 39 patients is shown in Table 2. It was observed that out of the 39 patients, 19 were likely infertile, 3 were probably infertile and 17 were unlikely infertile. The highest distribution was: 23 with age of menacre less than or equal to 15 years, 23 had thyroid disease, 22 had no family history of infertility, 20 had no previous terminated pregnancy, 21 had irregular menstrual cycle, 21 had diabetes mellitus, 21 had hypertension, 21 had polycyctic ovary and 21 had no genital infection.

Table 2. Description of the identified variables

Variable Type	Attributes	Labels	Values
Input	Age of Menacre	<=15 years	23
		>15 years	16
	Age of Marriage	<=30 years	20
		>30 years	19
	Family History of Infertility	No	22
		Yes	17
	Menstrual Cycle	Irregular	21
		Regular	18
	Diabetes Mellitus	No	18
		Yes	21
	Hypertension	No	18
		Yes	21
	Thyroid Disease	No	16
		Yes	23
	Pelvi-Abdominal Operation	No	20
		Yes	19
	Endometriosis	No	19
		Yes	20
	Fibroid	No	20
		Yes	19
	Polycyctic Ovary	No	18
		Yes	21
	Genital Infection	No	21
		Yes	18
	Previous Terminated Pregnancy	No	22
		Yes	17
Output	Infertility Status	Likely	19
		Probably	3
		Unlikely	17

The lowest distribution was: 16 had age of menacre more than 15 years, 16 had no thyroid disease, 17 had family history of infertility, 17 had previously terminated pregnancy, 18 had irregular menstrual cycle, 18 had no diabetes mellitus, 18 had no hypertension, 18 had no polycyctic ovary and 18 had genital infection.

Simulation Results

Three different decision trees algorithms were used to train the development of the prediction model for the likelihood of infertility using the dataset collected containing the 39 patients' record. The decision trees algorithm used were: C45 algorithm – implemented on WEKA as J48 algorithm, ID3 algorithm and the Random tree algorithm. As discussed earlier, two training methods were used: the full training dataset and the 10-fold cross validation method. The performance of the model developed using each algorithm with each training method was evaluated and compared using the performance evaluation metrics.

Results of the C4.5 Decision Trees Algorithm

The J48 decision trees algorithm is a classifier used for generating pruned and unpruned C4.5 decision trees using the training dataset. Using the full training method for model training it was discovered that out of the 39 records, there were 34 (87.18%) correct classifications with 5 misclassifications (12.82%) made – this showed an accuracy of 87.2% (Figure 4). Out of 19 likely cases there were 18 correct classifications and 1 misclassified as unlikely; out of 3 probable cases there was 1 correct classification with 2 misclassifications for likely and out of 17 unlikely cases there was 15 correct classifications with 1 misclassification each to likely and probable (Figure 5 on the left). The size of the tree constructed was 9 with the number of leaves recorded as 5. The number of relevant attributes selected by the C4.5 decision Trees algorithm using the full training method was 4 (see Table 3).

Using the 10-fold cross validation training method for model training it was discovered that out of the 39 records, there were 29 (74.36%) correct classifications and 10 (25.64%) misclassifications made – this showed an accuracy of 74.36% (Figure 6). Out of 19 likely cases there were 15 correct classifications with 1 misclassification to probable and 3 to unlikely; out of 3 probable cases there was no correct classification with 2 misclassifications to likely and 1 to unlikely; out of 17 unlikely cases there were 14 correct classifications with 3 misclassifications to likely (Figure 5 on the right). The size of the tree constructed was 9 with the number of leaves recorded as 5. The number of relevant attributes selected by the C4.5 decision trees algorithm using the 10-fold cross validation method was also 4 (see Table 3).

Results of the ID3 Decision Trees Algorithm

The ID3 decision tree algorithm is a classifier used for constructing an unpruned decision tree based on the ID3 algorithm using the training dataset. Using the full training method for model training it was discovered that out of the 39 records, all records were correctly classified – this showed an accuracy of 100% (Figure 7). All 19 likely cases, 3 probable cases and 17 unlikely cases were correctly classified (Figure 9 on the left).

The size of the tree constructed was 24 with the number of leaves recorded as 13. The number of relevant attributes selected by the ID3 decision trees algorithm using full training set was 8 (Table 3).

Figure 4. Results of the full training simulation using J48 algorithm

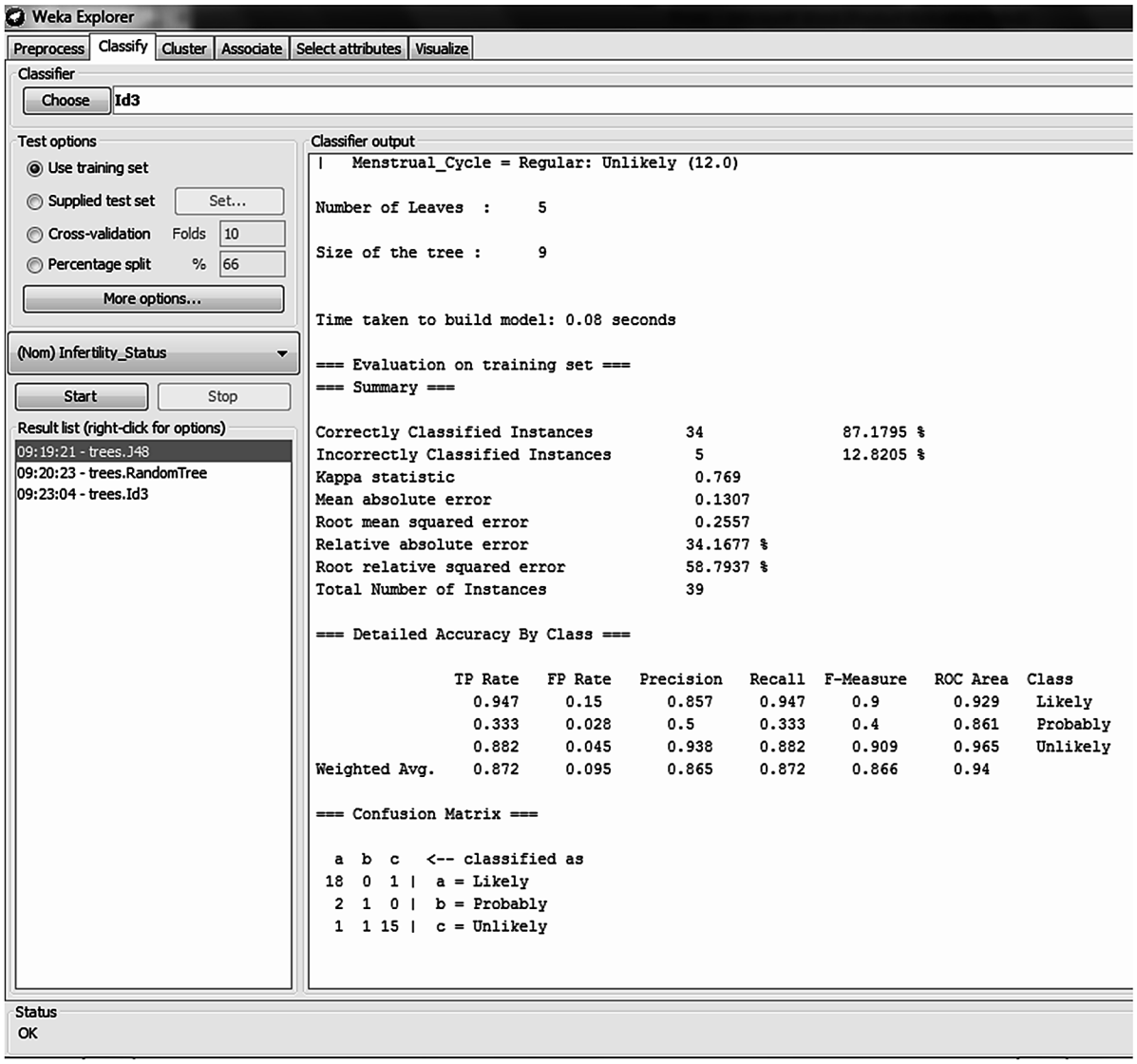


Figure 5. Confusion matrix for each simulation process using J48

a	b	c	<--- classified as		
18	0	1	a	=	Likely
2	1	0	b	=	Probable
1	1	15	c	=	Unlikely

a	b	c	<--- classified as		
15	1	3	a	=	Likely
2	0	1	b	=	Probable
3	0	14	c	=	Unlikely

Table 3. Summary of the relevant attributes selected

Training Method	C4.5 Decision Trees		ID3 Decision Trees		Random Decision Trees	
S/N	Full Training	10-Fold Cross Validation	Full Training	10-Fold Cross Validation	Full Training	10-Fold Cross Validation
1.	Termination of Pregnancy	Termination of Pregnancy	Termination of Pregnancy	Termination of Pregnancy	Termination of Pregnancy	Termination of Pregnancy
2.			Fibroid	Fibroid	Fibroid	Fibroid
3.					Thyroid Disease	Thyroid Disease
4.			Age of Marriage	Age of Marriage	Age of Marriage	Age of Marriage
5.	Menstrual Cycle	Menstrual Cycle	Menstrual Cycle	Menstrual Cycle	Menstrual Cycle	Menstrual Cycle
6.	Age of Menacre	Age of Menacre	Age of Menacre	Age of Menacre	Age of Menacre	Age of Menacre
7.					Endometriosis	Endometriosis
8.			Family History	Family History	Family History	Family History
9.	Genital Infection	Genital Infection	Genital Infection	Genital Infection	Pelvi-abdominal Operation	Pelvi-abdominal Operation
10.						
11.			Diabetes Mellitus	Diabetes Mellitus		

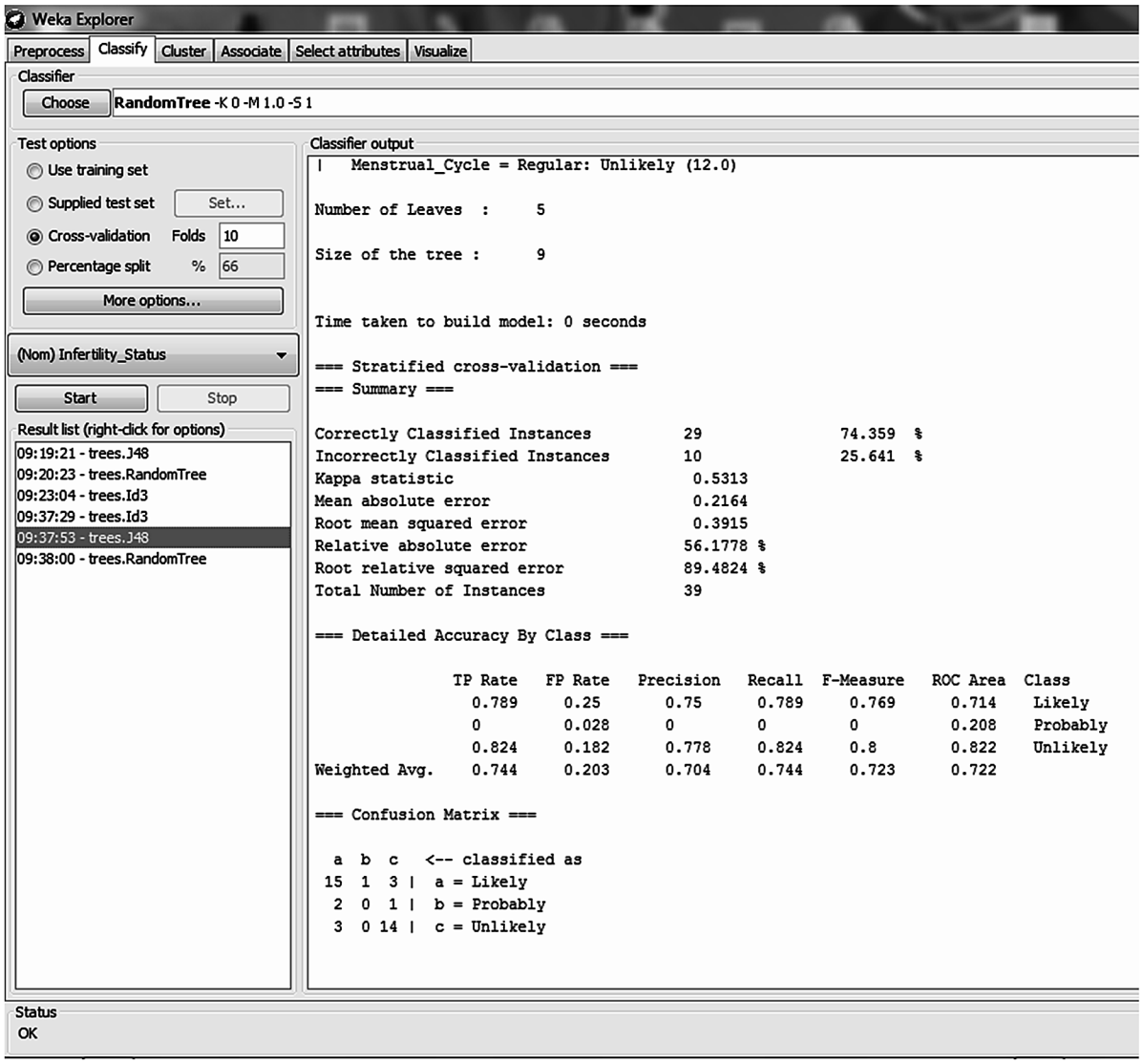
Using the 10-fold cross validation training method for model training it was discovered that out of the 39 records, there were 24 (61.54%) correct classifications and 15 (38.46%) misclassifications made – this showed an accuracy of 61.5% (Figure 8). Out of 19 likely cases there were 11 correct classifications with 4 misclassifications to probable and 4 to unlikely; out of 3 probable cases all 3 were misclassified to likely cases; out of 17 unlikely cases there were 13 correct classifications with 3 misclassifications to likely and 1 misclassification to probable (Figure 9 on the right). The size of the tree constructed was 24 with the number of leaves recorded as 12. The number of relevant attributes selected by the ID3 decision trees algorithm using the 10-fold cross validation method was 8 (Table 3).

Results of the Random Decision Trees Algorithm

The Random decision tree algorithm is a classifier used for constructing a tree that considers k randomly chosen attributes at each node without any pruning using the training dataset. Using the full training method for model training it was discovered that out of the 39 records, all records were correctly classified – this showed an accuracy of 100% (Figure 10). All 19 likely cases, 3 probable cases and 17 unlikely cases were correctly classified (Figure 11 on the left). The size of the tree constructed was 27 with the number of leaves recorded as 14. The number of relevant attributes selected by the random tree decision trees algorithm using the full training method was 9 (Table 3).

Using the 10-fold cross validation training method for model training it was discovered that out of the 39 records, there were 21 (53.85%) correct classifications and 18 (46.15%) misclassifications made – this showed an accuracy of 53.85% (Figure 12). Out of 19 likely cases there were 12 correct classifications with 2 misclassifications to probable and 5 to unlikely; out of 3 probable cases all 3 were misclassified to unlikely cases; out of 17 unlikely cases there were 9 correct classifications with 6 misclassifications to likely and 9 misclassifications to probable (Figure 11 on the right). The size of the tree constructed was

Figure 6. Results of the 10-fold cross validation simulation using J48 algorithm

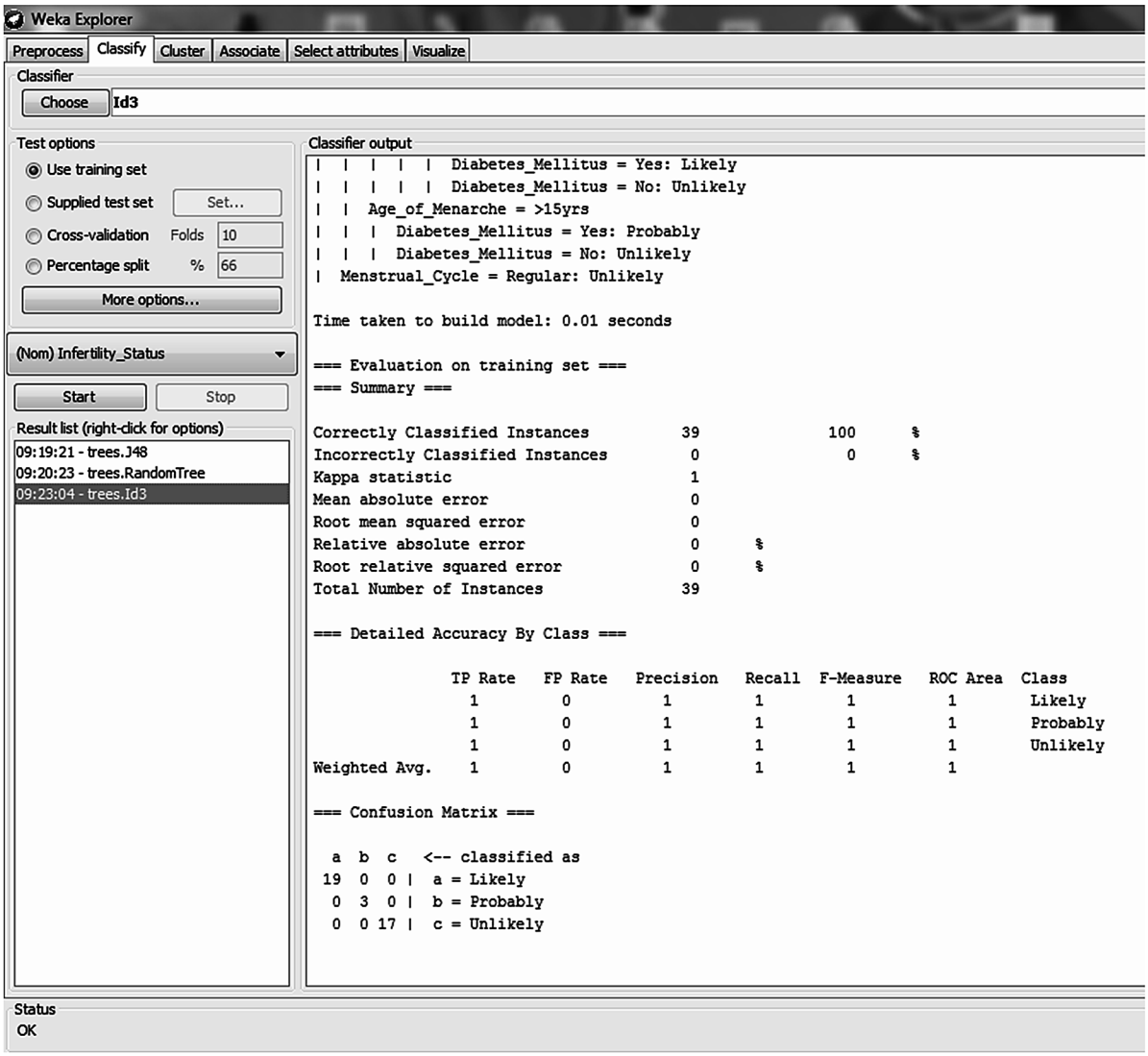


27 with the number of leaves recorded as 14. The number of relevant attributes selected by the random tree decision trees algorithm was 9 (Table 3).

DISCUSSIONS

Table 4 gives a summary of the simulation results by presenting the average value of each performance metrics identified using the two training methods selected for the three decision trees algorithms selected for the study. It was discovered that using the training method for model development, the ID3 and the Random decision tree algorithms showed the highest accuracy with a value of 100% owing for

Figure 7. Results of the full training simulation using ID3 algorithm



39 correct classifications while the C4.5 decision trees algorithm showed an accuracy of 87.2% with 34 correct classifications. Using this method it was discovered that the C4.5 algorithm was able to predict 87.2% of the actual positive cases (likely) while 9.5% of the negative (probably and unlikely) predicted cases were actually positive cases. The percentage of positive predicted cases that were actually positive cases was 74.4% while the value of 94% for the area under the ROC curve shows how effective the C4.5 algorithm is at prediction with a bias rate of 6%.

Using the 10-fold cross validation training method which is usually considered a more effective model development process due to its lesser likelihood of over-fitting data unlike the full training method, a number of observations were made. The C4.5 out-performed the other two algorithms with an accuracy of 74.4% while the ID3 and Random tree had accuracies of 61.5% and 53.8% respectively. 74.4% of the actual positive cases were correctly predicted by C4.5 unlike ID3 and Random tree which predicted

Figure 8. Results of the 10-fold cross validation simulation using ID3 algorithm

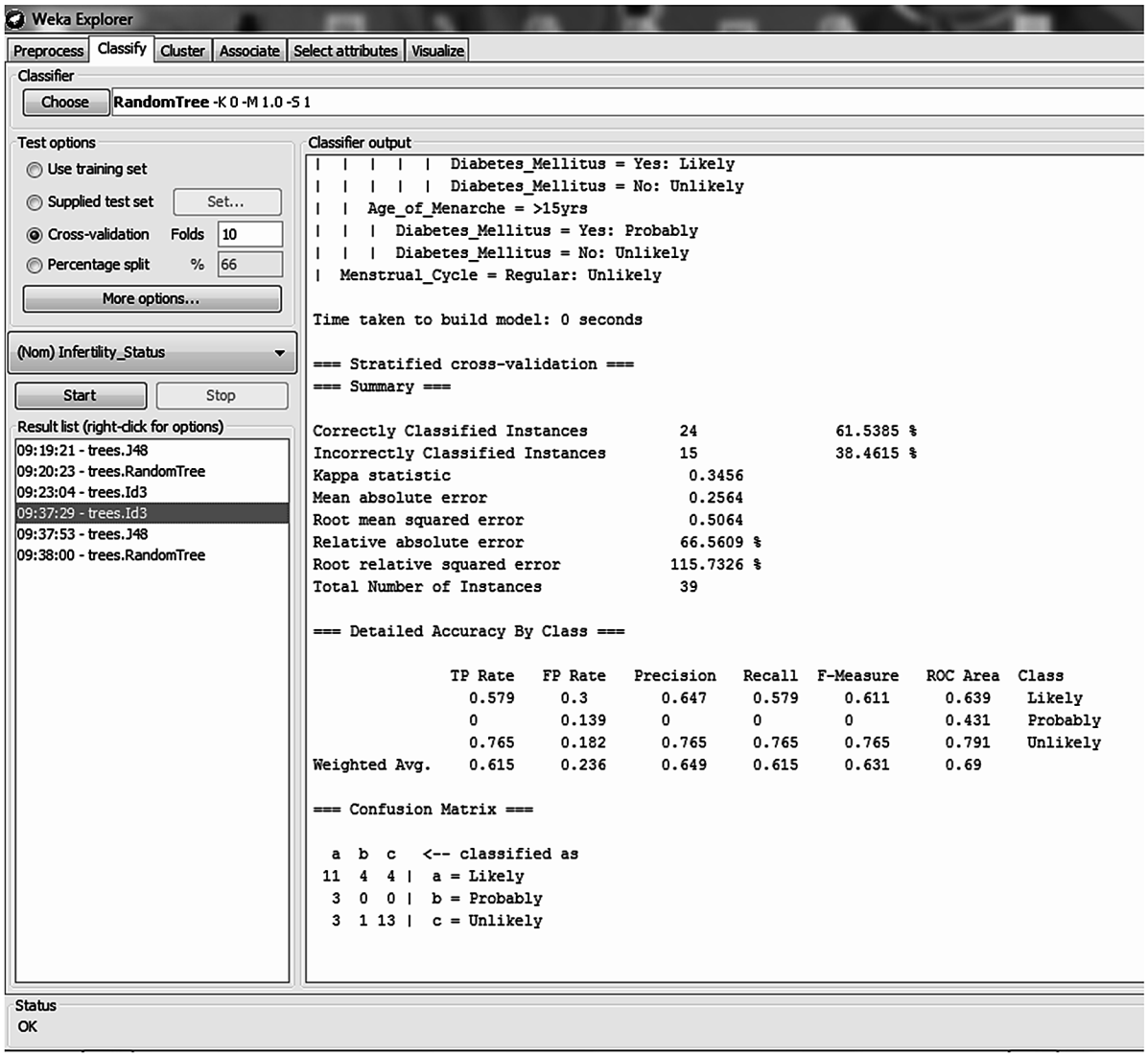


Figure 9. Confusion matrix for each simulation process using ID3

a	b	c	<--- classified as
19	0	0	a = Likely
0	3	0	b = Probable
0	0	17	c = Unlikely

a	b	c	<--- classified as
11	4	4	a = Likely
3	0	0	b = Probable
3	1	13	c = Unlikely

Figure 10. Results of the full training simulation using Random decision tree algorithm

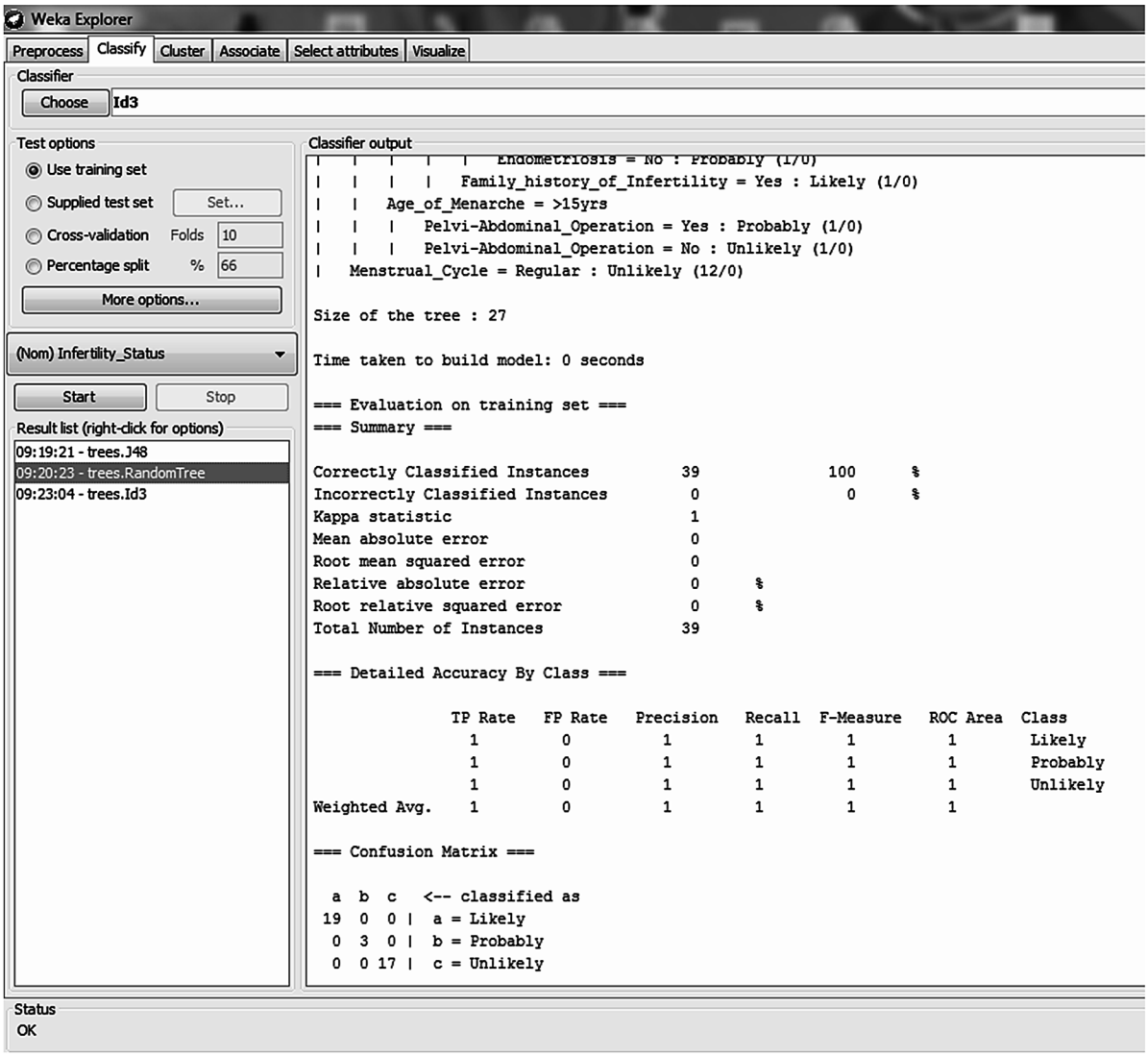


Figure 11. Confusion matrix for each simulation process using ID3

a	b	c	<--- classified as	
19	0	0	a	= Likely
0	3	0	b	= Probable
0	0	17	c	= Unlikely

a	b	c	<--- classified as	
12	2	5	a	= Likely
0	0	3	b	= Probable
6	2	9	c	= Unlikely

Figure 12. Results of the 10-fold cross validation simulation using Random tree

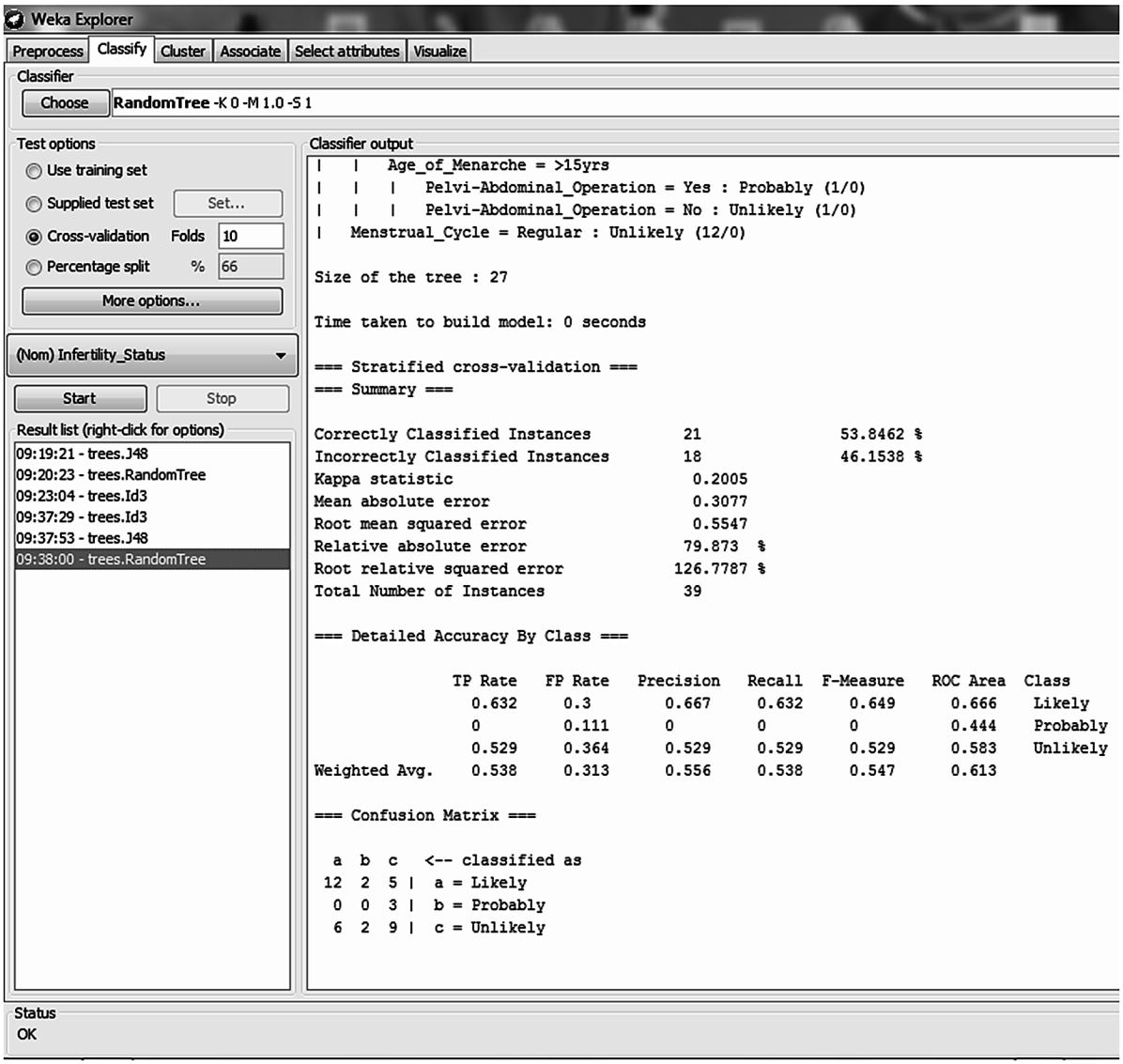


Table 4. Results of the performance evaluation of the decision trees algorithm

Metrics		Accuracy	TP Rate (Recall or Sensitivity)	FP Rate (False Alarm or 1-Specificity)	Precision	Area Under ROC Curve (AUC)
C4.5	Full training	87.180	0.872	0.095	0.865	0.940
	10-fold cross validation	74.359	0.744	0.203	0.744	0.722
ID3	Full training	100.000	1.000	0.000	1.000	1.000
	10-fold cross validation	61.539	0.615	0.236	0.649	0.690
Random Tree	Full training	100.000	1.000	0.000	1.000	1.000
	10-fold cross validation	53.846	0.538	0.313	0.547	0.613

61.5% and 53.8% respectively. 20.3% of the negative predicted cases were actually positive cases for the C4.5 algorithm unlike the ID3 and the random tree algorithm which had values of 23.6% and 31.3% respectively. The C4.5 decision trees algorithm also out-performed the other algorithms for the evaluation of the precision and the area under the ROC curve with values of 74.4% and 72.2% respectively.

The result shows that the C4.5 decision trees algorithm is an effective model which can be used in predicting the likelihood of infertility in women given a number of relevant variables. It was also discovered that using the C4.5 decision trees algorithm, the number of relevant attributes identified to be predictive for infertility likelihood are:

- Previous termination of pregnancy;
- Menstrual cycle;
- Age of menacre; and
- Genital infection.

The tree developed using the C4.5 decision trees algorithm was used to induce the set of rules needed for predicting the likelihood of infertility in women. It is important that the accuracy of the model is 74.4% given a 95% confidence interval but the model can be improved by collecting more information on infertility which can help identify hidden trends not observed in the datasets used in developing the predictive model. The induced rule is as follows:

```
If Previous termination of pregnancy = "Yes" then infertility likelihood =
"Likely"
Else If Previous termination of pregnancy = "No" then
        If Menstrual Cycle = "Irregular" then
                If Age of Menacre = "<= 15 years" then
                        If Genital Infection = "Yes" then infertility
likelihood="Likely"
                Else If Genital Infection = "No" then infertility likelihood
="Unlikely"
        Else If Age of Menacre = "> 15 years" then infertility
likelihood="Probably"
        Else if Menstrual Cycle = "Regular" then likelihood of
infertility="Unlikely"
```

CONCLUSION

In this paper, the development of a predictive model for determining the likelihood of infertility in Nigerian women was proposed using dataset collected from patients in one of the Teaching Hospitals located in South-western Nigeria. 14 variables were identified by gynecologist to be necessary in predicting infertility in women for which a dataset containing information of 39 patients alongside their respective infertility status (likely, unlikely and probably) was also provided with 14 attributes following the iden-

tification of the required variables. Three decision trees algorithms were used to develop the predictive model using two different training methods – the full training and the 10-fold cross validation method.

After the process of data collection and pre-processing, the three decision trees algorithms were used to develop the predictive model using two different types of training method while the dataset collected from 39 patients was used as the historical dataset from which the training and testing dataset was collected. Using the full training method which is likely over-fitted; C4.5 had the least performance while ID3 and Random trees showed accuracy of 100% each. Using the 10-fold cross validation technique, the C4.5 decision trees algorithm out-performed the other two decision trees algorithm showing the effectiveness of the C4.5 decision trees algorithm in developing predictive model needed for the likelihood of infertility with an accuracy of 74.4%.

In addition, the three algorithms were able to identify a number of relevant variables – all identified termination of pregnancy, menstrual cycle and age of menacre; Age of Marriage, Fibroid and Family History were identified in addition by ID3 and Random trees; Thyroid disease, endometriosis and pelvi-abdominal operation in addition was identified by only random trees while diabetes mellitus in addition was identified by only the ID3 algorithm.

The C4.5 decision trees algorithm proved to be an effective algorithm for predicting infertility in women in addition to the attributes identified but it is believed that higher accuracy could be attained by increasing the number of records used and be identifying other relevant attributes which could help predict infertility in women. The model can also be integrated into existing health information systems used by hospitals to retrieve information regarding infertility which can be used in predicting the likelihood of infertility thus proving affective and efficient decision-support to practicing gynecologist.

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Section 2

Healthcare Process Aspects

Chapter 7
Operations Project and Management in Trauma Centers: The Case of Brazilian Units

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ABSTRACT

Topic of discussions over the last decades, the literature related to the care of patients suffering from poly-trauma, under the assistance point of view, is sufficiently consolidated concerning to the adoption of best practices, what, usually are conducted and disseminated by accrediting organizations. However, expanding the search frontier beyond the assistance dimension, it's noticed the divergences between the recent researches or theoretical shortcomings regarding to the design and management of these operations. In face of this finding, noticed from a literature review in the most important bases of operations management and health, it's adopted a conceptual model which covers relevant elements of the project of an operation, such as: strategy, capacity, human resources, incentive systems, organizational structure and decision making; in order to systematize the current stage of the field, highlighting the differences between recent studies and proposing a set of practices and premises, which are necessary for the operationalization of the proposed model.

INTRODUCTION

Topic of discussions over the last decades, the literature related to the care of patients suffering from poly-trauma, under the assistance point of view, is sufficiently consolidated concerning to the adoption of best practices, what, usually are conducted and disseminated by accrediting organizations (for example, ACS). However, expanding the search frontier beyond the assistance dimension, it's noticed

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the divergences between the recent researches or theoretical shortcomings regarding to the design and management of these operations.

In face of this finding, noticed from a literature revision in the most important bases of operations management and health, it's adopted a conceptual model which covers relevant elements of the project of an operation, such as: strategy, capacity, human resources, incentive systems, organizational structure and decision making; in order to systematize the current stage of the field, highlighting the differences between recent studies and proposing a set of practices and premises, which are necessary for the operationalization of the proposed model.

BACKGROUND

The origin of the word" trauma" comes from the Greek trauma (plural: traumathos, traumas) whose significant is "wound". In medicine, the word accepts different meanings, all of them linked to unforeseen and undesirable events, which, in a more or less violent way, affect individuals involved therein, causing them any kind of lesion or damage (SBAIT, 2015). It has an agent (energy), a vector (i.e. fire gun, motor vehicle, etc.) and a host (patient). As a disease, it must be approached by prevention strategies, an early diagnosis, an appropriated treatment and rehabilitation, targeting the reduction of the related morbidity and mortality (ACS, 2014a).

In Brazil, from the 80s on, it constitutes one of the most important points of the epidemiological transition (Azevedo, 2010: 25). Despite being a disease that traditionally focuses on the younger population, the rate of death by trauma and the estimated recovery time increases with age. This generates a significant increase in the use of resources for these older patients (Beilman et al., 2004), and which must be managed in the allocation of resources in a trauma unit. Neto & Malik (2011) reinforce the issue of the demand and argue that each patient behaves in a certain way, hindering the rigid standardization of the work process and a rationalization of service delivery.

Enhancing the criticality of this type of operation, the first hour after the accident is said as critical to perform the rescue, patient referral and design of treatment that will be applied and that's why it's considered "The Gold Hour". The initial treatment done in an appropriate way and in timely can significantly improve the prognosis of severe trauma.

According to Brohi, Parr & Coats (2009), understand the incidence of the trauma and specially the major trauma in the region, is critical for the design and development of the systems. Generally, according to the same author, there is no strong population data that support the design of this kind of system. In the Brazilian case, researches performed by the DataSUS show in Figure 1 in an aggregated way, the relationship between the number and the death rate due to traffic accidents, which may be the start point for the development of this system.

THE RESEARCH

This text present results of a research project about the Organizational Solutions of treatment to the polytrauma patients in public hospitals in Brazil. Embrace their projects, their ways of management, resource allocation and the key processes and protocols adopted. The Figure 2 show the research method adopted.

Figure 1. Incidence of deaths due to traffic accidents
Source: DataSUS (2014).

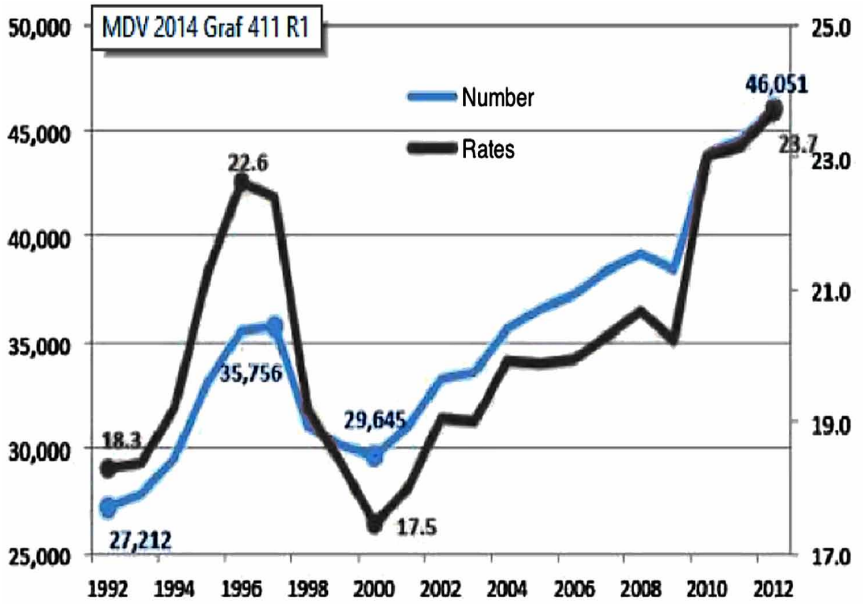
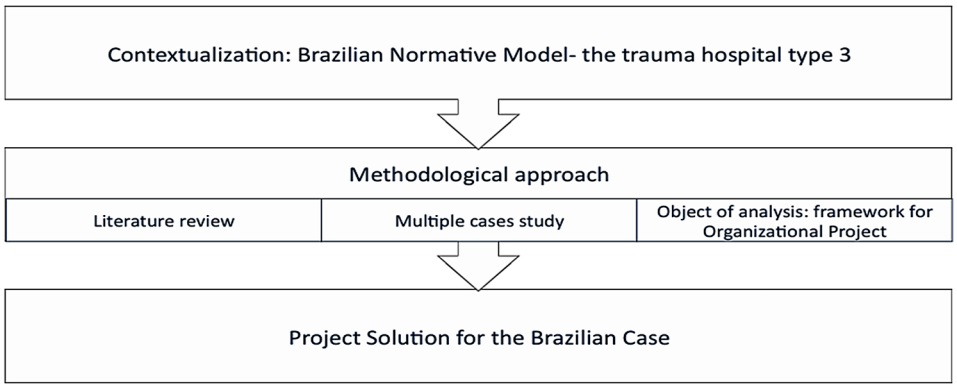


Figure 2. Research method
Source: Authors.



Contextualization: The Trauma Hospital Type 3 in Brazil

According to the Ordinance 1.366 (2013), the trauma Hospitals or Centers play the role of specialized reference for the care of the patients who are victims of trauma and must have as a target the improvement of these patients' care besides universalization and standardization of a service model in all its stages in order to reduce mortality and sequels of trauma patients. Therefore, the same ordinance defines the minimum requirements in terms of human resources, facilities and equipment, left to the discretion of

each County, State and Council of the involved professional classes (CRM and CONFEN) the establishment of the necessary standards and contingents.

Regarding the division by specialties for the treatment of trauma patients, the same Ordinance stablishes three types of Trauma Center, whose physical distribution; complexity and variety of the offered treatments are defined from the size of the population that should be treated.

In case the referred specialty is not available 24 hours a day in the hospital, it must be activated by it. Yet, in this Ordinance, it's not specified, for example, the waiting reference time for the arrival of the specialist at the hospital; neither the Number of beds by type or size of the Trauma Centers.

Methodological Approach

The research methods are the basis for the creation of knowledge, being the tools that lend themselves to understand the reality (Pinsonneault & Kraemer, 1993). To investigate how the Health Units design and manage their trauma centers, it was adopted an exploratory methodology (Jonsen & Jehn, 2011), aiming to obtain descriptive information of these organizations' practices; and that there is little recent literature devoted to discussion of the design and management of trauma centers.

On the other hand, there is a vast literature approaching the welfare aspects of this type of unit. What it at stake is exactly the development of a theoretical and conceptual perspective, empirically effective (MASON, 2006) to guide the designers and the decision makers when they have to face the demands of this kind of Health Unit's reality.

To get an insight of how the different characteristics of the models of management of trauma centers interact and interrelate with their organizational project's development and about the approach and parameters effectively used by the Health Units, it was adopted as a methodological approach the Multiple Cases Study (Yin, 2005; Eisenhardt, 1989), in the context of a comprehensive systematic review of the literature (Van Aken et al., 2007) on the basis: Science Direct, PubMed e ISI Web of Science.

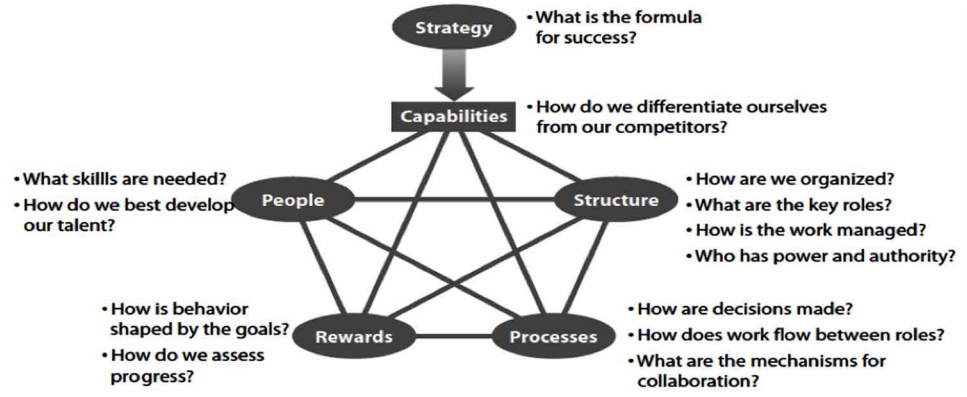
Object of Analysis: Organizational Solution

Bensabat et al. (1987) highlight the relevance of the definition of the analysis unit that is most appropriated for the study. Different analysis units imply in distinct ways to gather data and which results and conclusions might be withdrawn from the research (Patton, 2002), namely, the definition of what is waited to be said at the end of the study.

The Organizational Structure defines the units that an organization will have and the relationship among them. It has several degrees of aggregation: from the organization as a whole up to the position filled by the individuals/employees (Baligh, 2005); and define the lines of authority and responsibility of an organization (Burton et al., 2008). This means power to allocate resources, to increase or reduce the staff, to define the directions and/or strategies of the organization (Burlton, 2010). These formal structures are complemented by a myriad of arrangements, which help the everyday conduct of organizations, such as commissions, committees, communities of practice, organizational processes (Markus & Jacobson, 2010).

During the research, it's adopted the model Star of Galbraith et al. (2003).

Figure 3. Star mode
Source: Galbraith et al. (2003).



Research Protocol

To YIN (2005), the protocol is much more than just an information-gathering tool; it has not only the tool, but also the procedures and the general rules that must be followed. The author highlights that is essential to have a protocol in the case of a conduction of multiple cases' studies.

The content of this tool must include a general vision of the cases' study design (Mason, 2006), the field procedures, the issues of the research that the work aims to answer and a guide for the preparation of the case study report (Yin, 2005).

The research protocol considers a set of issues to be worked with the stakeholders of companies and guide the collection of documents and evidence.

Research Sample

In terms of the chosen cases, the focus of research is in the public units that currently take care the multiple trauma patients in a state in Brazil. To make the overall sample of the entire project research the following starting criteria were used: guided by the Ordinance 1.366 (2013), therefore, inserted in the no SUS/Brazil; number of beds offered to the patient victim of polytrauma; number of operating rooms dedicated to the care of the patient victim of polytrauma; number of professionals, by specialty allocated to the care of patients of polytrauma (ideal team); Promotion or monitoring of the patient in the rehabilitation phase.

Two State General Hospitals, reference in trauma, with 'open doors' units, were studied. Additionally, although it is a 'closed door' unit, the practices of the Federal Institute of Trauma Reference, were also analyzed. The three units are inserted in that State. Table 1 provides a summary of the cases.

SOLUTIONS AND RECOMMENDATIONS

Facing the object of analysis of this research, in this section, there will be presented under the optical of its five dimensions: the points not yet established in the literature, the points for which the literature is

Table 1. Summary of the visited units with reference in trauma

	State Hospital 1	State Hospital 2	Federal Institute
Education and research (residence)	Yes	No	Yes. Also offers Masters programs and has partnerships with some universities
Beds of ICU	8 dedicated	35 (shared)	48 (shared)
Operating Rooms	7 (being1 exclusively dedicated to trauma emergency)	3 for trauma and 4 in the Surgery Center	21
Time spent in the Trauma Center	4 hours	1:30 hours	Not applicable
Problems with the blood supply	Yes	No	There is, but it's not very serious, since they have their own blood bank and the collect is done at the very Institute.
Health professionals contracting model	"CLT", outsourced	"CLT", outsourced	Gazetted of the Ministry of Health
Remuneration (R$)	R$ 8.500,00 per 24 hours/week	*Information not available*	R$ 3.500,00 per 20 hours/week
Care (patient per month)	1.000	335	834
In-hospital rehabilitation	Yes	Yes	Yes
Ideal team to serve the greater trauma	3 surgeons 3 anesthetists 4 nurses 4 nursing technicians	2 surgeons 1 anesthetists 1 nurse 1 nursing technician	*Information not available*
Access to the Hospital	Own means and regulated by the centrals State regulation	Own means and regulated by the centrals State regulation	Regulated by the centrals State or Federal regulation

Source: Authors.

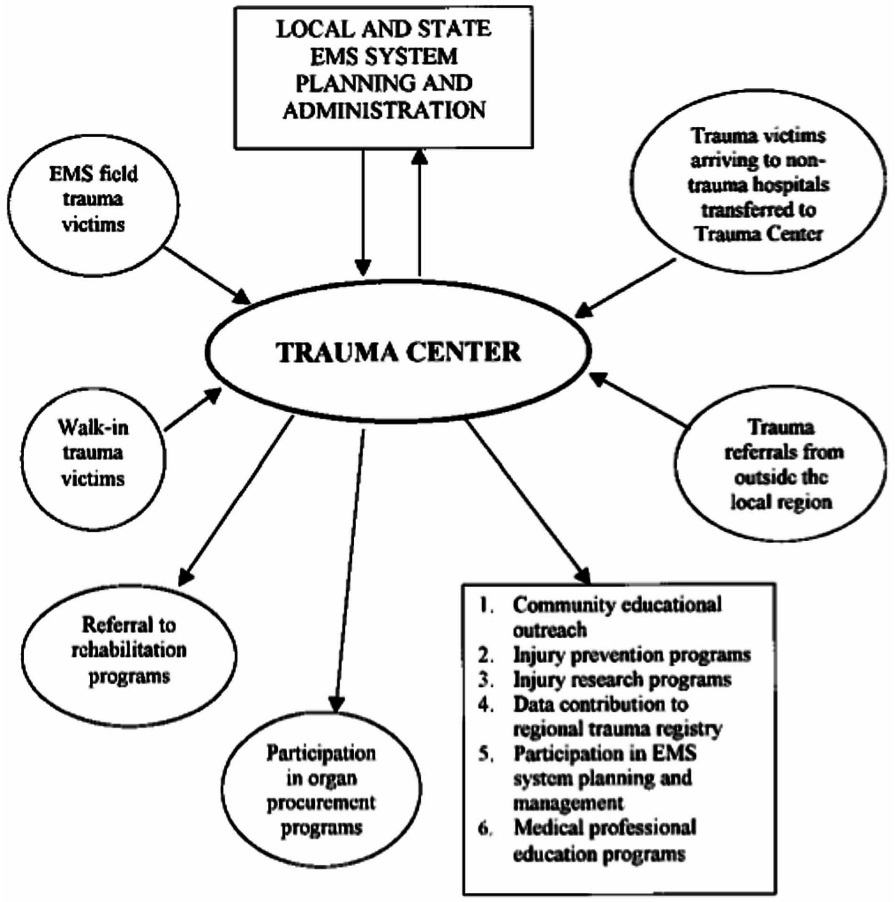
already established and the points for which the present document launches proposals in order to have a continuous improvement.

Strategy: Training

A system of trauma care consists of an organized approach to facilitate and coordinate an answer from the multidisciplinary system to take care of those who have been serious injured (HRSA, 2006). The Trauma Center, serving as installation of definitive specialized care, is key component and differs from the other hospital units of the system insofar as it ensures the availability of all necessary specialties for the evaluation and handle of the patient with multiple lesions. These centers must be integrated with the other components of the system to allow the best use of the resources according to the patients' necessity. The coordinated care system involves all the facilities' levels, so the rapid and efficient integration of hospital resources may occur according to the needs of the patient (Boffard, 2003).

In order to enable the operation of this coordinated system as proposed above, the resource management strategy must reflect the relationship between the resources demand and its supply. Depending on the availability of these resources (abundant or scarce), different strategies of allocation might be adopted, such as, cancel one or more elective surgeries to meet a peak of demand (accident with multiple victims) or creating tools to solve the systemic deficiencies of significant resources (Christian et al., 2009).

Figure 4. Typical inputs and outputs of a trauma center
Source: Demetriades & Asensio (2000:4).



Deriving from the possibility of the imbalance between supply and demand inherent to the nature of the transaction, it's possible that the professionals from this kind of organization face a scenery of limited resources, and for these cases, the doctors will be required to decide the best way of deal with a potential of saving lives. It makes a difference the complexity involved in this decision and its orientation according to an ethical sight, there are common ways to share scarce resources, considering as main factors, the patient's condition and the result potential of the medical care medico (Christian et al., 2009).

In conditions of operation for which the care demand doesn't exceed the offer, the objectives of a trauma care system are (HRSA, 2006):

- Reduce the incidence and severity of the traumas;
- Assure equitable and accessible care for all persons with trauma;
- Avoid unnecessary deaths and disability resulting from trauma
- Contain costs and improve efficiency;
- Implement the improvement of quality and performance of the trauma care at the whole system;
- Assure that the designated facilities have the appropriate resources to meet the injured' needs

Structure

Under the organizational perspective, the literature supports that a focused Trauma Unit is an administrative one inside a bigger organization, where the resources are allocated, and seen as a planning and controlling point and accountable for performance and improvement (Hyer et al., 2009).

Organizationally, the Trauma Unit tends to be a dominant part, multi-functional, since it encompasses a range of activities such as, for instance, the pain management, small surgeries, some laboratory tests, several therapies, case management, patient safety, among others. The care with the critical trauma patients also includes the burn unit and the unit of neurosciences (ACS, 2014a; Hyer et al., 2009).

In some configurations, as Figure 5, the Director of Trauma provides the care to the patients, while the Trauma Unit itself is managed by an administrative director ("subordinated" to the Nursing Direction) and a medical director (trauma surgeon) (Hyer et al., 2009).

In other configurations, the trauma's medical Director and the coordination of the trauma's program provide the care to the Trauma Center's patients, as Figure 6.

In another configuration, as Figure 7, in units with resources dedicated to trauma, there is:

In the reference manuals, it's highlighted that the trauma service must be dedicated and previously idealized according to the organizational structure of the hospital, taking into consideration some aspects, such as:

- A Medical Director, hired to run and supervise the operation of the trauma service;
- A manager of the trauma program (usually, nursing coordination), specifically designed for trauma service;
- At least one surgeon qualified in trauma (ATLS, etc.) and be a part of the primary trauma care, in all moments;
- At least one surgeon qualified in trauma ready to provide backup in all moments of the trauma service;
- At least one surgeon qualified in pediatric trauma for the trauma service;

Figure 5. Organizational solution for the trauma unit
Source: From Hyer et al. (2009)'s Description.

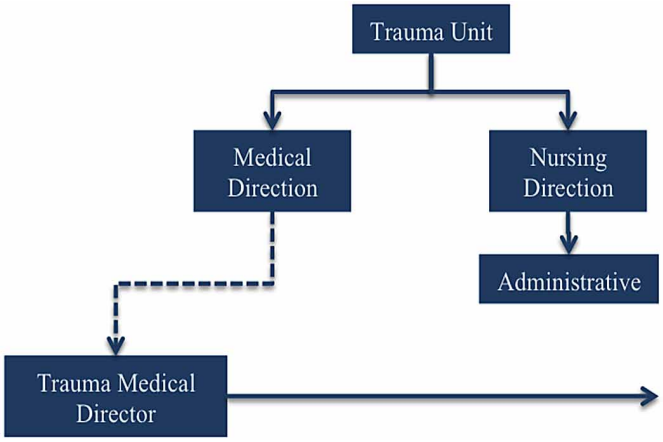


Figure 6. Organizational solution for the trauma unit
Source: From ACS (2014a)'s description.

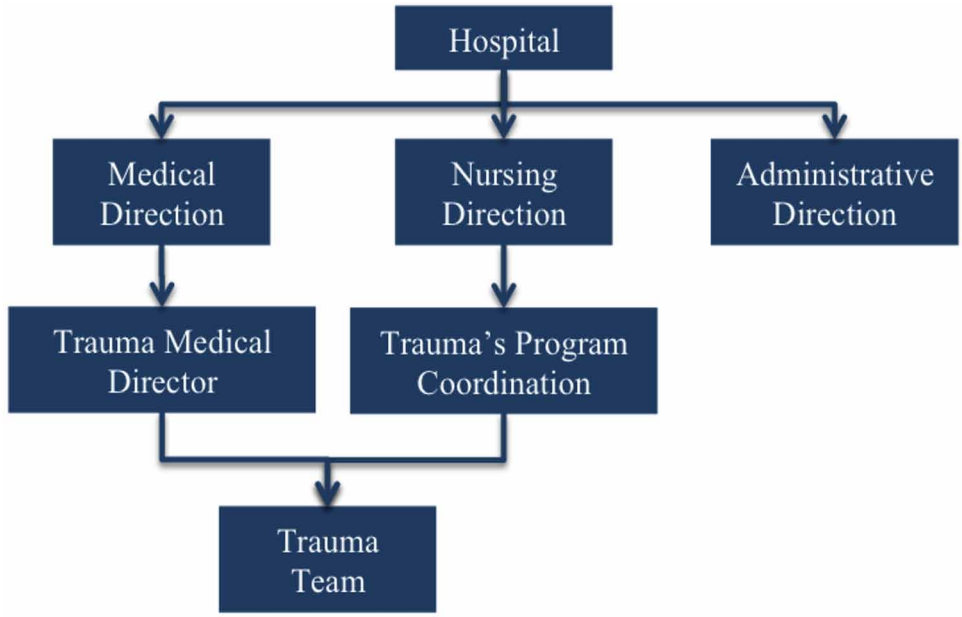
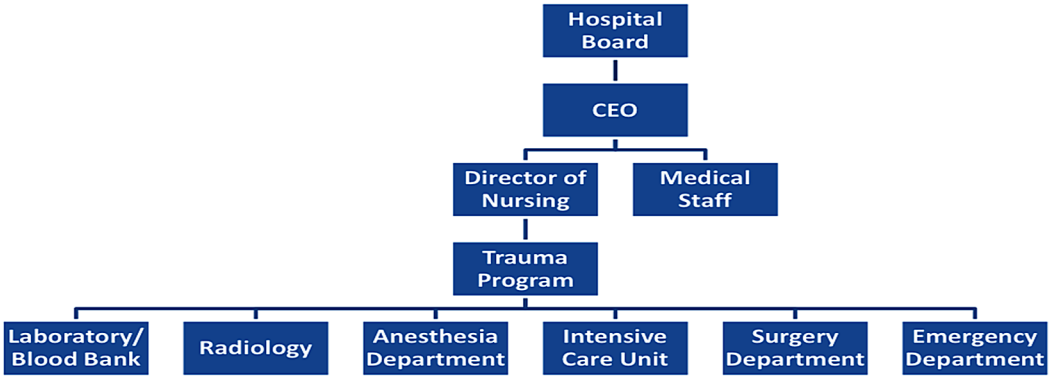


Figure 7. Organizational solution for trauma program
Source: Peterson (2013).



The trauma program should involve several disciplines and transcend normal departmental hierarchies (Alo & Griffith, 2000). As the best care extends itself since the place of a wound through the establishment of sharp care until the rehabilitation center, the trauma program must count with the appropriate specialties in all phases of treatment. Representatives of all disciplines provide the appropriate competencies as members of a team that work together to implement a treatment based on a priority plan of care (ACS, 2014b).

Processes

In the Trauma Centers, there must be places with easily access for the rescue vehicles that will be used in the initial care of the polytrauma patient, and these places are called trauma rooms, in other words, places where the initial emergency procedures may be performed, and even offering the possibility of performing small surgery procedures, once essential.

Aiming to define the patient's initial prognostic (viable or not) in the shortest time possible (it's recommended that the patients should not remain in the room for longer than 60 minutes), the trauma room requires great technical skill and scientific foundation from the team that works there (Freire, 2001).

The activation of the room trauma should be done based on the patient's condition. By easing the activation criteria, the great demand can lead to patients with severe lesions not having the necessary care, as well as too strict criteria can lead to avoidable deaths. The literature highlights several protocols for the emergency care. The most established ones are found in the package of the course/certification *Advanced Trauma Life Support* – ATLS, which has been offered by the *American College of Surgeons* – ACS – in 1978. The use of the ATLS's recommendation assure that the level of care offered does not deteriorate at no time during the evaluation, resuscitation and initial care, besides preparing appropriately for the inter or intra hospital transfer of the patient.

The macro process proposed by ATLS – used as reference in the trauma room – consist of 9 stages, which are:

1. Preparation,
2. Screening,
3. Primary Survey (ABCDE),
4. Resuscitation,
5. Auxiliary measures to the primary survey and resuscitation,
6. Secondary examination (from head to toe),
7. Auxiliary measures to the secondary examination,
8. Reevaluation and continuous monitoring,
9. Definitive Care.

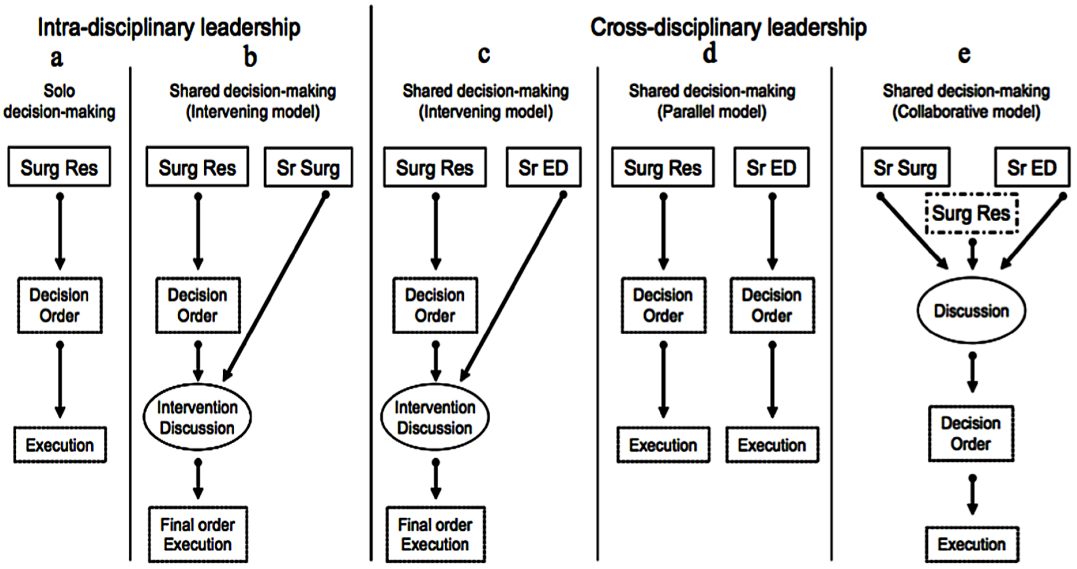
The accountability of the Emergency Department with the patient ends, when he/she is sent to the definitive care and there are three main ways for that: Release; Routing for performing a surgical procedure; Transfer to another care center.

Despite the convergence of literature regarding the sequence of activities throughout the care process, it's not conclusive regarding the flow of decision making where the model to be adopted will vary according to the necessity of the patient. As an example, Sarcevic (2011) illustrates in the following Figure 8, the alternatives of interdisciplinary decision models, considering that many Trauma Centers also incorporated the doctors who are shared with the emergency department and the surgery center.

System of People

Patients of trauma may need care from specialists, besides the one provided by the general surgeons, emergency doctors, orthopedists and neurosurgeons. The efficacy of a Trauma Center is reinforced by the commitment of these additional people. These specialists must be promptly available and qualified in

Figure 8. Leadership decision models of the trauma team
Source: Sarcevic (2011).



their specialization areas. The ready availability is defined as being available within 30 minutes counting from the notification (ACS, 2014a). For Stürmer & Neugebauer (2002) this response time should be from 15 to 20 minutes. So, the trauma service access other clinic services by the demand and needs to deal with ways to manage the resources. The perspective of the coordinated system involving all dimensions of this type of organization, as proposed by Boffard (2013), is translated, in the people's system dimension, in the role of the health unit coordinator. This role has as attributions (Peterson, 2013):

- Activate the trauma team after the notification from the pre hospital;
- Confirm the arrival of all team members;
- Determine if additional medical staff will be necessary;
- Keep direct contact with emergency service;
- Gather and copy all documentation for the transport team, for instance, letters, laboratories, X-rays;
- Prepare forms of patients transfer and get the signature from the emergency service provider, in case the patient needs to be transferred;
- Security request to ensure the heliport;

By meeting the welfare nature of the assignments, Murphy et al. (2011) highlight that the increasing complexity associated to the care to the polytrauma patient that assume operations in complex and dynamic environments, characterized by multifaceted decisions, information overload and great time restrictions with severe consequences for errors, require, not only the domain of knowledge and procedural's skills, but also the ability of communicating effectively with the patients and other care providers from where derives the necessity of develop and improve the strong skills of the interdisciplinary team.

As part of the continuous improvement, an efficient technique in the perspective of communication, quality perception and improvement of the teams' competences (knowledge, skills and attitudes) is the

learning through training and simulation that directly impacts the performance, providing: timely responses, high quality decisions' taking and reduction of the patient's safety risk. As an example, one may cite the "TraumaMan", which has been used in the ATLS courses in order to enable practical training of various surgical procedures in an anatomical dummy.

Reward System

Trauma systems are complex organizational structures, with the evolution of the methods and care standards. It's necessary to have an ongoing evaluation mechanism, based on: self-monitoring and external evaluation (Boffard, 2003). Boffard (2003) suggests that the trauma system would be monitored and evaluated through a continuous measurement of the results of the care providing process. Alo & Griffith (2000) argue that programs of trauma development improvement should provide a structured approach for the continuous improvement of the trauma care. The main target is to reduce an inappropriate variation and unwanted results in the care.

The following components are important for the efforts in the trauma development improvement:

1. Identification of the trauma patients' characteristics (epidemiological study):
    a. During the visits to these Brazilian State Trauma Centers, it was noticed a great variability of the demand by geographical and seasonal issues. While in some centers, the most recurrent problem was the ones that have been stabbed, and particularly, on Sundays, those who were shot, in others there were traffic accident victims coming from the nearby expressways. New changes in the macro environment may affect the operation of a trauma center such as, for instance, the construction of new expressways, installation of new companies, great events among others.
2. Problem Identification:
    a. **Concurrent Review:** Revision of the patient assistance while it's been provided.
    b. **Retrospective Review:** Revision the care provided to the patient after their release.
    c. Revision of the problems related to the care in multiple patients over time.
    d. Indicators for improving the trauma performance.
    e. **Evaluation:** Multidisciplinary evaluation of the individual care to the patient in a detailed way during the whole process of the trauma care.
    f. **System of Analysis of the Root Cause:** Detailed evaluation of the problem, including all the related stages and processes, which could potentially affect the issue.
    g. **Conclusions:** Consensual assessment as to whether there is an opportunity for improvement. A causal factor should be determined, to help the planning of the appropriate corrective actions, whenever possible.
    h. **Corrective Actions:** An action is necessary only if there is an improving opportunity. It must correspond to a determined root cause. It may include, education, counseling, change in protocol, resource enhancement, refers to another area for further evaluation and disciplinary action.
    i. **Return and Loop Closure**: Assure that the corrective action was concluded and it was compatible with the desired effect. If the desired effect didn't occur, it may be necessary additional actions until the improvement is reached.

Alo & Griffith (2000) argue that programs of trauma development improvements should provide a structured and multidisciplinary approach for the continuous improvement to the trauma care, aiming to reduce the inadequate variation and undesirable results in the care. Therefore, it's necessary the development of a indicators chart that allows:

- Surveillance procedures and processes;
- Analysis of the protocols' adequacy;
- Analysis of material and technologies;
- Analysis of personal development;
- Suggestion of new practices based on scientific evidences;
- Analysis and release of statistic data related to the assistance quality and the patients' safety;
- Suggestion of training to the division of continuous education;

FUTURE RESEARCH DIRECTIONS

Throughout this document, it was clear several point where the literature, about the dimensions proposed in the Galbraith's model et al. (2003) was inconclusive or unexplored. Even not being the scope of this text, it's worth to highlight that the literature lacks quantitative models that relate the amount of the necessary resources to the care of polytrauma victim patients to a determined level of service. This kind of studies could be worth in the perspective of the trauma's network, where, by knowing for which number of patients such trauma center was firstly designed, the 'trauma coordinator' could trigger contingency plans or ask for help to units geographically close to it.

CONCLUSION

In this document, it's been developed a theoretical and conceptual perspective, which, from the dimensions proposed by the Galbraith's model et al. (2003), it was evident the consolidated and open points in the literature, reinforced by empiric researches, guided by a protocol extracted from the literature revision and the present regulatory mark, allowed the understanding of the practices and challenges of the three studied organizations.

From this understanding, it contributed to the body of knowledge on the subject by synthesizing the cross-organizational variables to the departments, which should be considered in the context of design and management of a line of trauma care.

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KEY TERMS AND DEFINITIONS

Operations Management: Set of goals, policies and restrictions that describe how the organizations aims to direct and develop all the resources invested in the production to better accomplish the mission.

Organizational Structure: Administrative tools that guided to a determined objective, groups activities, resources, hierarchical levels and decision-making processes of an organization.

People: Decision-makers, who, by facing a set of information, match their will and previous experience to conduct an action.

Process: Activities sequenced logical and temporally.

Rewards: Award that is granted or obtained from satisfactory result in the execution of a task.

Strategy: Most appropriate action or path to be executed to achieve a goal.

Trauma Center: Health Unit dedicated to the care line of the trauma patients.

Trauma: External nature event to an individual, in a more or less violent manner and that could produce any lesion or damage.

Chapter 8
Lean Thinking in Global Health Care:
Theory and Applications

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ABSTRACT

This chapter explains the overview of Lean production; the overview of value stream mapping (VSM); the applications of Lean production in global health care; the implementation of Lean production in global health care; and the challenges and implications of Lean production in global health care. Lean production can be used to identify and eliminate the wastes in any health care activity performed within a health care facility. Lean production can be applied to hospitals and health care organizations to redesign health care processes toward improving the quality of care and reducing costs and wastes. Successful Lean health care efforts result in the measurable improvements in patient outcomes, such as improved quality, less harm due to preventable errors, better access, shorter waiting times, and better service. Implementing Lean production has the potential to enhance health care performance and gain sustainable competitive advantage in global health care.

INTRODUCTION

Recently, there has been an increasing interest in implementing Lean thinking in the health care industry (Poksinska, 2010). Many Lean studies in modern health care have been published (Fillingham, 2007), with results that show the potential of Lean for reducing waiting times and costs in health care systems (Kaplan & Patterson, 2008). To be safe, efficient, and cost-effective in health care organizations, health care staff usually adopt various improvement concepts (Dannapfel, Poksinska, & Thomas, 2014). Lean is mostly utilized in modern health care as an essential process improvement approach (Poksinska, 2010). Lean principles aim to ensure quality services and to promote the productive and customer-focused culture throughout the organization (Wu, Liu, & Belson, 2010).

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The health care industry is one of the world's largest and fastest-growing industries (Bhat, Gijo, & Jnanesh, 2014). Health care is a complex business that must continuously balance the need for medical care together with an attention to financial constraints (Laureani, Brady, & Antony, 2013). In today's rapidly changing health care environment, health care organizations are expected to continuously improve the quality of care delivered to an expanding population of patients (Rutman, Stone, Reid, Woodward, & Migita, 2015). Lean thinking offers not only quality improvement methodologies (Mazur, McCreery, & Rothenberg, 2012), but also a management system that makes it possible for health care organizations to implement the change and to hold the benefits (Steinfeld et al., 2015). Lean production and other quality management methodologies have been used by manufacturing and health care for many years (Merlino, Petit, Weisser, & Bowen, 2015).

Major approaches based on Lean principles in health care settings, particularly in hospitals, are reported to have a significant impact on quality, cost, time, and satisfaction of both staff and customers (Papadopoulos, Radnor, & Merali, 2011). Health care system performance needs information on cost and revenue of care because of the rising health care costs (Ma, 2016). Transferring Lean to health care is relatively new (Burgess & Radnor, 2013). Lean thinking has been appealing for health care, after achieving good results in different industries (Haddad, Gregory, & Wickramasinghe, 2014). The beneficial changes through Lean thinking have been shown to create the essential improvements in how hospitals are effectively run (McDermott & Venditti, 2015). The application of Lean concept in modern health care can increase process integration which results in the higher value-added activities to the patients (Khodambashi, 2015).

This chapter aims to bridge the gap in the literature on the thorough literature consolidation of Lean production. The extensive literature of Lean production provides a contribution to practitioners and researchers by describing the theory and applications of Lean production in order to maximize the health care impact of Lean production in global health care.

BACKGROUND

The Lean production concept was emerged on the Japanese manufacturing shop floor and was promoted through the success of the Toyota Motor Corporation (Womack, Jones, & Roos, 1990). The Lean production management design included among other things just-in-time (JIT), kanban method, and a high level of employee problem solving (Kollberg et al., 2007). Lean production is described in five elements: Lean manufacturing, Lean product development, supply chain coordination, customer distribution, and Lean enterprise management (Womack et al., 1990). However, several researchers have focused on Lean manufacturing because of its major impact on peoples' work on the shop floor and manufacturers' interest in these techniques (Hines, Holwe, & Rich, 2004). Womack and Jones' book titled "Lean thinking: Banish the waste and create wealth in your corporation" published in 1996 described the concept of Lean production.

Today, Lean production is no longer exclusive to manufacturing companies (Drotz & Poksinska, 2014). Organizations from all business sectors attempt to improve their performance using Lean production methods (Liker, 2004). Health care is one of the most important sectors in which Lean production is being considered and adopted as an improvement program (Poksinska, 2010). The key principle of Lean thinking lies in the perception of value from the customer perspective (Al-Hakim, 2014). The strategic

goal of implementing Lean in organizations is to streamline processes, which involves a linking of the enterprise to its network of suppliers and distributors (Abouzahra & Tan, 2014).

Health care systems are complex and currently facing several challenges (Chalasani & Wickramasinghe, 2014). Health care organizations are contending with the pressures of aging population, longer-term care for lifestyle diseases (e.g., cancer and diabetes), and reduced government spending on public services (Waring & Bishop, 2010). Providing effective health care services to patients are gaining an increasing attention over the past few years (Chetouane & Ibraheem, 2016). Public demand regarding quality has potentially led the health care organization-based management teams to reevaluate their health care operation strategy (Carpenter, 2011). Health care settings (e.g., hospitals and health care organizations) operate the improvement programs, thus adding to the pressures of operations rather than dealing with the problems in the existing systems (Fillingham, 2007).

There is an increasing need for the improvements in processes in health care systems around the world regarding quality, safety, effectiveness, suitability, speed, efficiency, and uniformity (Institute of Medicine, 2001). Rapidly rising health care costs, partially due to preventable medical errors, have led hospitals to redouble their process improvement efforts (Gowen, McFadden, & Settaluri, 2012). To deal with these issues, health care organizations have been seeking more efficient ways of delivering their services and have been giving the consideration to the beneficial adoption of managerial tools from the manufacturing sector (Kim, Spahlinger, Kin, & Bili, 2006). Lean management principles provide a wide range of business environments, where they have led to the significant benefits in quality and efficiency for the relatively low investments (Young et al., 2004). The awareness of Lean applications in health care settings and interest in the health care success stories are increasing among professionals in health care and academic communities (Poksinska, 2010).

TRENDS AND ISSUES WITH LEAN THINKING IN GLOBAL HEALTH CARE

This section emphasizes the overview of Lean production; the overview of VSM; the applications of Lean production in global health care; the implementation of Lean production in global health care; and the challenges and implications of Lean production in global health care.

Overview of Lean Production

Lean production (also known as Lean manufacturing or Lean) is a well-established management concept in many manufacturing organizations (Kollberg, Dahlgaard, & Brehmer, 2007) and is a quality improvement tool which utilizes quantitative methods for tracking data to reach the stated goals by documenting progress to improve quality and reduce costs (DelliFraine, Langabeer, & Nembhard, 2010). Lean management process is a set of interventions, each of which creates value for the customer (Faulkner, 2013). Womack et al. (2005) indicated that Lean organizations try to reduce waste, which in turn leads to the reduced costs and improved customer satisfaction.

Lean is based upon five core principles (Womack & Jones, 1996). The first is the maximization of customer value as determined by the customer rather than by the provider. The second involves identifying the value stream for each product providing that value, and challenge all of the wasted steps. The third is ensuring that there is a continuous flow throughout the process. Standardizing processes around

best practice allows smooth running, which frees up time for creativity and innovation. The fourth suggests the introduction of "pull" between all steps where continuous flow is impossible. This involves focusing upon the demand from the customer and trigger events backwards through the value chain. The fifth seeks "perfection" so that non-value-adding activity will be removed from the value chain, so that continuous improvement (i.e., kaizen) becomes embedded in the organization (Radnor & Boaden, 2008). Integral to Lean production are the practices of total quality management (TQM) and kaizen (Wickramasinghe, 2014).

Lean production aims to improve efficiency by eliminating non-value added activities that is known as waste (Schweikhart & Dembe, 2009). Any activity within the value stream that does not serve the purpose, needs, or preferences of the customer is termed "waste" (Young & McClean, 2009). The Lean approach espouses the elimination of sources of waste throughout a process, so that only value-added activities that address the desires of the customer should be implemented (Dohan, Xenodemetropoulos, & Tan, 2014). Lean is a well-approved strategy to enhance quality, improve productivity, and reduce cost through eliminating all non-value-added activities (Almomani, Abdelhadi, Mumani, Momani, & Aladeemy, 2014).

Lean production implies a comprehensive set of philosophies, rules, guidelines, tools, and techniques for improving and optimizing the production systems (Abdelhadi & Shakoor, 2014). The benefits of applying Lean production include the lower levels of inventory, greater levels of stock turnover, less space required, fewer defects and rework, fewer machine and process breakdowns, higher efficiencies, improved delivery performance, faster development, greater customer satisfaction, improved employee involvement, and higher profits (Kasemsap, 2016a). It is common to find the high levels of safety stocks in several points of health care units due to poorly implemented inventory management practices and personal judgment in determining safety stock levels in the silo-structured health care organizations (Guimaraes, de Carvalho, & Maia, 2013).

There are several success stories of the strategic changes achieved through Lean initiatives in both the private and the public sector with effects, such as reduced lead time, improved work routines, teamwork, empowerment, quality improvements, and lower costs (Womack & Jones, 1996). From a perspective of manufacturing, Lean thinking is an important strategy to achieve competitiveness through the identification and elimination of wasteful procedures (Su, Soar, Shen, & Al-Hakim, 2014). Lean principles significantly help in the establishment of a more controlled environment from which to improve by standardizing processes and introducing methods of work that manage the effects of variation in demand (Westwood, James-Moore, & Cook, 2006). Lean supply chain and green supply chain strategies help firms maximize the improvement of Lean production in a global supply chain system (Kasemsap, 2016b).

Overview of Value Stream Mapping

Value stream mapping (VSM) technique can be used in identifying wastes in the process for elimination so as to improve overall efficiency and throughput (Gonzalez, Lau, & Wickramasinghe, 2014). VSM is an important tool of the Lean approach (Vinodh, Arvind, & Somanaathan, 2010). VSM is a structured diagram, originated by Toyota which includes steps that are major activities (e.g., resources, people, information, and material flow) graphically mapped in the explicit manner (Singh, Garg, Sharma, & Grewal, 2010). VSM is used to identify and track all types of waste and process flow integration (Forno, Pereira, Forcellini, & Kipper, 2014) to increase process efficiency by reorganizing and redesigning the system (Lasa, Laburu, & de Castro Vila, 2008). In Lean methodology, patient pathway is considered as

a value stream. Health care executives should utilize the Lean-related systematic perspective to organize health care processes and then identify problems and opportunities for the improvement through VSM (Simon & Canacari, 2012).

Applications of Lean Production in Global Health Care

Due to rising costs, the health care sector is forced to work more efficiently and to better utilize their resources (Adan, Lefeber, Timmermans, van de Waarsenburg, & Wolleswinkel-Schriek, 2014). Lean thinking has led to the considerable improvement in a wide variety of health care settings (van Leijen-Zeelenberg et al., 2016) and has been criticized for intensifying work and impairing the health and well-being of employees (Hasle, 2014). Adopting Lean requires a complete and radical change in organizational culture and leadership (White, Wells, & Butterworth, 2013). Culture change for Lean is a long-term project (Patterson, 2009). Lean is the first step toward a cultural change (Grunden, 2009). The most crucial element of Lean is developing the cultural change required to support a continuous improvement mindset (Roberts & Singh, 2009).

The health care-related resources of clinicians, laboratory staff, and Lean processes have resulted in the obvious examples of how automation and clinical decision support system play a major role in improving health care systems (Nallas & Moon, 2016). Lean thinking ideas (e.g., patient focus, continuous improvement, and employee empowerment) appeal to health care practitioners and are consistent with the existing health care values (Spear, 2005). Lean tools are applicable to an endless variety of processes in health care, addressing critical challenges, such as medical errors, escalating costs, and staffing shortages (Jimmerson, Weber, & Sobek, 2005). Through Lean production, the health care processes have become faster and more efficient with a notable reduction in costs mainly due to less waste and storage of the expensive drug (Chiarini, 2012).

Lean efforts should be carefully adapted to the complexity of the health care process and to the educational commitment of health care organizations (Mazzocato et al., 2014). Promoting the culture of continuous process improvement ensures that initial results are executed in modern health care (Murrell, Offerman, & Kauffman, 2011). The Lean thinking performance improvement model has enabled top leaders and employees at all levels of the health care organizations to work together to improve quality and processes for the benefit of patients and shareholders (Wong & Price, 2012). de Souza (2009) suggested that Lean thinking concepts make Lean thinking more applicable to the health care organizations than other process improvement methods. The application of Lean principles to the nursing processes is successful in improving specific outcomes (Brackett, Comer, & Whichello, 2013).

Taking effective and swift actions to reach the patients and the health care organizations in time may help reduce serious problems, and consequently improve the chances of patient treatment and/or survival that are of primary concern of the physicians (Akaichi & Mhadhbi, 2016). Lean methodology is effective in resolving the inefficiencies of emergency department (Institute for Healthcare Improvement, 2005). The majority of Lean applications focus on strengthening process capability, often in emergency department (Holden, 2011). This typically begins by defining value from the patient perspective, such as the timeliness of care (Mazzocato et al., 2014). The critical nature of health care operations entails that the excess capacity is effectively stored in the health care system to provide the necessary flexibility of response in order to reduce the patients' waiting times that they experience (Chadha & Singh, 1998).

Henzler et al. (2014) indicated that waiting times play an important role in emergency department. Waiting times and waste strongly affect the quality perception of health care service (Huang, Li, Wilck,

& Berg, 2012). In order to achieve a smooth flow of health care operations, multiple changes to the workflow and the physical layout are often implemented in combination (Mazzocato, Savage, Brommels, Aronsson, & Thor, 2010). Regarding VSM in health care operations, streaming has been based on the likelihood that patients will be admitted or discharged (Kelly, Bryant, Cox, & Jolley, 2007), and on their need for effective diagnostics or care (Walley, 2003). All the steps in health care operations that add value to the patient are seamlessly linked together in the VSM.

From decreased patient's waiting times to the improved patient's throughput in emergency department to more efficient bedside rounding practices, Lean has improved the quality of health care delivery in institutions that teach its ideals and goals (Houchens & Kim, 2014). Reducing waste in health facilities can generate the substantial cost savings in modern health care (Improta et al., 2015). In the hospital-based emergency department, the unexpected patient arrival, a frantic working environment, and poor communication with other health care-related departments are the reasons that contribute to poor medical outcomes, unhappy patients, and increased cost from waste and rework (Poole & Mazur, 2010).

Implementation of Lean Production in Global Health Care

Perception and satisfaction of patients with health care services are considered as the important parameters to evaluate the quality and competence of health care providers and the outcomes of their health care services in patients' health and in modern society (Dias-Souza, 2016). The primary reason for implementing Lean in health care is the increasing demands on health care services to provide care with high efficiency and quality (Joosten, Bongers, & Janssen, 2009). Since early 2000, Lean has become the important approach to health care improvement most commonly reported in the literature (Walshe, 2009). Both Great Britain's National Health Service (NHS) and the Joint Commission Institute in the United States have promoted the utilization of Lean thinking as a significant strategy to help health care organizations provide more value to their patients, while at the same time using less resources (Mazzocato et al., 2014).

Health care is delivered by practitioners in medicine, chiropractic, dentistry, nursing, pharmacy, allied health, and other health care providers (Nemutanzhela & Iyamu, 2016). Before embarking upon Lean projects, hospital leaderships should explore the adequacy and entireness of their information systems, decision-taking structures, and inter-unit coordination mechanisms in modern health care (Kinder & Burgoyne, 2013). The utilization of Lean methodology has increased teamwork, created user-friendly work processes, changed management styles and expectations, increased staff empowerment and involvement, and streamlined the supply chain within the health care systems (Kimsey, 2010).

Similar to other industries, the nature of health care industry has changed over time, from a relatively stable conservative industry to a dynamic one (Shaanika, 2016). Lean production implementation dimensions are important to the manufacturing organizations trying to realize manufacturing excellence for competing in the highly dynamic global marketplace (Kasemsap, 2014). The major health care Lean implementation success factor is staff confidence. Lean production is often considered as an automotive manufacturing notion that resists the knowledge transfer to the health care sector (Fillingham, 2007). Hospitals that have adopted Lean management practices report the reduced lengths of stay and shorter wait times for appointments and surgeries (Toussaint & Berry, 2013).

Two Lean implementation steps significantly include training staff and performing pilot projects (Dickson, Singh, Cheung, Wyatt, & Nugent, 2008). Aherne (2007) emphasized training and staff empowerment to establish the Lean-related improvement process ownership. Jimmerson et al. (2005)

exhibited a bottom-up Lean implementation process, including piloting and staff training, recognized as the important success criteria. Frequently mentioned challenges include staff-competencies, customer concepts, and hierarchical structure with physicians as the basic decision makers (Radnor, Holweg, & Waring, 2012). Joosten et al. (2009) showed the weak evidence for supporting the Lean implementation and the inadequacy of before-and-after studies exploring the Lean outcomes.

Lean in health care is primarily implemented as a process improvement approach (Poksinska, 2010) and tends to focus only on tools and techniques that often fail to align the improvements with culture and strategy (Radnor et al., 2012). Simple processes regarding Lean implementation lead to less mistakes, higher quality, and improved financial performance (Pedersen & Huniche, 2011). Lean implementation is often focused on process improvement that it loses its perspective on people (Dahlgaard & Dahlgaard-Park, 2006). Balle and Regnier (2007) emphasized that the essence of Lean health care is developing a culture in which the health care staff is empowered and encouraged to make improvements. The health care staff should focus not only on taking care of patients, but also on finding the improved ways to take better care of patients (Spear, 2005).

To reach success in Lean implementation, health care organizations need to select, adapt, apply, and evaluate their selected approaches to the local context (Waring & Bishop, 2010), and ensure that key personnel (e.g., physicians and nurses) have adequate recourses (e.g., financial, information technology, and training) and the long-term health care approach (Hayward, 2012). In health care organizations, the human factor plays the most important role as a determinant not only of health care performance, but also of change processes (Guimaraes & de Carvalho, 2013). Lean implementation in the health care industry is about developing a Lean culture that leads to the involvement of everyone (Dahlgaard, Pettersen, & Dahlgaard-Park, 2011) and requires the development of leaders and its importance (Ljungblom, 2014). The high quality of leadership is necessary to get through the change regarding Lean implementation in modern health care (Kimsey, 2010). In health care settings, Lean leadership (Mann, 2009), which takes into account the politics associated with health care quality improvement (Langley & Denis, 2011), has changed the focus of managerial work from managing operations to managing people (Poksinska, Swartling, & Drotz, 2013).

The major barriers to Lean implementation in modern health care are the staff's disbelief that Lean can be applied in health care settings despite its origin in the automobile industry (Fillingham, 2007) and the lack of educators and consultants who have knowledge and experience of both work organization and culture of health care and principles, methods, and tools regarding Lean production (Dickson et al., 2008). Providing the hospital-based laboratory staff with the training to see the wastes, and arranging executive's support to make the significant changes, can produce the benefits for patients, clinicians, and hospital managers (Hayes, Reed, Fitzgerald, & Watt, 2014).

In the health care organizations, the inadequate facility layout negatively affects the health care performance of the service staff, the quality of care provision, and the service temporally over time (Soriano-Meier, Forrester, Markose, & Garza-Reyes, 2011). Quality of care from the patient's perspective and patient satisfaction are two major multidimensional concepts that are interchangeably utilized in modern health care (Xesfingi & Vozikis, 2016). Another barrier for implementation of Lean in health care is to reconstruct the massive impact of historical top-down change approaches into Lean's bottom-up improvement methodology (Hayward, 2012) or to find a combination of the two. Health care organizations are strictly hierarchical, while Lean requires teamwork building, collaboration, and open communication (Poksinska, 2010).

Challenges and Implications of Lean Production in Global Health Care

Health care systems in the developed world have been under increasing pressure from the state to control costs and improve quality since at least the 1970s (Timmons, Coffey, & Vezyridis, 2014). Although many global health programs focus on providing clinical care or medical education, improving clinical operations can have a significant effect on patient care delivery, especially in developing health systems without high-level operations management (Carter et al., 2012). Hospitals can make substantial progress toward high reliability by managing several specific organizational change initiatives (Chassin & Loeb, 2013).

Over the years, health care organizations have improved their processes, services, and outcomes (Moghimi & Wickramasinghe, 2014). Maximizing health care value to patients must be at the essence of process improvement strategy (Grove, Meredith, MacIntyre, Angelis, & Neailey, 2010). Health care organizations face the increasing pressure to improve their operations and to provide the evidence of the quality and efficiency of their organizations (Kujala, Lillrank, Kronstrom, & Peltokorpi, 2006). This means that health care executives who have focused on the quality of care are forced to review their overall management practices for the sake of effectiveness (Hellstrom, Lifvergren, & Quist, 2009). Weiner et al. (2006) indicated that involving hospital staff in quality improvement has a positive impact on clinical performance.

The translation of health care quality into meaningful and actionable strategies requires the utilization of a holistic, rigorous, and well-organized approach to quality improvement (Pate, 2012). Regarding Lean principles, health care organizations can benefit from cost reduction and increased care quality through applying Lean techniques toward reducing turnaround time in critical health services (McIntosh, Sheppy, & Cohen, 2014). However, applying Lean principles to health care has limitations. The basic difficulty is that the large health care providers are the different organizations with complex demand and resource issues, enhanced by technological developments and human perceptions. While service timeliness is relatively easily accepted in manufacturing settings, delivery in the health sector is not always linear, but is dependent on the complex supply factors. Timely service is affected by culture, expectations, and perceptions that differ regionally and internationally (McIntosh et al., 2014).

Lean implementation requires the leadership team to play a significant role in changing the hierarchical culture regarding the extent of exhibiting support for, commitment to, and a demonstrated understanding of Lean principles in health care settings (Radnor et al., 2012). Top management of health care organizations should be ready to demonstrate their support for the Lean projects whenever Lean issues arise (Carpenter, 2011). Al-Balushi et al. (2014) stated that leadership's ability to enable the availability of health care resources to ensure the progress of Lean initiatives effectively reinforces its position in health care settings. Flexibility and individual initiative cannot be attributed to health care perspective's hierarchy without the visible and sustained support of the senior executive (Ben-Tovim et al., 2007).

The flow of patients through a hospital is essential to manage the capacity and cope with the variation in the number of admissions and discharges (Castle & Harvey, 2009). An understanding of patient needs and preferences is crucial in providing helpful information regarding hospital quality (Simon & Wickramasinghe, 2014). Patient satisfaction and quality care are the significant indicators for the success of health care enterprises (Chadha, Singh, & Kalra, 2012). Patient satisfaction is commonly measured by reduced lengths of stays and prevention of readmission (Naidu, 2009). To sustain growth and competency, it is necessary for a hospital to focus its attention on quality and efficiency of its services in a continuous manner (Buhaug, 2002).

Many researchers have studied the cases of process redesign in the health care-related supply chains (Huarng, 1998). The challenge of designing, integrating, and implementing the flexible and cost-effective health care systems is to apply the interdisciplinary system approach, where the health care processes and flow of patients are in focus (Aronsson, Abrahamsson, & Spens, 2011). Alt (1997) indicated that the increase in health care cost and inefficiencies are due to the inadequate purchasing procedures and purchasing information systems. Ford and Scanlong (2007) discussed the utilization and evolution of supply chain management (SCM) principles in health care and identified the particular elements of the supply chain practically targeted through the purchaser's initiatives.

FUTURE RESEARCH DIRECTIONS

The classification of the extensive literature in the domains of Lean production will provide the potential opportunities for future research. Lean production in modern health care emphasizes the use of space, time, staff, equipment, and materials to enhance the flow of any patient's visit from start to finish. The key for the health care organization is to be prepared with a Lean infrastructure that meets the internal and external challenges that are the daily occurrences in health care settings. In order to facilitate quality performance and achieve the effectiveness of the whole quality management system, researchers and managers should develop and maintain their organization's TQM practices related to quality performance in organization (Kasemsap, 2015a). The driving force of higher standards and higher levels of expectation in TQM practices should compel executives and managers to do their best to improve quality (Kasemsap, 2015b). The relationship between Lean production and TQM toward increasing the quality of care in the health care industry will be the useful topic for future research direction.

CONCLUSION

This chapter highlighted the overview of Lean production; the overview of VSM; the applications of Lean production in global health care; the implementation of Lean production in global health care; and the challenges and implications of Lean production in global health care. Lean production can be used to identify and eliminate the wastes in any health care activity performed within a health care facility. Lean methodologies involve not only a focus on operational aspects of health care processes, but also consideration for human and cultural factors as well. Lean production can be applied to hospitals and health care organizations to redesign health care processes toward improving the quality of care and reducing costs and wastes.

Successful Lean health care efforts result in the measurable improvements in patient outcomes, such as improved quality, less harm due to preventable errors, better access, shorter waiting times, and better service. Through Lean production in health care, the patient benefits come from a joint focus on improving the work life for health care providers and hospital staff, improving processes to prevent systemic errors, reducing stress levels, and reducing waste so that hospital personnel can spend more time on and focus more on patient care. The health care organization benefits in a long-term perspective due to reduced capital costs and ongoing expenditures, growth opportunities created by freed-up capacity, and an improved reputation that results from better quality and service.

Adopting a Lean process gets to the essence of the matter by improving flow of each patient's experience and operating an efficient health care organization. To implement Lean principles in health care organizations, health care leaders must first work to create an organizational culture that is approachable to Lean production. The commitment to Lean principles in health care must start at the management team of the organization, and all health care staff should be involved in helping to redesign processes to improve flow and reduce wastes toward promoting the Lean culture in modern health care. Implementing Lean production has the potential to enhance health care performance and gain sustainable competitive advantage in global health care.

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KEY TERMS AND DEFINITIONS

Continuous Improvement: The unbroken flow of improvement practically realized under a scheme, such as Kaizan and Lean production.

Health Care: The act of taking the preventative or necessary medical procedures to improve a person's well-being.

Just-In-Time: A strategy that exposes waste, makes continuous improvement a reality, and relies on total employee involvement.

Lead Time: The amount of time, defined by the supplier, that is required to meet a customer request or demand.

Lean Production: The perspective focused on eliminating all wastes in manufacturing processes.

Method: An established and systematic process of achieving certain results with accuracy and efficiency, usually in an ordered sequence of fixed steps.

Process Improvement: The systematic approach to the closing of system performance gaps through streamlining and cycle time reduction, and identification and elimination of causes of unreliable quality, process variation, and non-valued-adding activities.

Value Stream Mapping: A method to keep track of products and material as they move through the product-creating process that helps a business enhance productivity and reduce wastes.

Chapter 9
The First Step in Attainment Way Toward Excellence Quality and Productivity in Organization:
Case Study on Hasheminejad Hospital

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ABSTRACT

New words are generated in quality & productivity every year. Some words point to basis & the words have an advertisement aspect for management consultant firms. Apart from these words, considering that the most important goal of any organization is obtaining (acquisition) high possible productivity or optimum productivity. We should have comprehensive & adequate acquaintance of organizational culture & present situation for making a choice of the best way of increasing productivity. We can say the way of increasing productivity is different in each organization considering important difference in organizational culture & present situation. In this chapter we explore productivity topic (subject) & practical mechanism for productivity establishment & ways of increasing productivity, then we survey established EFQM model (TQM) on Hasheminejad Hospital (Tehran, Iran) as a case study. Ultimately the first place (step) in attainment way toward excellence quality & productivity organization is presented based on output of questionnaire by utilization MADM methods.

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1. INTRODUCTION

Complexities of modern organizations are somewhat difficult to describe. The changes in the environment bring uncertainty and hence demand the organizations to have new capabilities and plans. Utilizing the dynamic changes in the environment, management has a unique position nowadays and to deal with the environmental and non-environmental challenges, it seeks novel approaches. One of the major fundamental changes in the Management is the change in the attitude toward the organization (Wendell, 1995). Until a few decades ago, it was thought that organizations have been intellectual tools for the coordination and control of people to achieve their goals which are hierarchical and they are all based on the relations of power. But nowadays our managers pay attention to the satisfaction of their employees. Customers point to the fact that it is a big movement towards building a culture of quality within organizations (Shimon & Randall, 1987). Creating the culture of quality is the result of the informed choice of an appropriate management philosophy in the organization. Just the choice that is based on belief and knowledge can release the energy for the orientation of the new organizations.

Any organization's survival and doom relies on the extent to which it can produce wealth (added value), that is, its "outcome value" exceeds its "consumed resource value" (Abtahi & Kazemi, 1996). Boosting productivity enables organizations and institutions to extend their international competition and growth, and improve their own cooperation. A low productivity shows that the organization is wasting its resources, and this will eventually result in loss of its international competition and thus reduction of its mercantile activities (Rena, 1997). Robins believes that a productive organization is one that achieves its objectives as soon as possible and with the least cost (Appelbaum et al., 2005).

The more productive an industry is, the better its competitive status is; since it will have less cost. When productivity increases, businesses can pay higher wages without causing inflation. Productivity is a way of bettering the standards of life. Simply, productivity improvement means achieving more output than input, which does not mean enhancing production via increasing such resources as time, money, materials or individuals, but it means doing better with what we have. Improving productivity does not mean working harder, but means working more subtly and cleverly.

Manpower, as the clever possessions of organizations, is considered to be the biggest capital of any organization. Organizations view manpower as a competitive edge on the basis of their knowledge, capability and qualification (Abel & Movaffaghi, 2007). Therefore, managers are supposed to recognize, motivate, and optimize the hidden big power of their organizations' human talents.

On the other hand, in the world economy, most companies are not able to compensate the increase in the costs of materials, staff and other production resources merely through augmenting the products' prices.

Recognizing the related factors to productivity and their impact amount is essential to achievement of productivity improvement mechanisms. As Lema (1995) stated, it is necessary to study the factors affecting productivity (all the factors with positive or negative effects), as it is possible to recognize and make use of the positive factors and leave out the negative ones, and thus pave the way for an increase in productivity (Ema, 1955).

In recent decades, quickness of growth & development in Iranian industry has shown, Iran is a country in transition from a semi-industry economy to an industry economy. Attention to productivity in production can conduct it in a proper path mean while increase rapidity of industry development. For this reason, it seems essential for each organization acquaint to concepts of productivity & the ways for

increasing it, therefore we can say volume of organization development particularly in industries is depend on optimum & desirable utilization of facilities & resources for production or presenting services. Thus productivity & its increasing continuously in organizations have specific considering & for development industries we should consider it seriously. Surveying in different organizations indicates attention to productivity & its increasing but in different forms. It is obvious that different solutions & proportional to present situation, is setting as foundation of productivity improvement & organizational excellence attainment, in accordance with organizations situation & management policies. Identification activities with lack of value added & eliminate all of them & increasing the value added of the another activities from procurement to production & ultimately sale in industry domain from the commencement to the end of presenting services process is the final target for all productivity & quality promotion systems such as: Just in time production, Zero defect production, Net production, presenting optimum services & …., however some organizations has lost main tools for attaining to this target.

The productivity topic (subject) of governmental organizations & their improvement is always an important challenge for researchers in governmental management & executive managers. They always have explored ways for improving productivity indicators in organizations & have presented some suggestions in this topic & whether due to scientific studies or thereby empirical trials some factors have identified however we can observe such a debility in empirical & knowledge of the commencement manner & the first place to proceed into this way, for this reason we try to present the first place (step) of this way to managers in accordance with gathered information more over indicating main concepts & productivity increasing mechanism.

2. REVIEW OF THE HISTORY OF PRODUCTIVITY

Since the end of the fifteenth century until the beginning of the Industrial Revolution in the mid-eighteenth century, a period of 250 years, Western scholars thought were engaged with Creating a government in Western Europe and involvement in industry and agriculture, and have been shown In most scientific, political, economic and social theories. With the growth of the capitalist class and the emergence of new economic schools such as Mrtytnyzm that believed unlimited competition at the national level is necessary and useful, Authority of the feudal lords, nobles, barons and monopolists began to reduce and support of commercial organizations in the international competition in global markets for products, was considered as a national duty and governments were actually entered the scene of manufacturing states.

In 1644, English economist Thomas Mann wrote a book to explain the “theory of support”. Then, James Stewart and Jean Baptiste Klbr Louis XIV’s finance minister, supporting this theory provide basis for the unity of the trade and collectors of gold and silver, the expansion of national government, the unification of markets, expansion of export policies, and actually opened the government in use of human and natural resources.

Political thinkers, William Petit and Dudley North, since 1641 to 1691 establish the foreign competition theory and have a large impact in governments with creation new organizations in the field of foreign trade, customs, and port organizations. Champions of the Industrial Revolution and the productivity movement began to try to entrance to international market and gain a larger share in it, relying on the quality of goods. Abraham Darby, the creator of the ability of national industries, Jymz·hard Graves, industrial chemistry theorist, James Watt, inventor of the diesel, Arg Richard Wright, inventor of the spinning and weaving machines (1732- 1792) popularized the use of technology in the industry.

Activities in terms of efficiency, Natural resource exploitation and domination over nature, that have done parallel to the molten iron. The use of the steam engine, the spinning and weaving with change in the ownership of mines and production tools and creating a strata managers and entrepreneurs in the stage production, cause of growth of imports and exports, freedom of industry and the maturing of the classical school of economics.

By writing the book "Wealth of Nations" by Adam Smith (1790- 1723) Scottish thoughtful, valve of Productivity knowledge was opened to the world. This economic movement should be considered as point of departure, because moving to take advantage of the resources of the National began with it and then governments, found the effect of quality of the goods to appearing in global markets through it. Smith knew productivity as a cause to crating new values to a phenomenon. With the advent of the industrial revolution, economic growth was seen as the result of productivity and nowadays productivity has become a national priority that its growth considered as a solution maintains the standard state of living. Hence, nowadays productivity is interested by politicians, businesspersons, industrialists, employers, managers and even ordinary people and even housewives.

In today's world, productivity is almost synonymous with progress. The standard of living in a community is depending on some degree in providing at least of community needs. In other words, the quantity and quality of food, clothing, housing, education and social security, will determine the standard of living. To improve the living standard, it should be generated more food, clothing, housing and so on. Increase the amount of goods and services can be achieved through increased labor and capital, or be as efficient use of available resources.

Measurement is the essential component and as some people said, it is the starting point of the scientific process of productivity management. If we want to show productivity in the corporate culture, an essential condition for it is the existence of tools to control and monitor progress, provide feedback, set measurable goals, and evaluate performance of management. In other words, Efficiency measurement means providing information that creates possibility of evaluate moving towards the goal from the point of departure and the previous condition and help the organizations in the proper communication of productivity with its strategic goals, assists. For example, improving productivity can be primary tool to achieve organization stock increasing in stock market.

Productivity measure, apart from its strategic interests, also has other relays functions for the organization. Continued economic activities of organizations without the knowledge of the present situation, despite the huge spending to improve productivity, is not impossible but it is difficult and it always will be grappling with crisis's such as waste, increases in reworks and lower quality products. One way to getting out of this dilemma is the productivity cycle. Activities that occur on productivity should be methodical meaning that followed by a special program and clear concepts that this can be called the productivity cycle. Productivity cycle is a process that productivity measuring and programs in any organization is based on it.

A productivity cycle consists of four followed stages, which acts as a closed cycle. Productivity measurement, evaluation, and analysis of indicators, programming of productivity and productivity improve (doing improvement activities). With proper implementation of the productivity cycle always we can control current status of the organization and try to improve it. For productivity improvement planning should know where we are now in terms of productivity levels and where we want to go and what strategies are best suited to reach the destination.

3. TOTAL QUALITY MANAGEMENT

The emergence of total quality management is one of the most important aspects of management performance. Total quality management is based on the assumption that people make efforts and want to show the highest level of effort and trial in doing their tasks. The main idea of total quality management is to create the context for continuous improvement and efficiency. The concept of improvement in total quality management involves the phenomenon in which every person in the organization has to continuously seek the ways to improve quality in the working process, the system and the product (Bowls, 1985). The principles of total quality management were first proposed in 1950 by Deming in Japan. The basis for total quality management has been mainly contributed by Deming and Juran (Kohler & Pankovski, 1996). Using their ideas and due to the development of the foundations of TQM, the set of proposed principles for implementing TQM has been formed. Sometimes, it is assumed that the principles of total quality management which have been proposed by Edward Deming only function in large and for-profit organizations. However, the fact is that total quality management can be implemented and applied in any organization including universities, educational institutes, and service organizations and so on. In previous decades, this philosophy was considered as a key factor in reaching business success, growth and creating a competitive edge (Kensi & Dun, 2011). Total quality management is an alternative for some management concepts such as goal-based management, participatory management, quality cycles, added value and appraisal (Stingraber, 1995).

Total quality management started in the U.S. around 1980 as a response to the competitive challenges of Japanese firms. The appreciation of total quality management as a competitive edge was rapidly increasing around the world, especially in western countries and nowadays there are only a few companies which have neglected the term total quality management (Dian & Boon, 1994, p3). Bemozeski (1992) argues that total quality management is based on the participation of all the members of the organization in improving processes, products, services and workspace culture (Bemozeski, 1992). Kinak (2003) defines total quality management as a holistic philosophy of management in which it is tried to reach continuous improvement of the organization (Kinak, 2003).

3.1 Aspects of Total Quality Management

The foundations of total quality management can be considered as fulfilling the expectations of customers, the continuous improvement of processes, comprehensive participation of the staff and delegating power to the staff as well as gathering and analyzing data (Hubert & Rampersad, 2001). According to Kinak (2003), total quality management is a holistic management philosophy which tries to reach continuous improvement in all of the tasks of the organization (Kinak, 2003). There have been different aspects considered for total quality management including the support of the senior management, customer relation, supplier relation, human resource management, the features and characteristics of the employees, the process of designing a product, managing the manufacturing process and the quality guarantee unit. The senior management plays the most prominent role in implementing and running total quality management in a way that the support and commitment of the senior management is one of the main characteristics of the successful implementation of total quality management, which will be discussed later (Wankhade, Lalit, Dabade & Balaji, 2010). The support of the senior management deals with the fact that the senior management should apply a thinking pattern which distinguishes structures, systems, methods and staff. For senior management, structures should include process management,

quality planning, quality guarantee, quality improvement and integrating these with appropriate skills (Deterzginzi, 2008). Customer relation: in total quality management, customer is the most important factor in directing the activities and functions for improving the quality. Based on the principles of quality leadership, the organization should always try to over deliver the needs of the customer to be able to provide desirable value for the customers (Hubert & Rampersad, 2001).

- **Supplier Relation:** From the point of view of operations process, total quality management considers suppliers as an important part of the total manufacturing process and believes that much like customers, material suppliers should directly involve in the organizational process and participate in it. the access of suppliers to the needs of the company and coordinating their systems with the manufacturing system of the company is one of the significant objectives of each total quality management program (Hubert & Rampersad, 2001). Human resource management: from the point of view of human resource management, the most prominent resources of the organization are the workforce. Management should create an environment where excellency-orientation and stable and reliable working relations are improved (Hubert & Rampersad, 2001).
- **Characteristics and Behavior of the Staff:** Characteristics and the behavior of the staff is the key factor in the success of total quality management. The reason behind the failure of many quality programs is the management neglecting this important issue and its inability to change the behavior of the employees towards total quality management programs. Companies should behave in a way that positive working characteristics such as loyalty to the organization, being proud of working, focusing on the goals of the organization and ability to accurately perform the tasks, improve significantly (Hubert & Rampersad, 2001). Product designing process: all the departments of the company should participate in the designing process so that the design can be prepared based on the needs of the customers by considering the technical, technological and cost limitations.
- **Management of Manufacturing Process:** The manufacturing process involves a series of activities, methods, machinery and tools for realizing the desirable quality (Hubert & Rampersad, 2001). Accordingly, organization should be carried out based on 5S principles, the internal auditing should be based on related directives and the manufacturing process should be statistically controlled (Wankhade, Lalit, Dabade and Balaji, 2010). Quality guarantee unit: the quality guarantee unit should have free access to the senior management and should have continuous communication with other units (Wankhade, Lalit, Dabade and Balaji, 2010).

4. THE PRACTICAL MECHANISMS OF PRODUCTIVITY ESTABLISHMENT

According to the article about the identification of the first step on the path of Organizational Excellence, at first by reviewing the literature and consulting with professionals and experts in the field of quality, Practical solutions for improvement and achieve operational excellence as programmable steps are identified and as the options for selecting the first step in the achievement of excellence in quality and productivity have been raised. 9-fold strategies are summarized in Table 1 (Further description is presented in Appendix)

The remarkable thing is that all items listed in the 9 previous paragraph (practical mechanism of productivity stabilization) without committed, compassionate, creative leadership and familiar with the principles of quality and efficiency excellence in the organization, do not implement, or if implemented,

Table 1. Evaluation of functional mechanisms of productivity establishment

Description	Strategy	Row
Underpinning the establishment of productivity improve management cycle is that employees in a manufacturing organization, think. Successful and productive organizations, in addition to the bureaucratic system, have taken special policies for using all of intellectual and practical capacities of their employees. Pioneer organizations in productivity have gradually achieved to appropriate mechanisms and leadership procedures and culturally fields to synergistic efforts and ideas of the scientific staff and Succeed to have more benefited from thoughts, innovations, and knowledge creation of organization and development of this employee's ideas. Effective management of scientist's labor need to strategies that result in qualitative and quantitative develop of learning, effective use of knowledge and the development of it in national and organizational level. If you manage on think and knowledge of workers, the productivity of the ideas will come. This vast Source of knowledge covers many of different types of organizational processes, best practices, customer trust, management information systems, culture and norms.	Creating such culture of excellence in the organization through institutionalization of productivity in the individual idea	1
Achieve continuous productivity by saving, will not reached with giving slogan but it needs to design appropriate structures. Usually savings through two mechanisms of structuring and encouraging is institutionalized in the organization. Savings Institutionalizing had been experienced in large industrial organizations through Various ways, such as establishing a good relationship between the good consuming and rewarding and written encouragement by employees who are saving star	Institutionalizing of savings in all of organization	2
To establishment of efficiency improve management cycle in making culture, it must be designed and implemented scientific and appropriate structures. It is often observed that there are many people in organizations who are volunteer to manufacturing productivity, But there is no proper structure to use of their thought, ability, talent and compassion in a reasonable figure. Accordingly, organizations should to think about design of productive structures that as an instance, establish a permanent improvement strategy and design a comprehensive repair and maintenance system can be mentioned.	Design of Productive Systems	3
A comparative assessment is one of the most effective ways to improve the organization. Nowadays, the management of any organization can find the best practices to continuously improve performance in his organization with emulate of successful organizations and implement them. Modeling not only can be a technique for detecting problems, but also can be so helpful in the design of process design. In fact, benchmarking is an answer to this question that when the need to improve diagnosed, performance standards should be set at what level? Detection performance of successful organizations And figure out how to do it, identify that how others can motivate change in the organization and minimize their mistakes, And identify gaps in performance between successful organizations with other organizations and reduce the gap between them, all can be seen from the results of modeling.	optimal modeling	4
A committed staff with doing things in proper time and having a feel of responsibility can be effective in increasing production and productivity. Managers with meet the basic needs of employees, establishing mutual trust between themselves and them, and create a culture free from blame, can make the employees committed to the organization. Until Psychological needs are not fulfilled, the employee never fully feels committed to the organization. Proper motivation of employees through granting financial rewards, delegating, creating a friendly environment and non-formal relations between staff, also cause to productivity increasing. There is a fair payment system that employees touch and feel it well, is one of the most important things in order to increase productivity. According to Adams' Equity theory that is a motivation process theory, people have compare their services (education, experience, diligence and loyalty) with what they received that it's most important and visible is the individual's salary, and then, by comparing their services and received with another person services and received, if conclude that justice is implemented in the organization, the motivation will be created.	Commitment, motivation and job satisfaction of employees	5
Experience has shown that an organization can be successful by relying on their employees. So The pioneer organizations are always having a special attention to continuous improve of the quality of work of their staff. And this behavioral pattern of managers reduces waste, improve product quality and increase productivity, which is the final result. With association of people in things and fair, the moral of variability increased and Change-oriented thinking style becomes a habit for all of staff. And with continuous review of all processes and systems through people's ideas, organizational development is facilitated and there was this ensure that in an emergency situation arises, the organization is able to manage the crisis. Through the creation of these factors, we can encourage employees in solving the problems of organization with using several tools such an offers system. Sense of staff to belonging and closeness to the organization And a sense of ownership of the organization can go as far as for example, Japanese workers often introduce themselves with their work organization. !	Cooperation and participation of workers	6

continued on following page

Table 1. Continued

Description	Strategy	Row
The starting point for any changes or improvements, a full understanding of the situation and find the problem that called as a complication. The organizational that in both field of performance and results will be proved to be perfect called excellent in definitions. Clearly, organizations that are far away from excellence and do not have the necessary infrastructure for it, cannot use the excellence models and at first it is necessary to carry organization's out fault finding process found the organization's diseases and then defining improvement projects, take the first step for their preparation consequence on the path to excellence. Organizational fault finding as a basic and useful tool for organizations that are think to excellence and trying to act in this way is very important. Certainly, fault finding is effective when done continuously and consistently. In general, any problems can be fault found, analyzed and diagnosed with the use of the question word "Why?" and it answer	Continuous fault finding (The issue)	7
"Continuous improvement" is the only solution to eliminate redundancy and having a productive and qualified system in manufacturing. This fact has shown clearly in Robinson and Schroeder explanations (2004, 173) on the implementation of the Toyota well-timed production: ‹‹The organization was forced to pay attention to details too common, By targeting the well-timed production And managers could not able to provide the solution of all big and small problems allonym, so the organization had to be helped with all off the production line workers, and finally a very active idea making created in Toyota. » Similarly, in the case of lean production, Bodek (2006) believes that "the most important challenge facing organizations become lean enterprise, creating the habit of continuous improvement in employees." Patel (2005) also believes in total Quality Management: << the "Total" word (Total) has a different means in Total Quality Management and its engaging everyone in the organization from the managing director to the lowest level employee.>>	Continuous Improvement	8
Leadership (in some conductivity texts) is one of the five main tasks of managers. Leadership is the art of influencing subordinates so that they voluntarily and willingly perform predetermined activities within the specific goals. Also in simply Leadership can be defined as the process by which the organization manager with creating motivate and communicate effectively seeks to encourage staff to perform organizational task willingly, and so facilitate achievement to organizational goals. However, experts believe that the leaders stood before the group and use the maximum of their abilities, to help the group to achieve the desired goals. Transcendental leadership, codify vision and mission and facilitate access to them. These have created values and systems required for sustainable success of organizations, and the with their proper operation and behavior, perform them and with executive commitment to the values, are the suitable models for their employees in this regard.	Determine and establish of committed leaders (leadership system)	9

their growth and development and effectiveness in the organization will be trimmed. Committed, dedicated, and creative Leaders will help staff to achieve both of the organization and of personal goals. They create Transparency needed in defining of organizational posts and positions and help the group setting goals. They also remove the ahead barriers to achieving the goals.

5. EXCELLENCE QUALITY AND PRODUCTIVITY IN ORGANIZATION MODEL SURVEYING, ON "SHAHID HASHEMINEJAD SPECIALIZED HOSPITAL" (RENAL & URETHRAL DISEASES REMEDIAL CENTER)

It doesn't seem logical selecting one step merely & propound it as a unique solution for commencing to traverse rout of organizational excellence considering extension of organizations about their commission, therefore any organization should survey & analyze corresponding to its commission. In this chapter we survey our topic on service organizations such as Hasheminejad Hospital. Hence forth, we depict (illustrate) organizational excellence model of hospital mentioned as well as its history:

Shahid Hasheminejad specialized hospital (Renal & Urethral Diseases Remedial Center) has devoted in 1957(1336) by the deceased Mr. Daryani. This hospital has activated as a renal & urethral diseases remedial center since 1985(1364). This hospital is an educational & remedial center under supervision medical training & remedy & hygiene & health ministry of Iran & more over had been a sub-organization of Iran Medical Sciences University. This center has settled as a sub-organization of Tehran Medical Sciences University so far, subsequent to merge Iran Medical Sciences University & Tehran Medical Sciences University. This hospital for the time being have multitude beds - for confining - & clinical & paraclinical segments, as well as it has lots of active infirmary & operating rooms for presenting supper-specialized services in some fields such as: Urology, Nephrology, Kidney graft open heart surgical operation, Vessels surgery…

Although before 2003(1382) when had not established EFQM model on this center, organizational challenges were to some extent comprehensive even this topic had discussed on social media because of clientele problem & disrupting or breaking off electrical power, at present this organization has acquired upper rank in recently evaluation among Iranian hospitals, so as this center has recognized (identified) as a Benchmark for Iranian hospitals & hygienic centers, by Iranian health ministry.

The event that has occurred in recently years in this hospital & has been an awesome evolution, commenced in 2003(1382) by self-evaluation & utilization EFQM model establishment. Ultimately this occurrence, compel Health Ministry to obligate all governmental hospital of country for utilizing EFQM model establishment & taking self-evaluation & promote their distinction to 10% on route of excellence. Whatever has occurred in Hasheminejad hospital, it has been continuous monitoring with feedback from outputs of self-evaluation & designing route plan corresponding to values & desires of model. Whatever has distinguished this center it has been leaders & staff of this organization has undertaken to promotion & progression that has obtained by EFQM establishment. Whatever has been pivotal core in this organization considering to Radar Logic & commencing from the end. Unless were produced an obligation for altering or from evaluated outcomes no event has occurred in this center in recently years. Unless its approach were determined transparently, no new activity would commence & unless were determined correlation between it on organizational strategy no approach would write in this organization. Targets & outlook of organization has determined transparently (obviously) for all of operation fields & all personnel & for obtaining strategic targets has determined each of their role & everybody knows, where should go & knows how should traverse by proper rapidity. For ensuring about stability of focus on customers in organization continuously & everybody from the leaders to low orders in organization has allied for undertaking to it. Such a worthy result, this organization has acquired so that customers' satisfaction index is measured widely all year long for accessibility to customer's pulse in the route of organizational excellence for taking care of desires & needs of customers (patients) in a proper manner. In Hasheminejad hospital, leadership is not a person rather, it is a process. Organization are not leaded by order & command rather are leaded by leadership system that are spreaded on trustee committee, leadership committee, main committees, secondary (subordinate) committees & work groups. In this organization who makes decisions & evaluates & processes them, is leadership system. In this center stability on targets exist until a tiny environmental alteration are occurred, however by monthly revisions despite fidelity of staff for attaining organizational targets, even on strategic targets level in accordance with environmental situation, targets are modified or a new target are replaced if necessary. Process of hospital corresponding to hospital specialized (expertism) international standards. Also all processes & organizational structure has been aligned to strategies & has been attempted gathering & analyzing scientific data be a unique determination for making decision.

Staff of hospital can present their opinions, ideas, innovations, thereby diverse & numerous channels & in this relation people involvement system enter staff into partnership in hospital administration as an established system by utilization of more than 27 committees & specialized work groups in brain ware form. Leaders & managers & experts of this hospital believe that main part of their prosperities indebted to aid & assistance of their key partnerships that have been included in value chain of hospital. Some Para clinical & even clinical segments administrate in private manner completely. Key partnerships companion in value chain such as: Tehran Medical Sciences University, Specialized contractors, specialized nursing faculties & Some International institutions. It is possible merely thereby have an effective approach undertaking & loyalty (fidelity) to excellence values of model are a settlement subject in this organization that everybody in this hospital undertakes to them. They believe that excellence always is a route without any imagined destination & therefore for this reason they believe that they have a long way for altering to an organization in universal class.

6. QUESTIONNAIRES SETTING UP METHOD AND THEIR ANALYSIS

According to the Excellence model described of Shahid Hashemi Nejad hospital and in order to find the first step on the road to excellence in quality and productivity management in the hospital, the action mechanisms of productivity establishment that described in terms of 9 ways in the article's beginning have been evaluated. There are different methods including questionnaires, interviews and observation, for information collecting in an area. In this chapter, due to the nature of work and the speed of the questionnaire method, this method was selected for data collecting. And for improving the process of obtaining information and increase reliability, Questionnaire was presented in person and with same and full description at the beginning of the questionnaire by the interviewer (semi-interview method).

The Questionnaire's questions were prepared in an open state at first (in order not to limit the reader's mind, and also confirming the productivity establishment of 9-fold). In addition, in order to possibility of quantity analysis of the questionnaire and according to relative familiarity derived from the results of the initial questionnaire, supplemental questionnaire was presented as a closed setting. It should be noted that the open and closed questionnaire reliability was evaluated by retest method. So that the closed questionnaire questions were prepared exactly Compliant with open questionnaire questions and according to earned results, this questionnaire reliability was qualitatively assessed. Since that one of the primary requirements of the questionnaire, is it's relevant and clear, after setting the initial version a survey was taken from 10 members of the audience in the fields of communication, clarity and simplicity of the questionnaire and they expressed their views on the relevance, clarity and simplicity of Questionnaire on a scale of four options are shown in Table 2.

Using the information provided in this article, and the information obtained from questionnaires and applying multiple criteria decision-making methods in the case study of Shahid Hashemi Nezhad Hospital, the results will be reported in the next section. Before explanation the results, a brief explanation of the multi-criteria decision making methods are presented.

Table 2. Validity questionnaire

Average	Simplicity	Clarity	Relevance	Audience
85%	80%	85%	90%	1
80%	75%	80%	85%	2
93%	90%	90%	100%	3
90%	90%	85%	95%	4
90%	85%	90%	95%	5
92%	90%	85%	100%	6
87%	85%	85%	90%	7
87%	85%	85%	90%	8
82%	80%	80%	85%	9
87%	90%	85%	85%	10
87%	Validity Questionnaire			

7. DETERMINATION OF DECISION METHOD, CRITERIA WEIGHTS, AND MULTI-CRITERIA MATRIX FORMATION

It should be noted that questionnaires distributed among 100 people, including four groups; hospital staff, nearby hospital, hospital clients (costumers) and senior managers that 90 questionnaires were Complete and returned. After an initial review of the completed questionnaire, five questions for reasons including a choice of several options, and no answer and etc. has been deleted, and finally, the information of 85 questionnaires were used as base of decision as follows:

In order to Utilization of ranks average combined method in decision (a method introduced in solving MADM), the score for each question in the questionnaire was collected at first. Due to the difference between each respondent group opinion a weight considered for each group of respondents that this weight is Retrieved from the weight ratio for capable makers and the equivalent results of the groups on the EFQM (Excellence Model has been implemented in the hospital) and the opinions of experts. Then the ranking between selections was performed and scores for each group were extracted. Full details are listed in Figure 1. Figure 1 points to a diagram of the proposed evaluation options and shows what percentage of the value of each option compared to other options, it has attracted.

By far the scores obtained by ABC chart options are shown in Figure 2. In Figure 2 options based on the rank obtained in the order shown, the option 9 (19%) had the highest score lowest score option 4 to 7% is obtained.

8. CONCLUDING REMARKS

In this chapter, we emphasize on requiring (under necessity of) an adequate identification of organizational culture and present situation in the case under consideration for selecting the optimum way for increasing productivity that is an important target in any organization, considering the propounded topics (subjects). We can say, the ways for increasing productivity are different, considering to organizational

Figure 1. Diagram of points obtained in the studied items

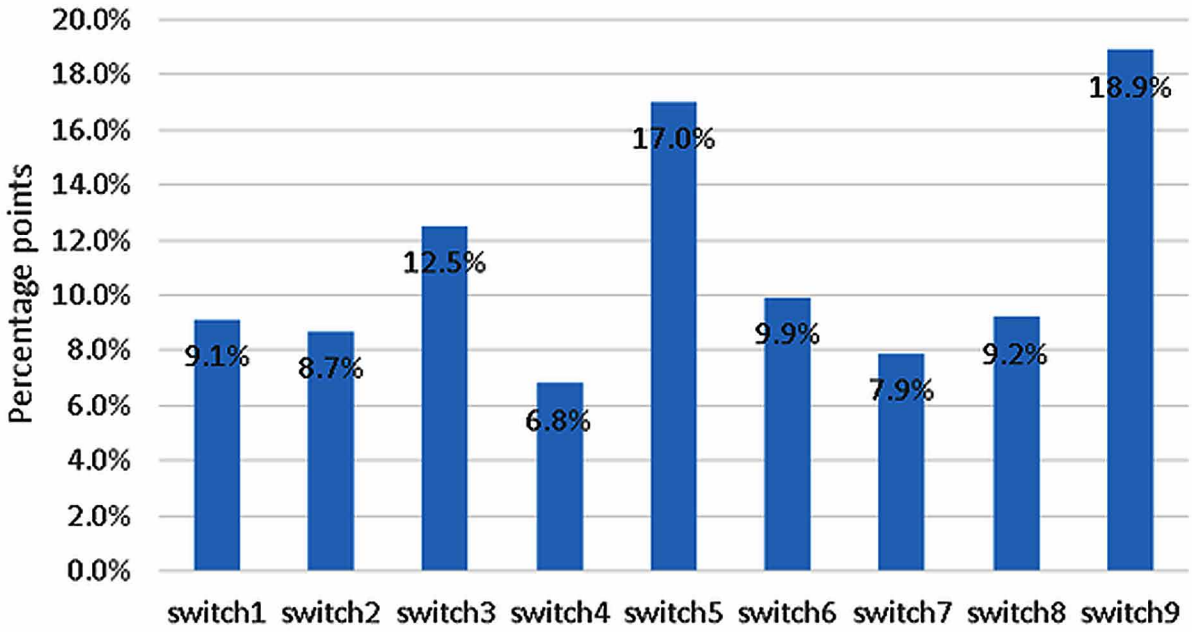
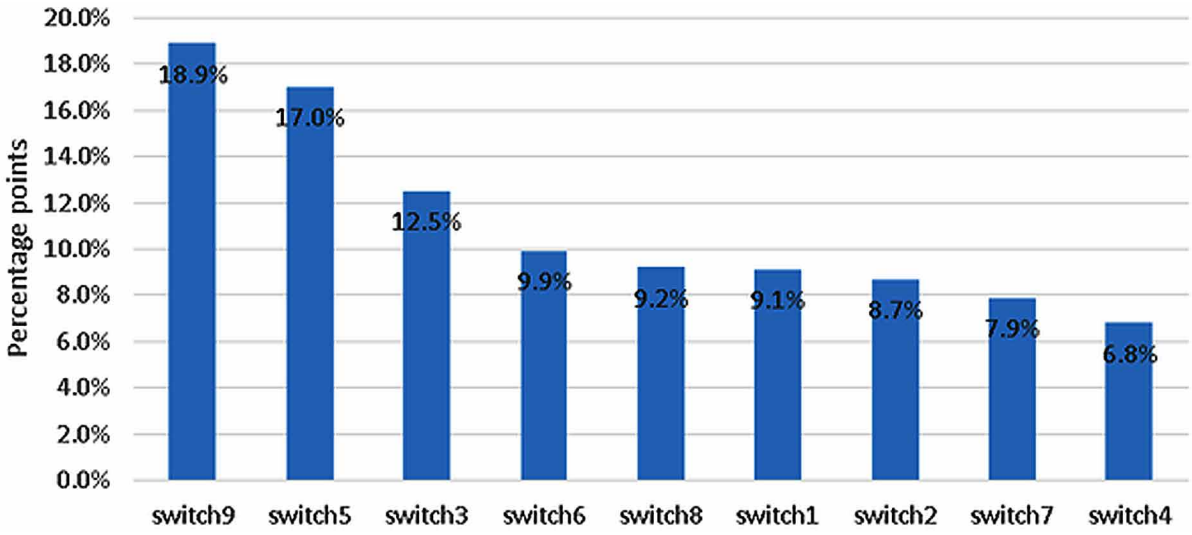


Figure 2. Diagram of points ABC obtained in the studied items



culture and present situation in the firms and they should traverse particular and proper excellence route for themselves. When you commence to traverse in this route and to increase productivity, encounter some reactions conclusively (because of obligation for alteration), that you can't attain your target, if there is lack of united undertaking (engagement). This united undertaking requires to a commencer in organization for being a paradigm to others (personnel), who is be able to set companion and involvement staff and the other proper patterns by establishing the excellence culture and undertaking and motivation in

organization. The senior manager and his/her undertaking to this subject would be commencer, considering to his/her affect and affection in organization, therefore in accordance with results of researching and analyzing question sheet information in this article we recommend, settlement and establishing of undertaken (engaged) leaders in organization or in the other hands, establishing an undertaken leadership system in organization as the first place in attainment way toward excellence quality and productivity in organization. Although considering to propositions that are mentioned in this chapter and because of variety in organizations commissions and attention to researching district of this article limited by service organizations that established in Tehran, particularly hospitals and hygienic centers, we can't generalize (propagate) acquired results in this chapter to the another organizations completely, thus, we recommend to research and surveying in the topic of attain to organizational excellence quality AND productivity and selecting the first place particularly for commencing to traverse in this route and also the manner of selecting the subsequent paces (steps) for the another organization that operates in different districts and fields, in the future, for eliminating bewilderment of some organizations in utilizing present tools for acquisition to this target for promoting our country, more and more.

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Section 3

Information Communication Technology Issues

Chapter 10
The Importance of Telemedicine in Global Health Care

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ABSTRACT

The chapter explains the challenges facing health care systems; the overview of telemedicine; the technological devices of telemedicine systems; telemedicine and chronic diseases; telemedicine and technology acceptance model (TAM); the applications of telemedicine in the oil and gas industry; and the importance of telemedicine in global health care. Telemedicine brings the health care value through its ability for the remote visits with patients, immediate access to health care professionals, real-time access to health data, and health monitoring capabilities. Telemedicine is an effective health care measure that can manage the new and affordable technology with the potential to deliver the convenient and effective care to patients, and provides an alternative way for the health care organizations to deliver the essential health outcomes. The chapter argues that applying telemedicine has the potential to increase health care performance and gain sustainable competitive advantage in global health care.

INTRODUCTION

Telemedicine services have been applied in public health care and private health care (Rho, Yoon, Kim, & Choi, 2015). Telemedicine serves as an alternative to traditional outpatient visits (Berkhof, van den Berg, Uil, & Kerstjens, 2015) and offers the potentially increasing benefits for improving both the accessibility and quality of health care (Le Goff-Pronost & Sicotte, 2010). Information and communication technology (ICT) is a significant component of the health care domain (Gajanayake, Sahama, & Iannella, 2014). Telemedicine includes the adoption of ICT (Doumbouya, Kamsu-Foguem, Kenfack, & Foguem, 2015) toward allowing patients to have the rapid health care-related evaluation, diagnosis, and treatment (Chanussot-Deprez & Contreras-Ruiz, 2008).

Telemedicine refers to a number of technologies, systems, and applications that can be adopted to provide the remote support of health care at home (Raffaeli, Spinsante, & Gambi, 2016). Telemedicine is a well-developed tool for medical practice whereby telecommunication is used to support health care

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delivery at a distance (Merrell, 2005) and can utilize the advanced telecommunication and information technology (IT) for the delivery of health care and the exchange of heath information across the globe (Kamsu-Foguem, Tiako, Fotso, & Foguem, 2015). The benefits of telemedicine are the accuracy, reliability, efficacy, and effectiveness (Demaerschalk, 2011). Patients can obtain information regardless of place or time and therefore receive telemedicine services at any place and any time (Park, Jung, Shin, Cho, & Lee, 2014).

Telemedicine introduces changes to the communication process between the doctor and patient that may affect health outcomes if not recognized and managed (LeRouge, Garfield, & Collins, 2012). Regarding telemedicine, robots, computers, telecommunication, and information networks are changing the aspects of health care systems (Satava, 2005). The perspectives of telemedicine-related digitization have the positive impacts on teleexpertise, where a medical professional can remotely ask the advices through the operation of ICT to provide treatment to a patient in critical conditions in the remote environment (Doumbouya et al., 2015). Telemedicine enables the essential synergy of technological improvements in the field of distant communication on the one hand, and the ongoing need to find cheaper but still effective ways to receive medical consultation for people living in rural areas, on the other hand (Idan, Wallach, Almagor, Waisman, & Linn, 2015).

This chapter aims to bridge the gap in the literature on the thorough literature consolidation of telemedicine. The extensive literature of telemedicine provides a contribution to practitioners and researchers by describing the multifaceted applications of telemedicine in order to maximize the health care impact of telemedicine in global health care.

BACKGROUND

Over the past two decades, the application of telemedicine as a way to provide medical services has grown as the patients seek more convenient ways to receive health care (Yang et al., 2015). There are rapid development in the field of medical imaging and telemedicine (Juliet, Rajsingh, & Ezra, 2015). The use of health information technology (health IT), such as telemedicine, is considered as a major contributing factor to health care service delivery (Karon, 2016) and has the potential to improve patient quality of care, reduce costs, and promote medical practices in modern health care (Pendergrass, Heart, Ranganathan, & Venkatakrishnan, 2014). Telemedicine has been used to address a wide range of health concerns in a wide variety of health care settings (Mackert & Whitten, 2007) and has proven useful in the delivery of health care in remote areas (Klotz, Muir, Cameron, & Delaney, 2005).

Telemedicine is the provision of patient care by telecommunication devices, including transfer of data for the formulation of the medical plan (Malasanos, 2006). Telemedicine allows collaborative activities between health professionals for the deployment of medical procedures remotely executed by means of using ICT (Doumbouya, Kamsu-Foguem, Kenfack, & Foguem, 2014). Patients become deeply in despair when telemedicine services stop without any alternative perspective to get medical care (Nakayasu & Sato, 2012). Advances in telecommunication technologies have created the new opportunities to provide the telemedicine as an adjunct to the medical management of patients (Anker, Koehler, & Abraham, 2011). With the advent of telemedicine, patients are likely to purchase more health care from foreign telemedical pharmacy clinics to avoid the costs and the hassle of travel (McLean & McLean, 2007).

Telemedicine facilitates the efficient provision of health care services (Doumbouya et al., 2015) and bridges the challenges often encountered across different service levels including the primary care, regional

and national care services, coordination between health care organizations, mobile medicine, medical and medical-social actors, promotion of virtual clustering, and new modalities for collaboration among health care organizations (Sene, Kamsu-Foguem, & Rumeau, 2015). Telemedicine holds the promise to affect the challenging problems of current health care system: access to care, cost-effective health care delivery, and distribution of limited providers. Telemedicine offers an innovative way to provide therapy at a distance (Nelson, Barnard, & Cain, 2006) and changes the current paradigm of care and allow for the improved health care access and increased health outcomes in the cost-effective manner.

Palaniappan et al. (2015) stated that telemedicine has two types (i.e., asynchronous and synchronous telemedicine). The asynchronous telemedicine is known as store and forward telemedicine. The synchronous telemedicine is known as the real-time telemedicine. In store and forward telemedicine, data is electronically collected and sent to the medical professionals for analysis and diagnosis (Palaniappan et al., 2015). Telemedicine networks can effectively improve the health care services in rural areas with requisite operational efficiency (Ishfaq & Raja, 2015). However, the deployment of telemedicine is faced with standards that are hard to use and application-specific data model that inhibit the adoption of telemedical solutions (Christensen, Hansen, Kyng, & Manikas, 2014). Individuals with less education and fewer computer skills, the aged, and the sick will experience the barriers to the telemedicine access (Newton, 2014).

IMPLICATIONS OF TELEMEDICINE IN GLOBAL HEALTH CARE

This section emphasizes the challenges facing health care systems; the overview of telemedicine; the technological devices of telemedicine systems; telemedicine and chronic diseases; telemedicine and TAM; the applications of telemedicine in the oil and gas industry; and the importance of telemedicine in global health care.

Challenges Facing Health Care Systems

Health care is characterized by the complex and interrelated processes (Lazakidou, Ilioudi, & Tsironi, 2012). The major challenges facing health care systems include the demographic change and the aging population; the increasing complexity of health care and technological developments; the high patient expectations and the growing pressure for accountability; and the greater than ever costs. All these challenges have influenced the quality and sustainability of health care services. The barriers to implementation of telemedicine tools include information overload, lack of mobile device usability among patients and clinicians, liability issues, and cost (Levine, Richardson, Granieri, & Reid, 2014).

Patient safety is a major component of quality in health care. Improving the safety of patient care requires system-wide action on a broad range of fronts to identify and manage actual and potential risks to patient safety, and implement long-term health care solutions. Telemedicine can improve health care outcomes. Patients diagnosed and treated earlier often have improved outcomes and less costly treatments, thus gaining patient safety. For example, the chronic nature of epilepsy requires consistent medical follow-up (Haddad, Grant, & Eswaran, 2015). Patients with epilepsy living in rural areas have limited availability of specialized neurology care (Haddad et al., 2015). Telemedicine can provide the effective medical service to patients in rural areas.

Telemedicine potentially holds the great promise in facilitating emergency medical practice (Amadi-Obi, Gilligan, Owens, & O'Donnell, 2014). Telemedicine reduces health care costs. Telemedicine-related home monitoring programs can reduce high-cost hospital visits. High-cost patient transfers for stroke and other emergencies are reduced through telemedicine applications. Telemedicine assists in addressing shortages and misdistribution of health care providers, toward reducing medical errors. Telemedicine specialists can serve more patients using telemedicine technologies. Nursing shortages can be addressed using telemedicine technologies.

Even though the health care services are intended to spread across the country, the services are not always available as patients require them (Hamunyela & Iyamu, 2016). Biermann et al. (2006) explained that the major challenges facing are the specific health care environment with many different health care professionals, the lack of adequate funding from health care payers, and the rapid development of technology required to be supported by governments and health care organizations. Government agencies and hospital executives should develop their leadership skill to oversee health-care projects (e.g., telemedicine implementation) and change management in health care settings.

Overview of Telemedicine

Telemedicine can be defined as the delivery of health care and sharing of medical information at a distance using telecommunication platforms (Chakraborty, Gupta, & Ghosh, 2016). Telemedicine is a subset of electronic process in health using ICT for teleconsultation, medical second opinion service or teleexpertise, telemonitoring, and remote handling or teleassistance (Kamsu-Foguem & Foguem, 2014). Teleconsultation is a procedure whereby medical professionals can remotely consult a patient and interpret the necessary data. Teleconsultation includes explanations and their rationale for the suggested diagnosis and management plans with counseling in risk factor control and indications of treatment designed to reduce the problem. Teleexpertise allows patients to obtain a valuable medical second opinion in the case of the diagnosis and treatment of non-critical and critical illnesses (e.g., skin disease, respiratory disease, and nephrology disorder).

Teleexpertise is intended to assist patients and their attending physician to improve the health care outcome by a diagnostic revision and treatment enhancement. Telemonitoring is the ability to remotely monitor and supervise patients. Regarding telemonitoring, the medical data can be obtained automatically on a pre-defined periodic basis (remote follow-up) or on a daily basis (remote monitoring) by the device which dispatches them from the patient's home to the medical doctor. Teleassistance is a procedure which enables a medical professional to remotely assist another health care professional during the realization of a medical service (Kamsu-Foguem & Foguem, 2014).

Telemedicine offers a wide range of potential health care applications (Ruckdäschel, Reiher, Rohrbacher, & Nagel, 2006). Telemedicine improves quality of health-care delivery in several fields of medicine (Brunetti et al., 2014), encompasses the medical activities (Wootton, 2001), and brings medical care closer to where patients live (Rasmusson & Hartshorn, 2005). Telemedicine is the delivery of health care and the exchange of health care information across distances (Singh & Das, 2010) and can enhance the power of multidisciplinary teams using communication technology to effectively allow health care to be delivered to a patient at distant locations (Mohktar, Lin, Redmond, Basilakis, & Lovell, 2013) and can lower the health care-related costs (Rafiq & Merrell, 2005).

Qaddoumi et al. (2007) stated that telemedicine is widely utilized in industrialized countries for educational purposes. Educating technology issues and providing training about telemedicine remain the

necessary matters for the implementation of telemedicine, but legal issues may constrain the practical deployment of telemedicine (Siegal, 2011). In order to effectively raise the telemedicine service usage, telemedicine service providers' variety support is important (Rho, Kim, Chung, & Choi, 2015). The utilization of telemedicine requires the proper organization formalized by protocols written by the health authorities who will carry them out with the support of legal professionals, health structures (e.g., public and private health facilities), and biomedical device manufacturers (Kamsu-Foguem, 2014).

Technological Devices of Telemedicine Systems

Modern health care organizations enhancing technology enables local adaptation with analytics for the continuous innovation to optimize the successes in care quality, cost-effectiveness, and efficiency (Shaha, 2016). Mobile devices, including phones and computers become the significant ICT tools for many activities of health care service delivery in both urban and rural areas (Nemutanzhela & Iyamu, 2016). Mobile telemedicine employs the advanced concepts and techniques from the fields of electrical engineering, computer science, biomedical engineering, and medicine to overcome the restrictions involved in conventional telemedicine and realize an improvement in the quality of medical service (Lin, 2012). Algaet et al. (2014) indicated that the telemedicine-related online medical consultation reduces time required for medical consultation and induces improvement in the quality and efficiency of health care services.

Mobile telemedicine opens up new health care perspectives where the design and implementation of telemedicine is better confined at an underlying service level enforcing modularity and abstraction, and exploited at a higher level for attaining the different functionalities depending on the medical context (Capozzi & Lanzola, 2013). Mobile telemedicine utilizes wireless communication services to deliver a medical service (Batistatos, Tsoulos, & Athanasiadou, 2012). Batistatos et al. (2012) proposed a solution of mobile telemedicine in the context of moving vehicle (ambulance). Kulkarni and Ozturk (2011) proposed a solution called mPHASIS (i.e., mobile patient health care and sensor information system), designed to be pervasive and ubiquitous. The mPHASIS is a complementary solution for the hospital information system in the sense that it can be coupled to the hospital information system by the utilization of Web services (Kulkarni & Ozturk, 2011). Lai et al. (2009) proposed a mobile telemedicine solution based on wireless multi-hop toward providing home care monitoring applications for the elderly people.

Current advances in video conferencing technology make telemedicine the reliable and cost-effective method for evaluating patients (Norman, 2006). Synchronous telemedicine is normally done by video conferencing with the audio and visual consultation augmented by distant examination (Hernandez, Mallow, & Narsavage, 2014). Peter et al. (2006) stated that real-time telemedicine assessment is performed with live video and audio connections with the transmitting and receiving units systematically set in the different areas of hospitals. Oostveen et al. (2014) stated that telemedicine can be of additional health care value as it is less time-consuming. Disaster telemedicine organizes communications networks to provide the remote diagnosis of injured people in areas affected by disasters, such as earthquakes (Cadger, Curran, Santos, & Moffett, 2016) and can be supported by video conferencing technology.

Medical video conferencing (MVC) involves the deployment of sophisticated video conferencing and the use of technological devices to achieve patient consultation and health education at a distance (LeRouge et al., 2012). MVC allows the investigation of a service interaction that demands the high-quality services and consumer satisfaction (LeRouge, Hevner, & Collins, 2007). The delivery of patient care using MVC is affected by the technologies used, the personnel who provide customer service in

these high-tech environments (e.g., physicians and health care providers), the patients, and the design of the service process (Ray, Muhanna, & Barney, 2005).

Telemedicine and Chronic Diseases

Telemedicine applications exploit ICT for bridging the gap existing between patients and the clinic staff and are often meant to support the remote provisioning of medical care in terms of diagnosis, treatment, and consultations (Tulu, Chatterjee, & Maheshwari, 2007). Telemedicine system is recognized as a possible solution for the remote monitoring of physiological parameters and can be useful for chronic patients treated at home (Capozzi & Lanzola, 2013). Remote care delivery for chronic diseases has always been a sensible topic since it improves the quality of life through the enforcement of a tighter control on health care policies (Celler, Lovell, & Chan, 1999) and it becomes a must since it is believed to help in curbing the unprecedented demands on the national health care budgets experienced by all developed countries (Fogel, 2009).

Many health care applications have been addressing telemedicine support for chronic diseases and there is a common belief that the latest advances in ICT, yielding mobile smartphones and miniaturized embedded devices, may push the shift toward home care ensuring an independent living for chronically ill as well as for the elderly or disabled people. For example, diabetes mellitus (DM) is a group of metabolic disorders featuring very high blood glucose levels (BGL) in individuals, which may be caused by defects in insulin secretion (Type 1 DM), in insulin action (Type 2 DM) or both (Gavin et al., 2003). DM due to its multi disciplinary character encompassing both clinical and technological issues as well as patient empowerment is the chronic disease featuring the highest number of ICT applications, a major part of which are addressing telemonitoring (Verhoeven, Tanja-Dijkstra, Nijland, Eysenbach, & Gemert-Pijnen, 2010).

Telemedicine and Technology Acceptance Model

Despite the proliferation of telemedicine technology, telemedicine service acceptance has been slow in actual health care settings (Rho, Choi, & Lee, 2014). Regarding technology acceptance model (TAM), the accessibility of medical records and of patients directly affects the perceived usefulness of telemedicine; self-efficacy has a positive effect on both the perceived ease of use and the perceived usefulness of telemedicine; and perceived incentives are found to be important with respect to the intention to utilize the telemedicine technology (Rho et al., 2014). The TAM was primarily developed by Fred Davis in 1986 for his dissertation, and it was published in 1989 (Davis, 1989).

Since the TAM was originally introduced, the initial model has been enhanced by the addition of certain constructs meant to explain the user acceptance of new IT (Aggelidis & Chatzoglou, 2009). Many studies are conducted to retest the original model in health care contexts (Schaper & Pervan, 2007). TAM attempts to describe, identify, and predict the factors that affect the intention of people to utilize the particular computer system (Kowitlawakul, Chan, Pulcini, & Wang, 2015). Chau and Hu (2002) indicated that the TAM is a good predictive model of physician behavioral intent to accept telemedicine technology. Yu et al. (2009) found that positive social norms and computer skills, as well as perceived ease of use and perceived usefulness, are the crucial factors for technology acceptance. Yi et al. (2006) proposed a complicated model that combined the TAM, theory of planned behavior, and innovation

diffusion theory and significantly applied it to explain the attitudes of health care professionals toward personal digital assistant (PDA) applications.

Regarding TAM, the accessibility of patients' medical records significantly increases the physicians' satisfaction (Rho et al., 2014). Effective access to patient records has led to the increased documentation of patients' health conditions such that accurate patient information can be supplied (Sandberg et al., 2009). Telemedicine service increases health care accessibility to the underserved patients who live in remote areas far from medical facilities (Whitten, Doolittle, & Mackert, 2005). The increased accessibility has resulted in the faster delivery of care, reduced health care service time, and accurate medical monitoring at low cost (Sandberg et al., 2009). Both the accessibility of patients and their medical records are recognized as an effective method of evaluating patient care (Martinez, Everss, Rojo-Alvarez, Figal, & Garcia-Alberola, 2006). However, the lack of an incentive system is a major impediment to the physician's telemedicine service utilization (Katz & Moyer, 2004).

Applications of Telemedicine in the Oil and Gas Industry

Telemedicine has been reported as the common practice in the petroleum industry for several decades, initially referring to radio communications between the offshore medical personnel and onshore physicians (Evensen & Fjaertoft, 2008). Telemedicine solutions include video conferencing systems and digital medical devices that enable the sharing of both subjective and objective medical information in real time between offshore and onshore medical personnel (Todnem, Evensen, & Oveland, 2012). During recent years, telemedicine has received the growing attention from oil and gas companies due to its potential advantages, such as reduction in the number of unnecessary evacuations (Webster, Fraser, Mair, & Ferguson, 2008), shorter response times and early initiation of treatment in critical conditions (Mika, Nicosia, Croitoru, Dalida, & de Sanctis, 2009), increased patient satisfaction and perception of safety by offshore personnel (Mair, Fraser, Ferguson, & Webster, 2008).

The telemedicine service in today's offshore installations is comprised of health personnel offshore who are supported by an onshore medical team (Evjemo, Reegård, & Fernandes, 2015). The ability of executives and managers to handle human capital is considerably significant in order to improve individuals' competency in modern organizations (Kasemsap, 2016a). The medical competency of the personnel both onshore and offshore can vary, but commonly the onshore medical personnel have a higher level of medical education than the offshore personnel, such as specialized medical experts (Ponsonby, Mika, & Irons, 2009). The medical experts are available to the offshore medical personnel for support in diagnosing and decision-making, most often via telephone and video conferencing (Evjemo et al., 2015).

Importance of Telemedicine in Global Health Care

The use of technology to deliver health care over a distance has shown dramatic growth over the last decade because of the possibility it has to reduce cost and improve access to modern medical care (Mastrogiannis, Igwe, & Homko, 2013). Telemedicine is an emerging field within medicine with potential to revolutionize the delivery of health care (Wurm, Hofmann-Wellenhof, Wurm, & Soyer, 2008). Telemedicine is developed as an effective solution to provide the effective health care to the underprivileged inaccessible regions, and aims to provide the equal access to the medical care irrespective of geographic locations (Sood et al., 2007).

Telemedicine created from the combination of IT and business technology has received increased attention for the improved quality of life in medically vulnerable regions (Park, Jung, Chung, & Yoon, 2015). The development of telemedicine has significantly changed the medical collaborative decision making and patient-physician relationships and has an impact on the responsibilities of physicians to patients and how to treat them (Kamsu-Foguem et al., 2015). Inexpensive and low-bandwidth telemedicine solutions can support the intermittent surgical services by providing patients to have contact with specialist care through their local primary caregivers (Mora, Cone, Rodas, & Merrell, 2006). Broens et al. (2007) indicated that telemedicine provides specialist care, thus improving access, reducing long travels, and increasing the overall quality of health care within rural areas.

When suitably utilized, telemedicine effectively complements the advanced nursing practice in the cost-effective ways and improves the health care access to the populations served (Reed, 2005). Martin et al. (2012) stated that telemedicine continues to be a viable solution for bridging geographic access gaps to a variety of specialty care. Telemedicine assists collaborating medical professionals with shared decision making in medical diagnosis and treatment (Kamsu-Foguem et al., 2015). Referring (requesting) physicians should involve patients in the decision to seek further medical actions involving the choice of a specialist, as a starting point for more in-depth investigations into analyzing causes. The procedure allows the specialist to carefully investigate the compatibility of the medical scheme with the specific situation and to pursue discussions with the referring (requesting) physicians about the proposed management plan including the supposed diagnosis and corresponding treatments (Kamsu-Foguem et al., 2015). Lee et al. (2010) stated that telemedicine has potential to alter the nature of the patient-physician relationship.

Telemedicine allows the organized health care networks to share information and skills, improve the management of patients, both for emergency care and chronic diseases (e.g., cardiovascular diseases, diabetes mellitus, respiratory diseases, chronic renal failure, cancer, nervous system disorders, and musculoskeletal disease) (van den Berg, Schumann, Kraft, & Hoffmann, 2012). Regarding telemedicine, the patient visiting a general practitioner can consult the specialist via telecommunication facilities, saving both time and money for quality medical care as opposed to the method of transporting patients to specialists for the face-to-face visits (Ekeland, Bowes, & Flottorp, 2010). Telemedicine is a method of providing appropriate support for mothers, and their families, following early hospital discharge as it offers alternative ways in which they can be guided by health care professionals in their transition into parenthood (Danbjørg, Wagner, Kristensen, & Clemensen, 2015).

Regarding a shortage of physicians trained in critical care (Pronovost, Waters, & Dorman, 2001), many health care systems have turned to telemedicine intensive care unit (Tele-ICU) to assist with patient care in their ICUs (Moeckli, Cram, Cunningham, & Reisinger, 2013). Tele-ICU programs vary in the technological and organizational complexity, but involve audio, video, and electronic communication connecting a centralized support center with the geographically dispersed ICUs to assist in patient monitoring and management. Tele-ICU coverage is associated with the improved guideline adherence, lower rates of preventable complications, lower hospital and ICU mortality, and shorter ICU lengths of stay (Willmitch, Golembeski, Kim, Nelson, & Gidel, 2012). Telemedicine ICU training, staff knowledge about when and how to use the Tele-ICU, perceived need, and organizational factors are the important components of ICU readiness and its impact on acceptance (Moeckli et al., 2013). Telemedicine ICUs can provide the additional mentoring during off-hour shifts and an opportunity for residents to gain experience on shared decision making with virtual teams in critical care environments, but training content needs to be developed and disseminated to support the learning opportunities (Moeckli et al.,

2013). Leaders of virtual support teams may need to assume a coordinating role to ensure effective collaboration and communication among virtual team members (Kasemsap, 2016b).

Retinopathy of prematurity (ROP) is a vasoproliferative disorder that affects low weight premature babies (Ossandón et al., 2015). Several multi-center studies have developed criteria for the classification and treatment of ROP. This disorder continues to be the first cause of childhood blindness in developed countries (Gilbert & Foster, 2001). Telemedicine is a strategy to resolve the limitations of ROP screening (Richter, Williams, Starren, Flynn, & Chiang, 2009), such as lack of specialist time, shortage of specialists in charge of screening and lack of clinical documentation in images. Telemedicine has demonstrated a better cost-effectiveness ratio than ophthalmoscopy (Castillo-Riquelme, Lord, Moseley, Fielder, & Haines, 2004).

FUTURE RESEARCH DIRECTIONS

The classification of the extensive literature in the domains of telemedicine will provide the potential opportunities for future research. Future research direction should broaden the perspectives in the implementation of telemedicine to be utilized in the health care organizations. Various forms of telemedicine (e.g., teleneuropsychology, telenursing, telepharmacy, telerehabilitation, telecardiology, and teleradiology) will be the beneficial topics for future research directions. It will be useful to bring the additional disciplines together (e.g., medicine, nursing, and health sciences) to support a more holistic examination of telemedicine in order to transfer the existing theories and approaches to the inquiry in this area.

Cloud computing is the modern pattern of digital computing technology in which virtualized resources are provided as the services over the Internet (Kasemsap, 2015). The adoption of the Internet of Things (IoT) is growing fast, especially in certain industries. With advancements in the IoT, health care professionals can interact with patients virtually from anywhere, eliminating the travel time required to see patients in person. The IoT holds the key to helping hospitals run more efficiently, while vastly improving the quality of care they provide. Exploring the roles of cloud computing and the IoT adoption in telemedicine will be the beneficial topic for future research direction.

CONCLUSION

This chapter highlighted the challenges facing health care systems; the overview of telemedicine; the technological devices of telemedicine systems; telemedicine and chronic diseases; telemedicine and TAM; the applications of telemedicine in the oil and gas industry; and the importance of telemedicine in global health care. Telemedicine brings the health care value through its ability for the remote visits with patients, immediate access to health care professionals, real-time access to health data, and health monitoring capabilities. Telemedicine has proven to be a crucial way of providing the high-quality and convenient care services. Telemedicine is an effective health care measure that can manage the new and affordable technology with the potential to deliver the convenient and effective care to patients, and provides an alternative way for the health care organizations to deliver the essential health outcomes. Applying telemedicine has the potential to increase health care performance and gain sustainable competitive advantage in global health care.

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KEY TERMS AND DEFINITIONS

Health Care: The act of taking necessary medical procedures to improve a person's well-being.

Information: The data that is specific and organized for a purpose.

Information Technology: The set of tools, processes, and associated equipment employed to collect, process, and present the information.

Patient: A person who is receiving medical care.

Physician: A medical doctor, especially one who has general health care skill.

Telecommunication: The science and technology associated with communications at a distance.

Telemedicine: The provision of diagnosis and health care from a distance using media, such as interactive computer programs and information technology.

Chapter 11
What E-Mental Health Can Offer to Saudi Arabia Using an Example of Australian E-Mental Health

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ABSTRACT

Mental health have become a very influential topic around the world due to the increase of mental health issues that have been reported through national research and surveys. Many studies have been done along the years around the barriers in regards to seeking help in deferent countries and communities. This research aims to look closely into these barriers targeting issues and potential solutions, specifically for Saudi Arabia. Recently, the use of e-mental health services have proven to be an effective method to improve is barriers to mental health treatment. However, this chapter addresses the application and suitably of e-mental health programs for Saudi Arabia mental health services. To do so, a case study of Australian e-mental health services was selected to assist with the investigations.

INTRODUCTION

E-mental health is defined as providing treatment and/or support to people with different mental disorders through sensible technologies (Anthony et al., 2010; Christensen and Petrie, 2013b; Whittaker et al., 2012; e-Mental Health Alliance, 2014). E-mental health services have the ability to improve accessibility, reduce cost, provide flexibility, and better consumer interactivity and engagement (Lal and Adair, 2014). A number of the sensible technologies that are used in the delivery of e-mental health are

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as follow: Short Message Service (SMS); Email; Website/apps; Shat or instant messaging (IM) tools; Social Media; Video/Audio via the Internet; Or Smart phones.

E-mental health services have the ability to overcome issues in the current mental health sector. These services have the ability to improve lack of access due to location, time or financial difficulties or poor mental health literacy (Booth et al., 2004). It also can reduce the load on mental health clinics which will improve the therapists' time efficacy and allow the service to be available for people who need higher level of medical attentions (Jorm et al., 2013; Jorm et al., 2007). However, there are a number of concerns found in the literature. These include lack of quality control; limited only for people with low to moderate mental illnesses; limited to people who are familiar with using technology (Lal & Adair, 2014)

The capability of e-mental can assist developed and developing countries to successfully deal with challenges that are currently exist in their mental health services. This by enabling early intervention and treatment, better promotion methods for various of people with different mental issues (Reavy, Hobbs, Hereford, & Crosby, 2012).

E-mental health is a useful tool to get information, treatments and support anonymously in most programs, which might help people avoiding the feelings of stigma. E-mental health also will help people who live in low population or rural areas, where access to mental health providers may be limited (Christensen & Hickie, 2010).

There is recognition globally that there are challenges to the current accessibility of mental health services. This includes stigma, location, service availability and geographic location (Lal and Adair, 2014; e-Mental Health Alliance, 2014; Gulliver et al., 2010). Besides these challenges, the Saudi Arabia has other challenges, which also found in some Muslim countries, that impact its mental health services accessibility, such as, religious healing (Koenig & Al Shohaib, 2014), gender versions (Al-Saggaf, 2004; Al-Shahri, 2002) and women's legal and social aspects (Saleh, 2014). These aspects are some of the factors that have been found that may impact mental health services delivery in a different way from the case (Australia) (Al-Saggaf, 2004; Koenig et al., 2014; Al-Shahri, 2002; Koenig and Al Shohaib, 2014; Saleh, 2014).

This study is investigating the capability of e-mental health services to facilitate the current mental health sector of Saudi Arabia. This will be by pointing out the potential of e-mental health to deal with challenges that affect the mental health services in Saudi Arabia. To do so, a case study of Australian e-mental health services was selected to assist with the investigations. Due to some of the main issues facing Saudi consumers such as: Mental health service provision, policies and legislations in Saudi Arabia, cultural barriers, stigma and religious healing and gender variation impact and women's legal and social aspects, e-mental health programs will be a productive solution for the mental health sector in Saudi Arabia. E-mental health services indicate significant outcomes to improve the barriers that affect traditional mental health services, as what will be discussed through examples of Australian e-mental health program.

BACKGROUND

Mental Health Service Provision, Policies, and Legislations in Saudi Arabia

Recently, the mental health sector has started to gain attention from Saudi authorities (Binhadyan, Troshani, & Wickramasinghe, 2014). In 2006, the national mental health policy was developed and spe-

cial mental health programmers in the general medical system were established. The following year the Saudi Arabian Mental and Social Health Atlas was introduced, which aimed to establish a well-developed plan that would improve the quality of mental health services, mental health promotion/education and improve the mental literacy (Al-Habeeb and Qureshi, 2010). Almalki et al. (2011) argue that the aims of the current of mental health act include:

- Improving accessibility,
- Improving the accreditation of professionals and facilities,
- Ensuring better mental health policy and procedure enforcement,
- Protecting patients and their family member's rights,
- 48.93% of the total number of visitors to mental health clinics were women,
- 53.19% were between the age of 15-40,
- Depression 35%,
- Anxiety 36%.

Most statistics of mental illness cases in Saudi Arabia are based on the number of people who actually accessed the services. Between 2006 and 2012, the Ministry of Health (MoH) reported that the total number of outpatients seeking mental health services at public hospitals increased by 59.4% (from 310,848 to 495,484 cases), and the total number of inpatients increased by 12.9% (Moh, 2011; Moh, 2012). Moh (2012) used the International Classification of Diseases (ICD-10) to identify disease groups and reported the following in 2012:

… e-mental health has the potential to provide a better public health intervention on a mass scale through online surveys and data collection, in which will help to reach more audience with more accurate data.

The Saudi community is going through rapid social changes in all areas, and social problems are increasing with the developments and changes in the different aspects of Saudi life, which has become the dominant feature of life as a result of the complexity of social life and the cultural attitudes that go along with the structure and composition of Saudi society. Exposure of individuals to some psychological problems and difficulties has come to be expected under these circumstances; therefore, health care professionals have found that they must assist and guide members of the community who face social and psychological problems resulting from these changes through the creation of reliable channels to guide them to potential solutions to their problems.

According to Al-Krenawi (2005), recent studies have found an increase in cultural acceptance of community psychiatric care services in countries like Saudi Arabia. Nevertheless, counselling is a modern concept in Saudi society that has emerged in social and psychological studies, especially after the society underwent rapid and significant changes in a number of systems and social infrastructure. On the Ministry of Social affairs' (MoSA) official web-site, which is the governing body for social services, the MoSA defines psychological counselling as "a service that aims to help individuals through a professional relationship between mentors and guides, and this relationship is governed by the principles of professional ethics". The MoSA has sought to establish social and preventive guidance units to provide professional counselling for the problems faced by some members of Saudi society and to provide appropriate guidance to them through the many services that are offered (MoSA, 2016). However, one noticeable aspect is the "serious deficiency and lack" of mental health care services in Arab countries

(Al-Krenawi, 2005). The number of professionals working in mental health services still falls far below the demand for such services. Many workers in psychiatric facilities hold minimal training in mental health and social work (Al-Krenawi, 2005). Moreover, mental health related policy and legislation is almost "non-existent" in many Arab countries (Al-Krenawi, 2005).

Cultural Barriers, Stigma, and Religious Healing

A study shows that most religions have ways to practices religious healing and it is not limited to Islam (Koenig and Al Shohaib, 2014; Greenberg, 1997). Religious healing is widely used among Muslims (Koenig et al., 2014). Koenig and Al Shohaib (2014) argue an individual seeks such practice because it increases his/her wellbeing and improves his/her hope and self-esteem and provide a sense of belonging. In Islam, the religious healing is referred to as 'Ruqya' which applied for the healing through reading of the specific verses of the Quran (Rahman, 2014).

Despite the strong belief in the efficacy of religious healing in Islamic treatment, this practice can delay diagnoses and treatment for mental illness, and can increase the stigma (Koenig and Al Shohaib, 2014). In Saudi Arabia more than 50% of people first sought the advice of a religious healer for different mental illness (Al-Habeeb, 2002; Alosaimi et al., 2014). A pervious study shows that the majority of people who consult religious healers were suffering from depression and anxiety (Alosaimi et al., 2014). The knowledge of mental illness and stigma associated by religious healers is directly related to their educational level according to Al-Habeeb (2002). He also argues that religious healers do not refer their patients to a mental health clinic or express interested in working with mental health professionals due to many religious and social factors.

Gender Variation Impact and Women's Legal and Social Aspects

Due to many differences between males and females in roles and responsibilities in Saudi Arabia, it is noted in many published papers (Al-Krenawi & Graham, 2000) that this will have a major impact on women's mental heal and wellbeing. Gender is "a critical determinant of health, including mental health. It influences the power and control men and women have over the determinants of their mental health, including their socioeconomic position, roles, rank and social status, access to resources and treatment in society" (Astbury, 2001). In regard to seeking help in such a society, studies have shown that women will have a more positive attitude than men in regard to seeking professional help e.g counseling. Hence, men and women have different attitudes to seeking help (Haj-Yahia, 2002). Some studies have suggested that traditional gender roles may impact a person's decision in regard to seeking professional help which may affect their attitude as a women or a man about seeking help. In general, men are more affected by gender roles which may identify them as being "independent and in control" (Daoud et al., 2014).

Globally, most healthcare facilities allocate patients to shared rooms based on genders. However, The Saudi Health Services follow stricter sex-segregation. This is because Islam requires that men are prohibited to mix with unrelated women and this applies to the work environment, education, hospitals (Al-Saggaf, 2004). This means male patients are examined by male mental health professional, and female patients are seen by female mental health professional. To meet these requirements is a challenge that mental health services delivery in Saudi currently faces. Quite often, men demand a female doctor to examine their female relatives, or a female will be refused to be seen by a male doctor (Al-Shahri, 2002). This power relationship between men and women might influence access to mental treatment.

According to Haj-Yahia (2005), the occupational structure of patriarchal societies leaves women with very few alternatives. However, the availability and perceived status of occupations and jobs open to women are inferior to those available to men, which will affect women's incomes and their dependence on their family members or "guardians" (Haj-Yahia, M. 2005). This effect may lead to emotional and mental disorders such as anxiety and by default this will affect their children's lives. He gives an example of Palestinian society in Israel which is a Middle Eastern society that shares many concepts with Saudi Arabian society. For this and other reasons, in many cases Palestinian women earn less than men who are employed in the same jobs. Without having access to good jobs, women will continue to be economically dependent on their spouses or partners (Haj-Yahia, 2005). Economic dependence is one of the factors that force battered women to continue living with a violent spouse. For them, divorce or separation means poverty (Haj-Yahia, 2005).

Depression is the most diagnosed mental illness globally and it is found in women more than men (Piccinelli & Wilkinson, 2000). In Saudi Arabia, 50.19% of visitors to psychiatric clinics were women (Moh, 2011). Many other social issues affect women more than men in Saudi Arabia. Divorce is one major example which might have a direct impact on Saudi women's mental health wellbeing. Unfortunately, Saudi Arabia has the highest divorce rate among the Gulf Cooperation Council countries at 35% and are also above the world average rate of 22% (Saleh, 2014). Another example is women limitation in moving freely out and about due to insufficient public transport and the public cultural ban on women against driving their own vehicles (Alghamdi & Beloff, 2014). Due to that, the access for mental health services for women might become a challenge.

The negative impacts of the factors mentioned earlier are some of the barriers to mental health access and treatment in Saudi Arabia. As mentioned, the number of people seeking mental health attention is increasing, which can be a challenge mental health providers may face in the future. Therefore, the need for e-solutions that will make more productive mental health sector is needed. E-mental health services indicate significant outcomes to improve the barriers that affect traditional mental health services.

METHODOLOGY

This study was conducted as a document review for the purpose of understanding the current Australian literature on e-mental health and it relevance to applying the knowledge in Saudi Arabia. E-mental health in Saudi Arabia has not been previously explored and it lacks defined characteristics. As such, an exploratory qualitative research method is the most suitable method and a single case study will be used (Yin, 2008). At this stage of the research, the answer to the research question of "How are e-mental health services implemented to facilitate the current mental health in Saudi Arabia?" will be examined and explored.

Case Study: Australian E-Mental Health Development

The Australian government is investing heavily in e-mental health services because of technology can assist in overcome issues that are preventing young people from seeing mental health services and providers and creating barriers to treatment. Problems include; lack of access of mental health services due to location, time or perhaps financial matters (Booth et al., 2004); stigma incurred by seeing a therapist (Burns, Davenport, Durkin, Luscombe, & Hickie, 2010; Christensen & Hickie, 2010) and therapist time

and efficacy (Jorm, Wright, & Morgan, 2007). Reynolds, Griffiths, and Christensen (2011) argue that there are two types of e-mental health programs in Australia:

According to the e-mental health alliance (2014), there are five main types of e-mental health programs, they have summaries it in:

1. Health promotion, wellness promotion and psycho-education such as Byondblue.
2. Prevention and early intervention support and assessment such as MoodGym.
3. Crisis intervention and suicide prevention diagnostics tools and screening methods such as LIFELINE.
4. Treatment these programs are designed to treat or manage specific mental illness such as depression and anxiety such as myCompass.
5. Recovery and mutual peer support Blueboard.

The Australian Government has invested $70.4 million to date in developing and funding e-mental health services and telephone crisis assistance, also the Australian Government will invest a further $110.4 million in the next four years targeting young adults (Australian Govermment, 2012). In addition, an estimate conducted between 2012 - 2013 showed that 96.5% of 15- to 24-year olds use the Internet in Australia (Australian Bureau of Statistics, 2014). This commitment to adoption of technology in Australia makes the country a potentially rich site in which to consider possibilities.

Finding and Discussion

To be able to the service provision will help identify the need for e-mental health programs. There is a difference between the types of mental health service provider in Saudi Arabia compared to Australia.

In Australia, Mental health patience and or the consumers of such services will be able to access more mental health providers and will have a variety of workers, doctors and/or nurses to help (WHO,2012). According to the mental health atlas created by WHO. Table 1 summarizes the type of mental health service providers with some example in comparison between Saudi Arabia and Australia.

In Table 1, it is noted that mental health provider maybe limited in access and resources, and many of the service provider may find it challenging to service people with mental health issues and their

Table 1.

Type of Service Providers	Saudi Arabia	Australia
Psychiatrics	Available mostly to prescribe medicines, First point of contact	Available to give some therapy and prescribe medicine if needed
Psychologists	Limited, due to insufficient training programs	Available to give therapy, diagnose and refer to other services
Counsellors	Not available	Available to support, give therapy and refer as needed
Social workers	limited due to insufficient training programs	Available to provide support with other issues patency may face, therapy, referral and education
Mental health nurses	Available to practice in psychiatric units in hospitals only	Available to provide support, therapy, medicine instrumenting in and out of the hospital
Allied health (Other therapy and lifestyle intervention)	unknown	Available to provide therapy, other support service "meditation, e.g." mental health education, referral to services

families due many factor such as: insufficient training, limited resources, gender role, local availability, and ease of access.

In regards to e-mental health, a new intuitive by the name "Qareeboon" which is an Arabic word referrer to "close" or being close is recently offered through the National Committee for the promotion of mental health (NCPMH) in Saudi Arabia. It was launched September 2013 as an online application. This application works on all smart devices. NCPMH climes on their website, that it is managed by consultants and specialists in the Saudi mental health field. Their websites suggest that the application is the first of its kind in the Middle East on smart devices. The application makes it possible to write a psychological consulting requests (free of charge), which are answered by consultants, psychologists and specialists in this field.

The application contains: Mental health educational materials (like: sings symptoms, issues) techniques to deal with emotional distress through visual content. Such as images and info-graphics, daily updated information, specialist educational text Variety content suitable for both genders and all age groups. Moreover, a link to communicate with suitable mental health providers.

The application however dose not state reliable references and the resource of the data and content available for consumers, and there is no evidence for any research conducted to come up with the content, or any recent scientific reference available on their website whatsoever. Furthermore, when targeting the Saudi consumer, such applications need to cautious with the presenter of the video material and content as it is a male, some consumers might feel it is only targeting male audience due to the cultural sensitivity with gender role in Saudi Arabia (Al-Krenawi, 2014). Moreover, the application does not direct people to further knowledge such as other websites, books, and/or any other useful resources. Also, it is not integrated to any other e-mental health services if exist. However, the application might be improved and enhanced and it will be a stepping stone for e-mental health in Saudi Arabia, as it has good potential.

FUTURE RESEARCH DIRECTIONS

E-mental health is an emerging new field of research and there is limited literature was conducted on the use of E-mental health in Saudi Arabia (Binhadyan, Peszynski, & Wickramasinghe, 2016; Binhadyan et al., 2014). Further research in e-mental health application and benefits will contribute to further understanding the Saudi consumers' concepts, beliefs, perspectives and attitudes toward mental health issues and service access. It will also help to understand some of the obstacles and difficulties they face to access/use available social and welfare services and how e-mental health could be the answer. The program reviewed earlier "Qareeboon" will be a good start, with further enhancement it will have good grounds to further the potential of e-mental health in Saudi Arabia. Also, due to some of the implications on e-mental health, such as internet access and literacy, further studies need to examine the challenges that might encounter Saudi consumers when using e-mental health programs.

CONCLUSION

The service provision, policies and legislations in Saudi Arabia, the stigma of mental illness, Gender variation and all the issues that is facing the Saudi consumer in Saudi Arabia plays a major role in affecting people's attitudes toward mental health in general and its considered a key factor in mental health

literacy (Jorm,2013). In terms of literacy, there is a need for accurate information about psychotherapy to help reduce public stigma in Saudi Arabia. Education efforts can be applied through e-mental health programs similar to the Australian version of *Beyondblue* reach out and the *Black Dog Institute*. Even brief intervention programs have been shown to have short-term effects on people's attitudes (Pinfold et al., 2003 E-mental health programs can enhances the awareness and the intervention of the evidenced-based medical, psychological and alternative treatments available such as online therapy, scientific knowledge based information about mental health issues, there symptoms and treatments. As a result, people will be more aware of such problems which may be a good tool to decrease stigma and help people with other berries they may face.

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Chapter 12
Smart Medication Management, Current Technologies, and Future Directions

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ABSTRACT

Medication non-adherence is a major healthcare challenge with irreversible consequences in terms of healthcare costs and quality of care. While recent years have seen some effort in developing sensor-based technologies to detect medication adherence and provide interventions, the community lacks a comprehensive study on the clinical utility, reliability, and effectiveness of such medication intake monitoring solutions. Furthermore, many opportunities inspired machine learning algorithms have largely remained unexplored. In an effort to highlight these knowledge gaps, in this paper, we take an interdisciplinary approach to (1) review and compare existing engineering products for medication intake monitoring; (2) discuss clinical applications where such technologies have demonstrated to be effective; (3) explore research gaps and shed light on unmet needs and future research opportunities in the area of medication management from both clinical and technology development points of view. The results of this paper may open several new avenues in the area of technology-based medication.

INTRODUCTION

Insufficient medication adherence is a big problem in medical field and contributes significantly to healthcare costs and poor quality of care, in particular in patients with chronic conditions. Studies show that medical prescriptions are never filled in almost 20% to 30% of the cases. Furthermore, 50% of medicines are not taken as prescribed for chronic patients (WHO, 2003), (Viswanathan et al., 2012).

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Of all medication-related hospitalizations in the US, 33% to 69% are as a result of patient's insufficient adherence to prescribed medication (Lüscher & Vetter, 1990), which annually costs about $100 billion to $289 billion (Viswanathan et al., 2012). The consequences of medication non-adherence are enormous. In the United States, more than 10% of hospitalizations, approximately 125,000 deaths, and a substantial growth in morbidity and mortality are due to medication non-adherence. For example, studies show if the patients fill no discharge medications by 120 days after a post-acute myocardial infarction, the probability of death at 1 year will increase 80% (Jackevicius, Li, & Tu, 2008).

Improving medication adherence can potentially influence large patient populations and result in significant cost savings. Each American adult has at least one chronic illness and currently 75% of the total cost of healthcare accounts for patients with one or more chronic conditions (Chisholm-Burns & Spivey, 2012). Average adherence to medication in chronic illnesses is generally higher than that of acute diseases (Jackevicius, Mamdani, & Tu, 2002). As an example, half of the patients with acute coronary syndromes discontinue to take hydroxymethylglutaryl–coenzyme six months after they start therapy (Lüscher & Vetter, 1990). These observations show that novel clinical and technological approaches are needed to enhance medication adherence which will significantly decrease the costs associated with poor adherence in patients with chronic conditions.

According to 2003 report of World Health Organization (WHO) (WHO, 2003), interventions could be deployed to improve medication adherence in patients with chronic diseases, such as asthma, heart failure, diabetes. Technological advancement in intervention methods results in higher rate and improving assessing methods of adherence. Electronic intervention and monitoring approaches such as mobile and wireless technologies, electronic sensors, and web portals are developing very fast and aim to provide patients and healthcare providers with a potential rapid and organized form of gathering, manipulating, and analyzing adherence patterns with customized reports to enhance medication adherence behaviors. Taking advantages of technology in medication adherence is not only useful for patients' health, but also can be utilized by clinicians and researchers to improve their clinical decisions, development strategies, and methods of intervention.

With the recent advancements in electronics, sensor design, communications, and data analytics, we can potentially develop novel technological approaches to objectively monitor patients, assess their medication adherence, and provide effective and timely interventions. While recent years have seen some effort in developing sensor-based technologies such as wireless electronic pillboxes to detect medication adherence and provide interventions, the community lacks a comprehensive study on the clinical utility, reliability, and effectiveness of current such medication intake monitoring solutions. Furthermore, many opportunities inspired by computational models such as signal processing and machine learning algorithms have largely remained unexplored. In fact, the literature is lacking a comprehensive study of existing technology-related medication adherence solutions, an analysis of advantages and shortcomings of the state-of-the-art technologies, a study of promises that these systems provide, and future directions in this research area. In an effort to highlight these knowledge gaps, in this paper, we take an interdisciplinary approach to

1. Review and compare existing engineering products for medication intake monitoring;
2. Discuss clinical applications where such technologies have demonstrated to be effective;
3. Explore research gaps and shed light on unmet needs and future research opportunities in the area of medication management from both clinical and technology development points of view.

The results of this paper may open several new avenues in the area of technology-based medication management focusing on:

1. Establishment of new and robust clinical definitions for medication adherence; and
2. Development of more robust medication monitoring devices and services;
3. Development of signal processing, pervasive computing, machine learning, and wearable computing solutions that facilitate robust and accurate and effective medication monitoring and clinical interventions.

BACKGROUND

Medication Adherence: A Definition

Adherence to medication is commonly defined as patients take the amount of medicine prescribed by their health care provider; yet, the community lacks a concrete definition of medication adherence where number, duration, and frequency of medicine intake are all reflected in it. Furthermore, most current studies use a discrete metric to describe medication adherence where a patient is either adherent or not. Some of the concerns that the current definitions of medication adherence raise are the following. Sometimes the patients take all of monthly prescribed medicine in one day. It might be no constraint on using the medication at specific time A literature review reveals that definition and methods of assessing adherence to medication is different from one researcher to another (Jackevicius et al., 2008). Measuring adherence to medication is important to evaluate clinical and economic outcomes of low adherence. The rate of adherence often measured as percentage of amount of taken medication to prescribed amount of it. This measure could become more precise if combined with correctness-taking assigned pills for that specific day and promptness-taking medication at appropriate time (Chisholm-Burns & Spivey, 2012). Adequate adherence is different from one study to another or from one illness to another. For instance, several trails assume that an adherence rate of higher than 70% is admissible while other trails do not accept adherence lower than 95% (Jackevicius et al., 2008).

Methods to Assess Medication Adherence

There exist different methods for measuring patient's adherence but quantitative approaches can be divided into two different categories:

1. Direct methods;
2. Indirect methods (Lüscher & Vetter, 1990), (Fairman & Matheral, 2000).

Although direct methods such as a blood test are the most accurate measurement methods for short time, they are expensive, need cooperation of health care provider, and are sensitive to by the patient's abuse such as "white coat adherence" (Feinstein, n. d.). Indirect approaches such as questioning the patient or pill-count are objective; meanwhile, they can be sensitive to misrepresentation and tend to result in overestimation of patient's adherence by healthcare providers (Lüscher & Vetter, 1990). While

there exists several methods for adherence assessment, none of them truly can be considered as a gold standard (Fairman & Matheral, 2000).

The selection of measurement methods depends on the type of disease and intervention, available resources and sometimes ethical and legal issues (Fairman & Matheral, 2000). Therefore, having a context-aware monitoring system is essential to improve medication adherence. For example, (Wagner & Arnfast, 2010), designing and testing a system to remind a patient to take his/her morning medication if the medication has not been taken within a fixed time interval after waking up. Although the study has been tested on 3 patients, the results show that weight sensor did not fully work as expected and also it is not really applicable and dependent to a gateway computer.

Commercially Available Electronic Pillboxes

Electronic pillboxes are perhaps the most common technology-based medication adherence monitoring solutions. In this section, we review existing electronic pillboxes briefly. In recent years, there have been many companies providing new pillboxes equipped with micro-electronic circuits, wireless connectivity, and several types of alarms to address the problem medication non-adherence. These commercially available pillboxes, can record information about date and time of cap opening. A summary of available products is shown in Table 1. These technologies, which are called "smart pillboxes", vary in different ways. Some, such as epill and iRemember, only provide reminders about the time of taking pills, while several others such as CleverCap and MedMinder provide mechanisms for reporting a history of medication adherence for each patient. Patients using AdhereTech have the option to receive customizable messaging and interventions, which is helpful in case of missing doses. In contrast with many other pillboxes, which only record data when the cap is opened, AdhereTech also records the number of pills or liquid remaining in the bottle.

Beside the clinical services they provide, different pillboxes appear to vary in their underlying technology for data communication and adherence detection. While MedSignal, doseCue and SIMPILL use a mobile phone as a gateway for data transmission, other products such as MEMS communicate with a reader connected to a computer. More recently, several products provide the ability to transmit adherence data directly by the use of cellular connectivity embedded into the pillbox, which eliminates the need for additional gateway. Such technologies intend to enhance robustness of data transmission by providing a continuous connection with the data server. Examples of such devices are GlowCap and SMRxT. Another technology difference is in the method used to detect whether the pill is taken or not. For example, eCAP and Quand Medication Compliance use RFID technology for detection while ePill cannot automatically detect that.

These electronic pillboxes provide different types of alarms. While talkingRx provides only audible alert message in addition to showing the clock, some others such as MedPro Pill Organizer provide light and audio alerts, calling, texting or sending emails in the condition of missing a pill as well as a web portal which reports a summary of the patient's adherence data.

Clearly, there is a tradeoff between the amount of service one receives and the cost associated with purchasing and maintaining the adherence monitoring technology. Packages such as Dose-Alert and didit are among inexpensive acting as a sticker on any available pillboxes. They, however, provide no more than a reminder service. On the other hand, AdhereTech or Med Pro, which are more expensive technologies, use more advanced technology and provide more extensive services and alerts such as reporting to family and caregivers.

Table 1. Available electronic pillboxes

Name	Transmission Technology	Additional Features
AdhereTech	Wireless transmission from bottle to server/ Real time analysis	
MedPro Pill Organizer/Automated Security Alert	Communicates through a cellular network and remote control using a web portal.	Reporting, History
iRemember	Bluetooth, Wi-Fi under development	
CleverCap	Connect to Wi-Fi, 2Net HUB	Linked to the cloud while in cellular range
eCAP/Med-ic	BT4, RFID, NFC/ Secure data report	
ePill	NA	Timer
GlowCap	AT&T Mobile Network	
Didit	NA	Manual Tracking Device
Adherence Solutions LLC/ Dose Alert	NA	Programmable Sticker on Bottle
MedMinder,Jon-Locked Pill Dispenser and Medical Alert	internal cellular modem	Weekly Report
doseCue	Bluetooth, mobile phone as gateway	Exception Report
SMRxT	Fits standard Rx vials/ Verizon telecommunication	
TalkingRx/Rex	NA	The pharmacist records up to 60 seconds of instructions when dispensing the medication
MedCenter	NA	Pill Organizer
Quand Medication Compliance	NFC and mobile phone	
Ubox	NA	
MedSignals	phone line	
MEMS 6 TrackCap/Aardex,..	Reader connected to computer	
SIMPill	Cell phone	

CLINICAL STUDIES WITH ELECTRONIC MEDICATION MONITORING

In spite of the rapid changes in technology and development of new products, there are still a few controlled studies that have actually been designed to demonstrate the using of technology, especially electronic devices, in improving adherence rates. Smaller number of studies shows that using electronic devices cannot result in meaningful improvements in adherence rates. In this section, we review exiting chronic conditions in which electronic approaches have been utilized for medication adherence. These clinical studies are summarized in Table 2.

Diabetes

Diabetes is a group of disorders which refers to high level blood glucose and needs precise monitoring of exercise, diet, and medication for achieving good glycemic control (Cramer, 2004). Complexity of diabetes treatment and duration of disease cause that healthcare systems often do not have sufficient

Table 2. Exiting chronic conditions using medical-adherence

Area	Source	Samples/Duration	Intervention	Results
Diabetes	(Morak et al., 2012)	59 samples/ 13 months	e-blister	Feasibility study
	(Cramer, 2004)	A literature search/ 38 years	MEMS; APREX	MEMS is useful in improving adherence
	(Franklin et al., 2008)	126 patient with type 1 diabetes / 1 year	Text message via SweetTalk software system	Sweet Talk may support intensive insulin therapy.
	(Brath et al., 2013)	53 patients (30 female)/ NA	Electronic blister	Feasibility of mHealth based adherence management.
	(Vervloet et al., 2012)	RCT on 104 type 2 diabetes patients/ 6 month	SMS reminder	Receiving text-message reminders led to significantly more doses taking and less miss doses comparing patients receiving no reminders.
HIV (antiretroviral therapy (ART))	(Horvath et al., 2012)	meta-analysis of Two RCTs from Kenya/ 48-52 weeks	Text Messaging	There is high-quality evidence that compared to standard care, text-messaging is efficacious in promoting adherence to ART.
	(Pop-Eleches et al., 2011)	431 adult patients Africa/ 48 weeks	SMS	During the 48 weeks, 53% of participants achieved adherence of at least 90%
	(Khonsari et al., 2014)	62 patients with ACS/ 8 weeks	SMS reminder	The risk of being low adherent among the control group was 4.09 times greater than the intervention group
Heart/Hypertension	(Burnier et al., 2001)	41 Forty-one hypertensive patients/ 2 months	Electronic monitoring	During monitoring, in more than 30% of participants, blood pressure was normalized and in another 20% insufficient compliance was unmasked.
	(Patel et al., 2013)	48 patients/ 12 weeks	mobile-phone-based automated medication reminder	During the study, average blood pressure improved significantly from baseline.
	(Park et al., 2014)	90 patients with mean age more than 59.2 years/ 30 days	Text messaging	Using MEMS and text-message responses, adherence to antiplatelet therapy increased.
Asthma	(Spaulding et al., 2011)	5 children/ 6 months	MDILogII	The number of children who were correctly using their medications doubled
	(Burgess et al., 2011)	26 children aged between 6 and 14 years/ NA	MDILogI	Adherence in the intervention group was significantly higher (79% vs. 58%)
	(Bender et al., 2000)	27 children/2 months	metered dose inhaler (MDI) equipped with an electronic Doser	Monitoring adherence using electronic devices is more reliable than canister weight measures or self-report.
	(Ostojic et al., 2005)	16-week/ 16 patients	GSM-SMS	GSM-SMS is an appropriate tool for telemedicine can enhance asthma control when using with a written plan and standard follow-up.
Smoking	(Shi, Jiang, Yu, & Zhang, 2013)	92 participants/12weeks	mobile phone text-messaging	Higher rate of smoking reduction in the intervention group (66% vs. 35%) compared to the control group. Also, higher rate in moving to quitting stages (52% vs. 18%)

continued on following page

Table 2. Continued

Area	Source	Samples/Duration	Intervention	Results
Schizophrenia	(Ben-Zeev et al., 2014)	33 individuals/1 months	Smart-phone App	Significant reductions in psychotic symptoms.
General (Each day they took at least one medication twice)	(de Oliveira, Cherubini, & Oliver, 2010)	18 elders/ 6 weeks	SMS reminder	A significant correlation between self-report and SMS acknowledgements
VitaminC	(Cocosila, Archer, Brian Haynes, & Yuan, 2009)	102 subjects/ 1 month	Smart-phone App. A Social network	Improvement in promptness and compliance to take the medication
Several Chronic disease (e.g. arthritis, diabetes, hypertension, and COPD)	(M. L. Lee & Dey, 2014)	12 old adults/ 10 months	Real-time sensor-based feedback(pillbox + in-home visual feedback	With real-time feedback, promptness, correctness of individuals increases and variability of their medication taking decreased, compared to their own baseline and to a control group
Cancer	(Spaulding et al., 2011)	375 patients/ NA	Video game	Significant improvement in adherence to medication and indicators of cancer-related knowledge and self-efficacy
Kidney Transplantation	(Burgess et al., 2011)	20 stable adult kidney transplants /a mean of 9.2 weeks.	Ingestible Sensor System (ISS)	Ingestible event marker detection accuracy and adherence was near 100%

resources to provide support to individuals with diabetes. Electronic devices have potential ability to help patients and clinician to fight this chronic illness. According to (Cramer, 2004), which is a literature search from 1966 to 2003, there are several studies demonstrating that using Medication Event Monitoring Systems (MEMS) and APREX are useful in improving adherence rates. A feasibility study in (Morak, Schwarz, Hayn, Schreier, & Member, 2012) with 59 individuals shows that medication adherence monitoring based on mHealth and Near Field Communication (NFC) technology is feasible. During 13 months of the study, patients with diabetes were monitored using 1,760 electronic blisters. Those devices were able to record events and transmit data via mobile phones. Leveraging e-Blisters and mHealth in (Brath et al., 2013) shows promising results. The authors in (Brath et al., 2013) claim that using Electronic blisters is not only accepted by patients but also can help to increase adherence in patients. This improvement happened even in patients with high baseline adherence and, subsequently, resulted in improvement of other indicators such as cholesterol concentrations and blood pressure. Unlike studies that use e-blisters, (Franklin, Greene, Waller, Greene, & Pagliari, 2008) and (Vervloet et al., 2012) utilize text messaging, in (Franklin et al., 2008), a randomized controlled trial with 126 patients suffering from diabetes, clinic visits were supported by daily text-messages generated using the Sweet Talk software system. The results show Sweet Talk was associated with improved patient's adherence and self-efficiency. Beside all previously mentioned studies, results of (Vervloet et al., 2012) are very impressive. They investigated the consequences of these text message reminders on adherence to oral anti-diabetics by collecting data in a randomized controlled trial involving 104 patients suffering from diabetes with suboptimal adherence to oral anti-diabetics. According to this study, within selected time windows patients who received text-message reminders took significantly more doses than patients didn't received reminders.

HIV

More than ten millions of people are suffering from HIV infection. By development of antiretroviral therapy (ART) by combining at least three antiretroviral drugs, HIV is not still a fatal disease, but a chronically controllable illness. Although, ART can help HIV infected patients to live healthier and longer, it is difficult to keep patient's adherence to ART. Non-adherence to this therapy specially in people who, previously have started taking them is a cause of resistance development (Bangsberg, Kroetz, & Deeks, 2007). Therefore, taking advantage of technology has the potential to help reinforce adherence and increase the chance of therapy in these patients.

A meta-analysis in (Horvath, Azman, Kennedy, & Rutherford, 2012) has been performed to determine effectiveness of mobile phone text-messaging in promoting adherence to ART in HIV infected patients. In their literature review which two randomized controlled trial in Kenya have been done for 48 to 52 weeks, they found that mobile phone text messaging at weekly intervals enhance adherence to ART, compared to standard care. Also, (Pop-Eleches et al., 2011) provides other evidence of effectiveness of text-messaging to promote HIV medication adherence. They suggest that text-message reminders are potential tools to achieve better treatment response in resource-poor settings. They studied 431 adult patients who had started ART within 3 months, daily or weekly SMS reminders that were sent to the intervention groups. The results of this study show that during the 48 weeks, 53% of patients receiving weekly text-message reminders achieved at least 90% adherence.

Other studies conducted, conclude having detail understating of patients' adherence patterns is applicable using diary-corrected MEMS data. They compare various methods of adherence assessment including therapeutic drug monitoring, medication event monitoring system (MEMS) caps, data of pharmacy refills, pill count, questionnaires and diaries on 26 patients and found MEMS data is significantly correlated with patient's self-report and therapeutic monitoring results. Also, authors of (Miller & Himelhoch, 2013) surveyed 100 HIV-positive patients attending an urban HIV outpatient clinic and found that vast majority of patients in the survey use their own mobile phone to promote adherence interventions to HIV medication.

Cardiovascular

Non-adherence to medications has been documented to occur in more than 60% of cardiovascular patients (Khonsari et al., 2014). Effectiveness of using SMS as a mean of reminding patient with acute coronary syndrome (ACS) has been shown in (Khonsari et al., 2014). They studied 62 patients with ACS and found that risk of being low adherent among the control group was 4.09 times greater than the intervention group. In (Park, Howie-Esquivel, Chung, & Dracup, 2014) a study has been conducted on the same disease for 90 patients during 30 days and the results show that text messaging increase adherence to antiplatelet therapy.

Mobile phone reminder not only increases the medication adherence in patient with acute coronary but also in patients with hypertension. According to (Patel et al., 2013) study on 48 patients, using mobile phone reminders cause significant improvement in average blood pressure and level of control after initiation of the study. Also, in (Burnier, Schneider, Chioléro, Stubi, & Brunner, 2001) study has been shown that using electronic monitoring led to normalizing blood pressure in more than 30% of the patients and in another 20% insufficient compliance was unmasked.

Asthma

Adherence to asthma medication tends to be very poor, with the reported rates of non-adherence ranging from 30 to 70 percent. In two different studies MDILogI and MDILogII shown to be effective to increase asthma medication adherence among children. In (Spaulding, Devine, Duncan, Wilson, & Hogan, 2011), using MDILogII caused the number of children who were using their medications correctly within four weeks, changed from 28.6% to 54.1%. Similarly, taking advantage of MDILogI among 26 children aged between 6 and 14 years led to significantly higher adherence in the intervention group (79% versus 58%) (Burgess, Sly, & Devadason, 2011). According to (Bender et al., 2000), compare to self-report or canister weight measures, electronic adherence monitoring are significantly more accurate. In addition to previous studies, successful usage of audio-visual reminder and text messaging has been reported by (Charles et al., 2007) and (Ostojic et al., 2005).

Using mobile application or SMS increase adherence to medication among patients with different disease. For example, (Franklin et al., 2008) shows that using text messaging led to a significantly higher rate of smoking reduction among the intervention group (66% vs. 35%). Effectiveness of text messaging is not only in chronic disease but also in simple regimens such as taking daily Vitamin C (WHO, 2003). Also, After 1 month of using a specific smart phone application in patients with schizophrenia, results demonstrate significant reductions in psychotic symptoms (Khonsari et al., 2014). Some studies such as (Spaulding et al., 2011) and (Park et al., 2014) using a smart phone application, provide a type of competition and show significantly improved treatment adherence and the accuracy of the drug intake time.

CHALLENGES AND FUTURE DIRECTIONS

Challenges associated with current medication management technologies can be divided into these major categories:

1. Context-Aware Interventions;
2. Scalability;
3. Reliability.

Context-aware intervention refers to the need for providing interventions that incorporate various contextual needs to the patient and environment. For example, most current interventions are static in nature. Current approaches provide fixed-time reminders. Scalability refers to the lack of approaches to adapt new sensor or sensor modalities with minimal computational efforts such as retraining of a machine learning algorithm. Reliability refers to the lack of accurate approach to detect medication intake. In this section, after presenting the existing machine learning and reliability assessment techniques, we discuss a medication management monitoring framework that addresses shortcomings of the state of the art technologies.

Data Analytics in Medication Monitoring

The utility of data analytics in healthcare delivery and interventions is growing. According to a survey, only 7% of health plans use predictive analytics, but more than half of the surveyed insurers plan on in-

corporating predictive analytics into their intervention targeting (Jones, 2014). Data analytics approaches have potential to assist medication management programs in many ways. In particular, they can be used for predictive modeling, personalized interventions, and clinical decision support.

The purpose of predictive modeling is to provide early interventions based on predictions made through machine learning algorithms. Data analytics and machine learning techniques provide tools to medication management programs to detect patients who are more likely to be non-adherent to their medication and predict the most effective intervention for each individual patient. There are several studies that use machine learning to construct a machine learning model to predict patient's future. For example, authors in (Son, Kim, Kim, Choi, & Lee, 2010) attempt to identify predictors of medication adherence in heart failure patients using Support Vector Machine (SVM) algorithms. It has been also shown that SVM achieves acceptable result in predicting adherence to medication in elderly patients with chronic diseases (S. K. Lee, Kang, Kim, & Son, 2013).

Data analytics can be also used to develop personalized interventions. Patients' response to clinical interventions varies according to different contextual attributes such as medical history, age, race, income and education level and many other factors. These factors result in different source of non-adherence and need distinctive interventions. For example, authors of (Raparelli et al., n.d.) have shown that medication adherence is related to socio-economic status of individuals. Therefore, it is needed to design medication management programs that are tailored toward individual patient's behavior, and predict adherent versus non-adherent patients. Cleary, the subsequent interventions need to be personalized according to the adherence level and socio-economic attributes of the people. In the context of medication intake monitoring, providing effective prompts or reminders is an important intervention strategy to enhance adherence to medications. Authors in (Vurgun et al., 2007) designed a reasoning system to detect elders' context and send appropriate prompts to elders to take their medication. The result of this study reveals that context-aware interventions are more effective than static rule-based interventions.

Data analytics approaches can be utilized for clinical decision support purposes. Using machine learning techniques, we can potentially predict most effective interventions. According to findings in (Sboner & Aliferis, 2005), it is possible to predict physician judgments. This finding is useful for designing expert clinical systems that help fine tune intervention strategies based on patient's physiological and contextual attributes. It means that the outcomes of the interventions (e.g., successful versus unsuccessful medicine reminder) can be used to continuously improve the predictive model and provide better interventions for each patient.

Reliability of Medication Adherence Monitoring Systems

Sensor-based technologies that detect medication intake can be divided into these categories:

1. Sensors embedded in pillboxes;
2. Sensors deployed in environment;
3. On-body or wearable sensors;
4. In-body sensors. The majority of the products available in the market fall within the first category.

While sensor-based technologies such as smart blister, bottle packs or RFID-enabled computer chip technology, can help increase medication adherence rate, they suffer from several weaknesses. These technologies are most beneficial when patients are motivated on taking their medication but often for-

gets to take the medication. Besides their cost and their limitation which should be physically attached to the medications, they are unable to draw reliable conclusion regarding patient's compliance. These systems provide no solution for acknowledging that a patient is in fact ingesting or not. For example, a patient may open the bottle without taking the medication but it activates the technology and counts as taking medication.

Approaches such as (Bilodeau & Ammouri, 2011), (Huynh, Sequeira, Daniel, & Meunier, 2010) use captured videos of the subject to detect medication intake. These vision-based methods are limited to in-home or in-building settings due to their requirement of taking a medication within the field of view of a camera.

Wearable sensors have been also used to assess medication intake. There are other approaches which try to identify wrist movement in order to determine in order to detect pattern of opening the pillbox and taking medication. For example, in (Chen, Kehtarnavaz, Fellow, Jafari, & Member, 2014), authors designed a wearable sensor network for medication adherence to confirm pill intake by identify the two consecutive actions of "twist-cap" and "hand-to-mouth".

In order to precisely measure patient's adherence, it needs to record when a pill is actually taken, we can rely on the approach of ingestible event marker (Eisenberger et al., 2013), (Belknap et al., 2013). These methods unlike RFID chips, which transmit a signal through the air, rely on the conductive characteristics of tissues to send confirming signals to the receiver. The adhesive patch worn by the patient can collect data and detect when a particular pill was taken. The signal then passes to a gateway such nearby wireless phone to transmit data to central server.

Conceptual Framework

As we described above, medical adherence in recent works was only about having sensors on the pillboxes; however, the previous techniques have some drawbacks such as the pillbox might have been opened by someone else, and none or more than one pill might have been taken by the patient. Many uncertainties will arise when the sensors are only placed on the pillboxes; therefore, we envision that future medication adherence monitoring and intervention systems will include smart sensors integrated with the patient's body, living environment, and medicine containers; besides, advance machine learning algorithms will be involved which provide reinforcement mechanisms such as context-aware prompting, adaptive rewarding, and motivational feedback to enhance compliance to medicine.

1. **Accurate Context Inference:** In this block we try to detect the current context including the activity, location, and the context of the environment. The inferences for the activity is to discriminate taking pills with other activities such as opening a bottle of water and drinking it, opening a chocolate bar and eating it, and etc. Detecting the location is to recognize that this is the patient taking the pill or someone else opened the pillbox by calculating the distance of patient from the pillbox. In this block some context-specific reminders will be delivered in order to remind the patient about his/her state such as sending a reminder to take the pill, sending a message that the patient has taken the pill successfully, and etc. It uses the patient's history and the sequence of the context. The goal for this block is to develop a learning approach in order to accurately recognize patient' activity and infer his/her context.
2. **Plug-n-Learn:** As we explained above we want to develop a learning approach for recognizing the patient's activity. Now suppose we have a sensor trained with that approach and we want to add

a new sensor in order to improve the accuracy of the system. Obviously we don't want to do the entire learning process from the scratch; therefore, we will develop a transfer learning approach in order to adapt the other sensor to our algorithm. By doing this new sensor can be easily adapted to the system, instead of starting over for each sensor we can train our sensor using existing model, and adding new sensors will contribute to improve the overall performance of the system.

3. **Reliable Medication Intake Measurement:** In order to keep track of the patient taking the medicine it is required to monitor his/her activities. There are some available solutions which have their own pros and cons.
   a. **Video Camera:** Its accuracy is high; however, it will violate the patient's privacy and it is not applicable in all situations.
   b. **Movement's Pattern Detection:** We can integrate it with available sensors; yet, the sensors will be learned in the labs using limited amount of patterns and the patterns won't be comprehensive.
   c. **Ingestible Event Marker:** It is a device for prescription which saves the time-stamps. Although it is accurate, it is not popular based on patient's amenability.

CONCLUSION AND FUTURE WORKS

In this paper, we studied medication adherence and the challenges associated with non-adherence from both technology development and clinical point of view. We discussed the impact of medication non-adherence and advantages of technology-driven solutions in chronic diseases; also, we highlighted different approaches for maintaining medication adherence as a means for enhancing clinical outcomes. We reviewed the state-of-the-art solutions for medication intake monitoring, discussed clinical utility of such technologies, and proposed a conceptual framework to address shortcomings of the current technologies. Discussions in this article can help researchers better identify unmet needs in the area of technology-based medication management from a multi-disciplinary point of view. In particular, our discussions in this paper highlight research gaps and future directions in the important research area.

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KEY TERMS AND DEFINITIONS

E-Health: An abbreviation of Electronic Health which is practicing medicine using electronic devices and communication.

Machine Learning: A field of computer science and artificial intelligence which enables computers to learn without being explicitly programmed.

Medication Adherence: The compliance of patients to the amount and process of medicine prescribed by their health care provider.

mHealth: An abbreviation of Mobile Health which is a subset of e-Health to practice medicine and patient health using mobile devices such as smart phone.

Remote Patient Monitoring: A technology which enable monitoring of patients outside of clinics.

RFID: An abbreviation of Radio-frequency Identification which enables identifying and tracking objects using electromagnetic fields.

Wearables: Sensors could be worn on body to acquire data of human context such as physical activity.

Chapter 13
Chaotic Function Based ECG Encryption System

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ABSTRACT

Remote health-care monitoring systems communicate biomedical information (e.g. Electrocardiogram (ECG)) over insecure networks. Protection of the integrity, authentication and confidentiality of the medical data is a challenging issue. This chapter proposed an encryption process having a 4-round five steps -encryption structure includes: the random pixel insertion, row separation, substitution of each separated row, row combination and rotation. Accuracy and security analysis of proposed method for 2D ECG encryption is evaluated on MIT-BIH arrhythmia database.

INTRODUCTION

The technology advancements in health care systems have dramatically increased the number of elderly patients. Remote health care monitoring of patients can decrease the traffic at specialized medical centers and provide reliable emergency services. The applications of remote healthcare technologies have also reduced the medical costs as well. In remote health care monitoring, body sensors acquire biological signals and other physiological parameters of the patient. The recorded signals and confidential side information or any urgent alerts are sent to the specialized hospital servers or medical cloud via the Internet. The security and privacy threats as well as crucial biomedical data integration issues are introduced with internet as a communication channel. Secure transmission of confidential biomedical data has become a common interest in both research and applications (Leeet al., 2008; Li et al., 2013; Hu et al., 2007). Accordingly, it is essential to employ a security protocol which will have powerful informa-

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tion security. One method to protect information from unauthorized eavesdropping is to use an encryption technique. The encryption is the process by which the information is transformed into intelligible form to construct the encrypted data/cipher data. Decryption is the process to reconstruct the original information from encrypted data.

An electrocardiogram (ECG) is an important physiological signal required to transmit in remote health care system used not only to analyze cardiac diseases, but also to provide crucial biometric information for identification and authentication. The ECG signal which monitors the electrical activity of heart is usually characterized by its various set points (P, QRS, T) and intervals (PR interval, QT interval and RR interval) that reflects the rhythmic electrical depolarisation and repolarisation of atria and ventricles (Singh et al., 2014). With an ECG signal, various arrhythmias, degree of myocardial damage and the structure of the atrium and ventricle can also be analyze and identified. While transmitting biomedical information such as ECG through the internet, protection of patient's privacy and confidentiality is a challenging issue (Jero et al., 2015). The methods of computer software should guarantee the information security on the server and inside the communication channels. Several researchers have proposed various security protocols to secure patient confidential information (Enginet al., 2005; Ibaida et al., 2013). The Encryption algorithms based techniques are commonly used to secure data during the communication and storage. As a result, the final data will be stored in encrypted format (Wang et al., 2010; Maglogiannis et al., 2009).

In 1998, Fridrich proposed the chaos-based approach for image encryption (Fridrich 1998), since then there have been increasing researches on chaotic encryption techniques. Chaos based algorithms are developed and considered as the core of encryption processes due to ergodicity, mixing property, the high sensitivity of chaotic systems to parameters and initial conditions (Zhu et al., 2011; Fu et al., 2011; Zhu et al., 2012). Recently, conventional logistic map and tent map based1D chaotic maps, and coupled map lattice based 2D chaotic maps have been developed for substitution-only encryption methods (Soma et al., 2013; Radwan et al., 2016). Chaos-based algorithms have shown exceptionally superior properties in aspects such as security, speed and complexity and computational cost.

Many researchers have proposed ECG signal processing techniques by treating 1D ECG signal as a 2D image and exploiting the inter- and intra-beat correlations by encoder (Chou et al., 2006; Wang et al., 2008). The "cut and align beats approach and 2D DCT" and "period normalization and truncated SVD algorithm" are available preprocessing techniques to get good compression results in ECG (Wei et al., 2001; Lee et al., 1999). This kind of preprocessing are also often associated with the use of state-of-the-art image encoders, like JPEG2000. In (Chou et al., 2006), the authors proposed a lousy compression technique based on converting the 1D ECG signal into 2D ECG image. A period sorting preprocessing technique was introduced, which consists of a length-based ordering of all periods. The authors exploited inter and intra-beat dependencies to compress irregular ECG signals. The technique is based on the supposition that periods with similar lengths tend to be highly correlated, which is not a very strong assumption and may not be valid for pathological ECG signals. Another preprocessing technique consists of QRS detector, period length normalization, period preprocessing and image transform was proposed in (Filho et al., 2008).

This chapter introduces a simple and efficient chaotic system approach using a combination of two existing 1D chaotic maps to encrypt 2D ECG signal. Security analysis reveals the performance of proposed method for 2D ECG encryption. ECG is encrypted in a lossless manner so that after reconstruction there will be zero difference between the original and the reconstructed ECG signal.

MATERIAL AND METHODS

In the emerging field of medical engineering, research subjects like cardiac arrhythmia detection, heart rate variability, cardiovascular and pulmonary dynamics, artificial intelligence based medical decision support and ECG compression, etc. are of major interest (Singh et al., 2012a; Singh et al., 2012b). The Massachusetts Institute of Technology (MIT) supplies some valuable resources for such research projects. These resources include databases containing recorded physiological signals and software for analyzing, viewing and creating such recordings. In the present study, ECG samples from Arrhythmia Database (http://ecg.mit.edu) have been taken for investigation of the efficiency of the proposed method. The Database contains 48 half-hour excerpts of two-channel ambulatory ECG recordings, obtained from 47 subjects studied by the BIH Arrhythmia Laboratory. The 11-bit resolutions over 10 mV range with sampling frequency of 360 Hz per sample channel were recorded.

PROPOSED TECHNIQUE

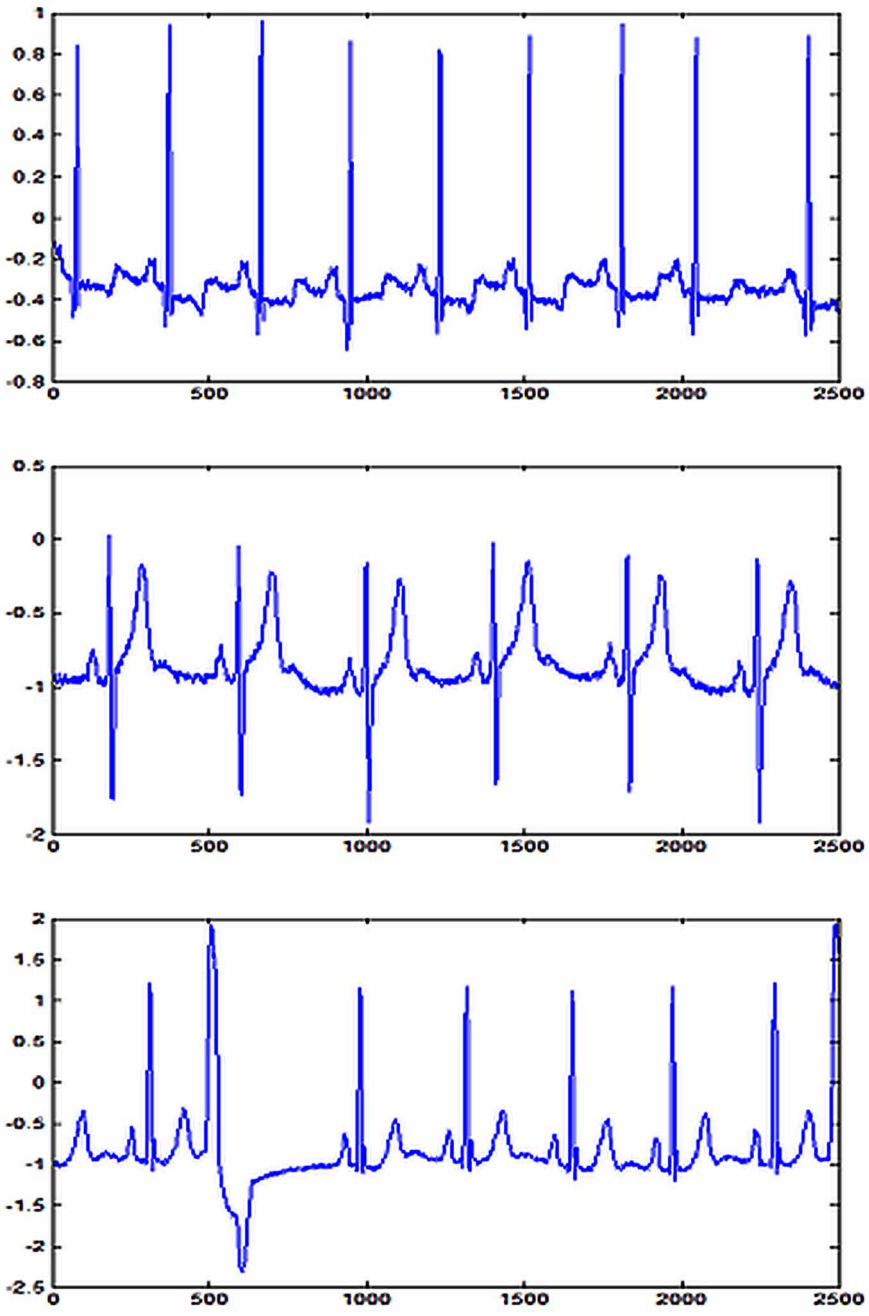
1D ECG to 2D ECG Signal

Formation of 2D ECG signal broadly consist steps: QRS detection, ECG segmentation, pre-processing, and transformation (Chou et al., 2006; Filho et al., 2008). First stage of process is the acquisition of ECG data from standard MIT-BIH arrhythmia database, for comparative analysis and validation of proposed technique. Details of this database are already discussed in section 2. The second stage involved QRS detection and R peak based ECG segmentation. The peaks of QRS complex were detected to identify each RR interval and to map 1D ECG signal to 2D ECG image, Many QRS detection algorithms have been proposed in literature and in the present work the RR interval time series were estimated by the Tompkins method proposed in (Pan et al., 1985)for its simple implementation and high detection accuracy In ECG segmentation, ECG samples from one R peak to next R peak are retained in one segmented block and each block (Row wise) is vertically stacked to form 2D ECG image(Chou et al., 2006). The segmentation and reassembling of ECG signal as an image was accomplished by choosing R peak as its delineation boundary, leaving half peak at each end of the row. Further the row oriented assembly was performed by retaining the ECG samples from one R-peak to the next R-peak. Then this 2D ECG will be encrypted by 2D chaotic method. Figure 1 shows the ECG samples for the record of 100, 117 and 119 from MIT-BIH arrhythmia ECG database. Figure 2 shows the result of 2D array of row wise stacking with their histograms in Figure 3. The resulted image was encoded through standard bitmap encoder which provides progressive quality. The resulted encrypted 2D ECG can be transmitted over cloud or a base station from remote place and can be reconstructed at receiving end. The first stage of reconstruction process is to split the side information and encrypted ECG from the merged data coming from communication channel. The next stage of reconstruction process is R peak based incorporation and estimation of raw ECG data.

Chaos Based ECG Encryption

To investigate the proposed chaotic system in information security for ECG, using the Logistic Tent System as its example, we used 1D chaotic image encryption algorithm for ECG encryption.

Figure 1. First 2500 ECG samples of data 100, 117, and 119 of MIT-BIH arrhythmia database



The proposed algorithm has a 4-round-encryption structure. Each encryption round includes five steps: the random pixel insertion, row separation, substitution of each separated row, row combination and rotation with 90° in anticlockwise direction (Figure 4). The algorithm first inserts a random pixel in the beginning of each row in the original 2D ECG, separates each row into a 1D data matrix, applies a substitution process to change data values in each 1D matrix, combines all 1D matrices back into a 2D

Figure 2. 2D ECG formation of complete data records 100, 117, and 119 of MIT-BIH arrhythmia database

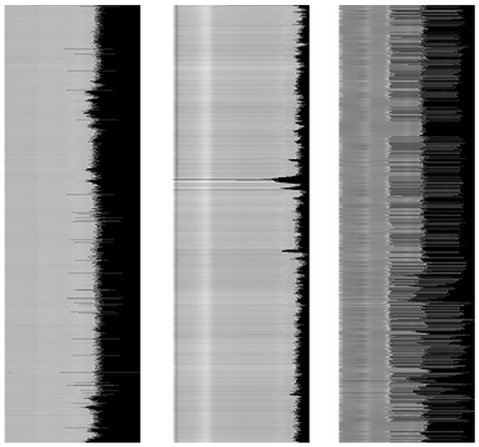
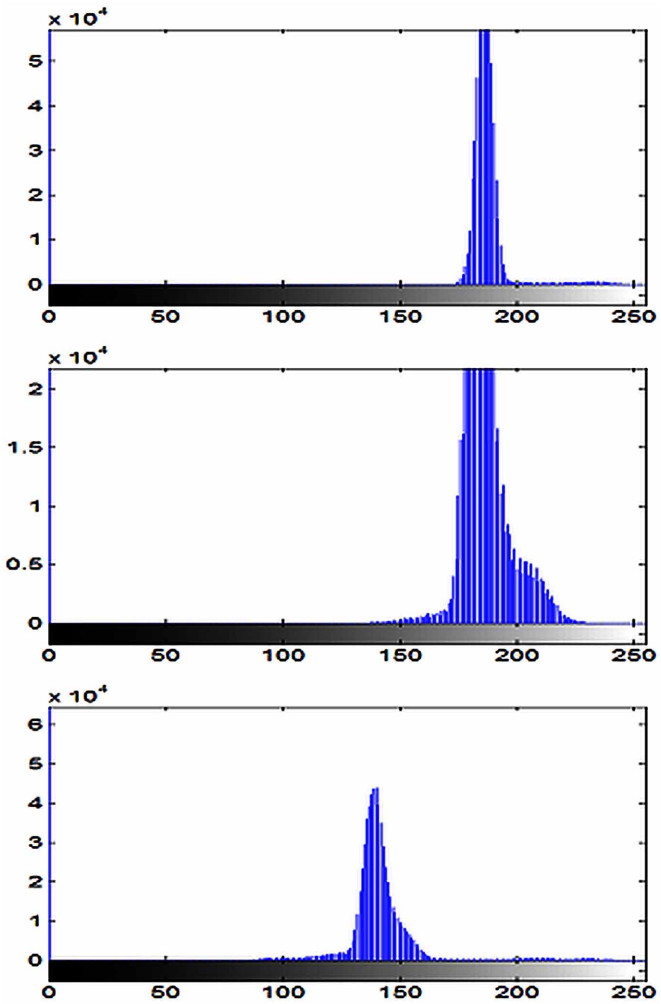


Figure 3. Histogram of 100, 117, and 119 data records of MIT-BIH arrhythmia database



data matrix according to their row positions in the original 2D ECG, and then rotates the 2D matrix 90° anti clockwise. Repeating these processes four times obtains the final encrypted ECG (Figure 5). The proposed algorithm is able to transform original 2D ECG randomly into different noise-like encrypted images with excellent confusion and diffusion properties.

Figure 4. Description of proposed ECG encryption and decryption technique

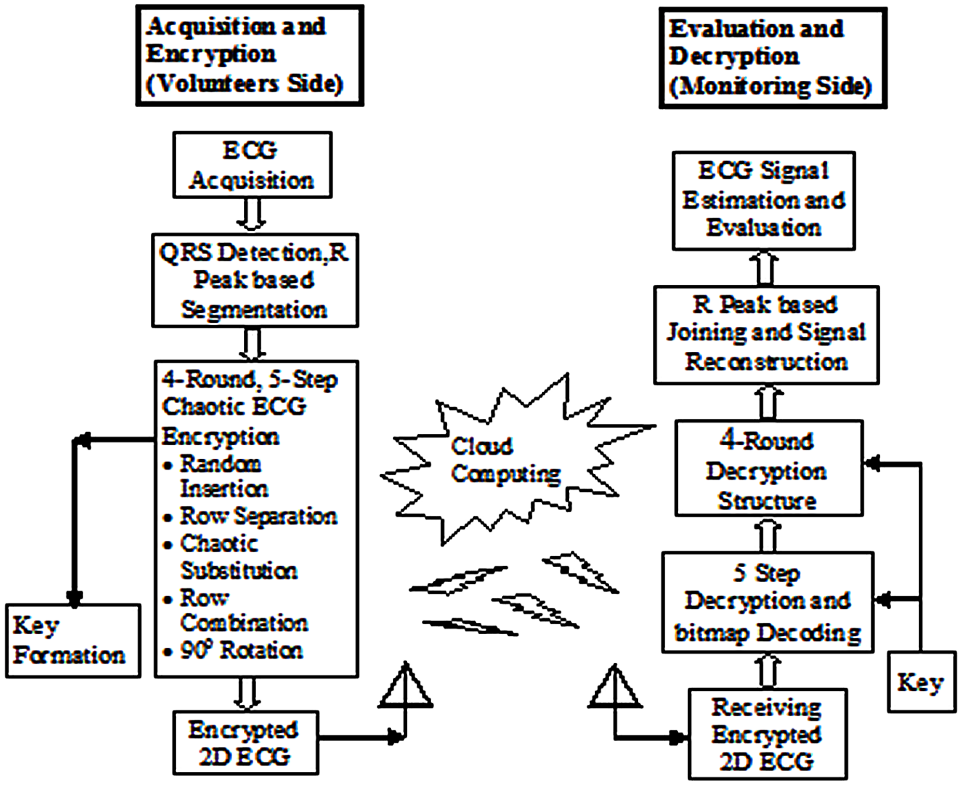
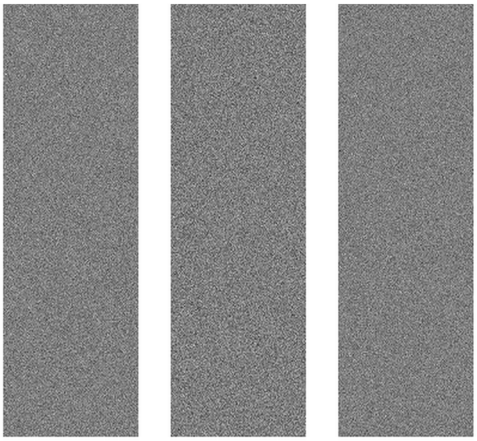


Figure 5. Encrypted ECG of complete data records 100, 117, and 119 of MIT-BIH arrhythmia database



Random ECG Sample Insertion

One ECG sample with a random value is inserted in the beginning of each row in the original 2D ECG signal.

$$PE(x,y)=\begin{cases} Rand(x) & y=1 \\ E(x,y-1) & otherwise \end{cases}$$

where *E* is the original 2D ECG with size of *M X N; PE(x,y)*is the processed ECG with size of*MX(N+1), 1≤x≤M, 1≤y≤N+1;*Random function *Rand(x)* produces random numbers.

Chaotic Substitution

The each row of PE is separated row by row into 1D array

$row_i(j)$=PE(x,y)

where row_i is the *ith* 1D row array with length of *(N+1)*

The chaotic substitution process replaces the samples in each 1D row array row_i by the following equation:

$$\phi_i(j)=\begin{cases} row_i(j) & j=1 \\ \phi_i(j-1)\oplus row_i(j)\oplus\left(\left\lfloor S_k(i,j)X10^{10}\right\rfloor \bmod 256\right) & otherwise \end{cases}$$

where $\oplus$ denotes the bit-level XOR operation, $\lfloor . \rfloor$ is the floor function, and $S_k(i,j)$ is the random sequence for the *kth* (k = 1, 2, 3, 4) encryption round, which is generated by the Logistic-Tent system(*LTS*) as defined by the following equation:

$$S_k(i,j)=\begin{cases} S_1(0,0) & i=0,j=0,k=1 \\ S_2(M,0) & i=0,j=0,k=3 \\ S_{k-1}(N,0) & i=0,j=0,k=2,4 \\ LTS(r_0,S_k(i-1,0) & i>1,j=0 \\ LTS(r_k,S_k(i,j-1) & i>1,j>0 \end{cases}$$

where r_k and $S_k(0,0)$are the parameter and initial value in the *kth* encryption round, respectively; $S_1(0,0)$, r_o and r_k are defined by users.

We utilized the Logistic and Tent maps as seed maps to form the LTS system, as defined in the following equation:

$$X_{n+1} = \begin{cases} (rX_n(1-X_n) + (4-r)X_n / 2) \bmod 1 & X_i < 0.5 \\ (rX_n(1-X_n) + (4-r)(1-X_n) / 2) \bmod 1 & X_i \geq 0.5 \end{cases}$$

where parameter *r*is with range of (0,4).

Row Combination

After changing data values in each row matrix in the 1D substitution process, the row combination is an inverse process of the row separation and random insertion. It combines all 1D matrices back into a 2D matrix, and removes the first pixel in each row. The process is defined in the following equation:

$$C(i,j) = \phi_i(j+1)$$

where *C* is the 2D matrix with size of *M X N* and *j*≤*N*.

Rotation

The process is to rotate the 2D ECG matrix 90 degrees counter clockwise as following equation:

$$E(i,j) = C(j, N-i+1)$$

After the first encryption round, E is the feedback to the input of the random pixel insertion process. Final encrypted ECG obtained by four encryption rounds. In this algorithm, security keys are composed of six portions: the LTS parameter (r_0) and initial value $S_1(0.0)$, the LTS parameters in each encryption round (r_1, r_2, r_3, r_4).

In decryption stage, the authorized users should have correct security keys and follow the inverse procedures of encryption. The inverse1D substitution is defined in the following equation:

$$R_i(j) = B_i(j-1) \oplus B_i(j) \oplus \left(\left\lfloor S_k(i,j) X 10^{10} \right\rfloor \bmod 256 \right)$$

RESULT AND DISCUSSION

Having described the proposed encryption technique, we present in this section the performance evaluation and simulation parameters. The proposed method encrypt ECG signal with excellent confusion and diffusion properties and high security level. These can evade the confidential medical information from leakage.

Accuracy Analysis

Percentage Root Mean Square Difference (PRD)

It is a measure of acceptable fidelity and degree of distortion introduced during encryption and decryption algorithm

$$PRD(\%) = 100 \times \sqrt{\frac{\sum_{n=1}^{N} (X_s(n) - X_r(n))^2}{\sum_{n=1}^{N} (X_s(n))^2}}$$

where $X_s(n)$ and $X_r(n)$ are the original and decrypted signal respectively of data length N.

Proposed method encrypt the ECG signal lossless way (PRD=0) for all the data records of MIT-BIH database (Table 1). From juridical and clinical point of view, the use of lossless encryption/decryption process is very much important.

Histogram Analysis

Histogram analysis shows the distribution of pixel values across the whole image where peaks for some specific gray scale value appear. For effectively encrypted images this distribution should be flat (Fuet al., 2011; Radwanet al., 2016). A visual investigation of the proposed method can be observed from the histograms of 2D ECG before and after the encryption (Figure 3 and Figure 6). After the encryption process all histograms became similar to a uniform distribution, independent of the nature of the original histogram, as expected for a strong encryption scheme.Figure 6 shows all encrypted ECG signals are noise- like ones.

Security Analysis

There are several statistical methods for evaluating the noise-like encrypted images, including the information entropy and correlation analysis. A good encryption should resist all kinds of known attacks, it should be sensitive to the secret keys, and the key space should be large enough to make brute-force attacks infeasible. Some security analysis has been performed on the proposed encryption scheme.

Information Entropy

Information entropy (IE) is a measure of uncertainty in a random variable and evaluates the randomness of an image (Fuet al., 2011; Zhuet al., 2012). Higher the IE ofan image means the excellent random property.

$$IE = \sum_{l=0}^{F-1} P(L = l) \log_2 \frac{1}{P(L = l)}$$

Table 1. Security analysis of proposed technique on MIT BIH arrhythmia database

Data	Correlation Coefficient (with -90^0 Rotation)	Correlation Coefficient (with $+90^0$ Rotation)	Original Information Entropy	Encrypted Information Entropy	Decrypted Information Entropy	PRD
100	0.006	-0.0014	3.9375	7.9914	3.9375	0
101	-0.0096	-0.0105	4.4612	7.993	4.4612	0
102	-0.0036	0.0071	4.6856	7.992	4.6856	0
103	-0.0022	-0.0144	4.6233	7.9922	4.6233	0
104	0.0005	-0.0034	4.8545	7.9928	4.8545	0
105	-0.0057	0.0082	4.2095	7.9947	4.2095	0
106	-0.0042	0.0068	4.7057	7.992	4.7057	0
107	0.0041	-0.0003	6.5215	7.9916	6.5215	0
108	-0.002	0.0017	3.3504	7.995	3.3504	0
109	-0.0033	-0.0038	5.4018	7.9927	5.4018	0
111	0.0029	0.0054	4.9472	7.9916	4.9472	0
112	-0.002	0.0002	5.1214	7.9903	5.1214	0
113	0.0139	0.0085	5.2189	7.992	5.2189	0
114	0.0034	0.0022	4.3191	7.9922	4.3191	0
115	0.0071	-0.0037	4.9676	7.9928	4.9676	0
116	0.0079	0.0023	5.3086	7.9912	5.3086	0
117	0.0099	-0.0006	5.021	7.9913	5.021	0
118	0.0063	0.0035	5.5502	7.9933	5.5502	0
119	0.0037	0.0106	4.6586	7.9944	4.6586	0
121	-0.002	0.0033	5.3168	7.9919	5.3168	0
122	0.0038	0.0018	4.8485	7.9917	4.8485	0
123	0.0017	-0.0056	4.4171	7.9937	4.4171	0
124	-0.0034	-0.0082	4.8685	7.991	4.8685	0
200	-0.0065	0	3.7793	7.9951	3.7793	0
201	-0.0015	0.0043	3.551	7.9935	3.551	0
202	-0.0006	0.0135	4.1958	7.9935	4.1958	0
203	0.0031	-0.0044	2.5367	7.9973	2.5367	0
205	0.0128	-0.0003	3.7393	7.9916	3.7393	0
207	-0.004	-0.0082	3.7522	7.995	3.7522	0
208	0.0009	-0.0131	4.6145	7.9945	4.6145	0
209	0.0107	-0.0027	4.708	7.9913	4.708	0
210	-0.0043	0.0013	3.1032	7.9963	3.1032	0
212	0.011	0.0092	5.3862	7.993	5.3862	0
213	0.0013	-0.0015	5.8204	7.9927	5.8204	0
214	-0.0078	-0.0113	4.2264	7.9944	4.2264	0
215	-0.0061	-0.0028	3.8604	7.9948	3.8604	0
217	-0.0041	-0.0102	6.1748	7.9921	6.1748	0

continued on following page

Table 1. Continued

Data	Correlation Coefficient (with -90⁰ Rotation)	Correlation Coefficient (with +90⁰ Rotation)	Original Information Entropy	Encrypted Information Entropy	Decrypted Information Entropy	PRD
219	0.0023	0.0033	4.3868	7.994	4.3868	0
220	0.0001	-0.0036	4.3864	7.9921	4.3864	0
221	-0.0024	-0.0029	3.632	7.9947	3.632	0
222	0.0028	0.0042	4.3512	7.9926	4.3512	0
223	0.0003	0.0033	3.4806	7.9954	3.4806	0
228	0.0024	-0.0073	3.6248	7.9957	3.6248	0
230	0.0027	-0.0031	4.9464	7.9912	4.9464	0
231	-0.0122	0.0034	3.7568	7.9942	3.7568	0
232	-0.0039	0.0021	2.618	7.9965	2.618	0
233	-0.0053	0.0016	4.9541	7.9945	4.9541	0
234	-0.0014	0.0032	4.8296	7.9911	4.8296	0

where F is the gray level and $P(L = l)$ is the percentage of pixels with value equal to *l*. For a gray scale image maximum IE is 8. Table 1 shows the IE of original, encrypted and decrypted 2D ECG signals of MIT BIH arrhythmia database. IE values of original and decrypted signal are similar for all the data records. Whereas IE values of encrypted signal are very high (>7.9) for all the records which shows the level of randomness in encrypted signals.

Correlation

To verify the robustness of the proposed algorithm against statistic attacks, Pearson correlation coefficients of neighbouring (adjacent) pixels in the original and encrypted 2D ECG signals have been analyzed. The objective of encryption procedure is to transform highly correlated original images in to noise-like encrypted images with low correlations (Fuet al., 2011; Zhuet al., 2012).

The correlation can be computed by

$$corr_{xy} = E\left[(x-\mu_x)(y-\mu_y)\right] / (\sigma_x \sigma_y)$$

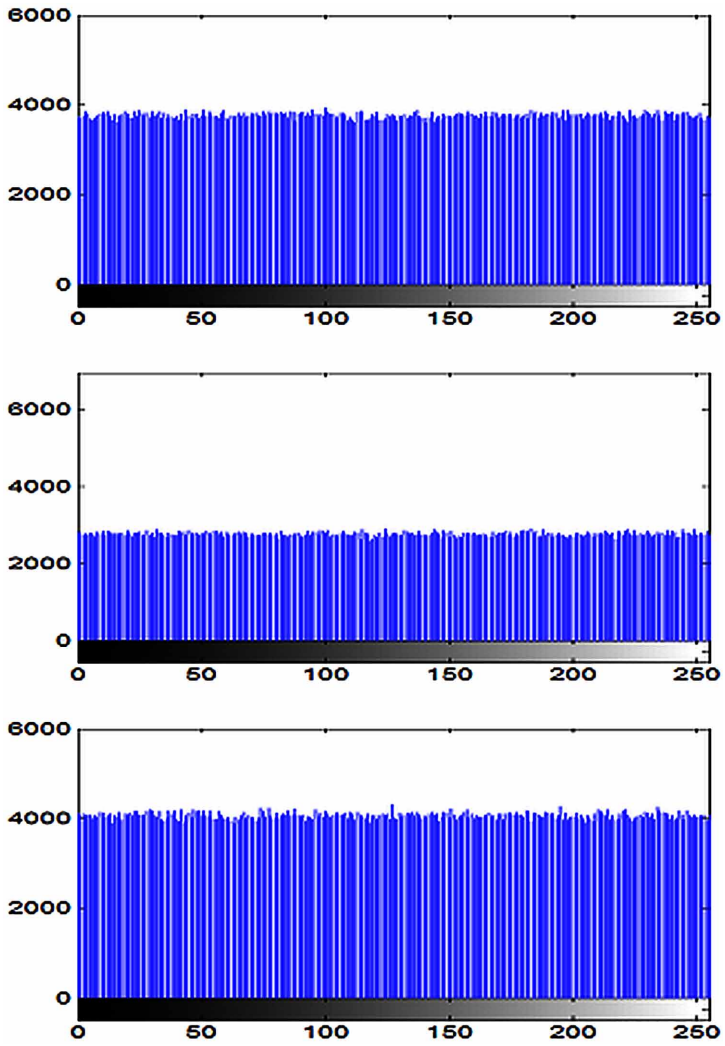
where μ and σ are the mean value and standard deviation, respectively.

Table 1 validate that the proposed method generated encrypted signal with sufficiently low correlation of adjacent pixels.

Security Key Analysis

Six parameters of encryption algorithmr_0, r_1, r_2, r_3 and $S_1(0,0)$ form the key space. In the key sensitivity test, ECG data from samples 100, 117 and 119 (Figure 1) are encrypted using proposed algorithm with an initial key set (K_1) as

Figure 6. Histograms of encrypted 100, 117, and 119 data records of MIT-BIH arrhythmia database



s_1=0.6;r_0=3.997;r_1=3.99;r_2=3.96;r_3=3.77;r_4=3.99;

Figure 7 and 8 show the decrypted signals and corresponding histograms respectively for data samples 100, 117 and 119 with keys K_1, and then another key set K_2 is generated with a small change applied to $r_0$while keeping all other parameters unchanged as

s_1=0.6;r_0=3.9970000001;r_1=3.99;r_2=3.96;r_3=3.77;r4=3.99;

Figure 9 and 10 show the decrypted signals and corresponding histograms respectively for data samples 100, 117 and 119 with keys K_2. It shows the high key sensitivity of the proposed method in both the encryption and decryption processes. Original signal can be reconstructed using correct key (K_1) only. Even a small change in the security key (e.g. K_2) will lead to the erroneous decryption process.

Figure 7. Decrypted ECG of complete data records 100, 117, and 119 of MIT-BIH arrhythmia database with key $K_1(s_1=0.6; r_0=3.997; r_1=3.99; r_2=3.96; r_3=3.77; r_4=3.99)$

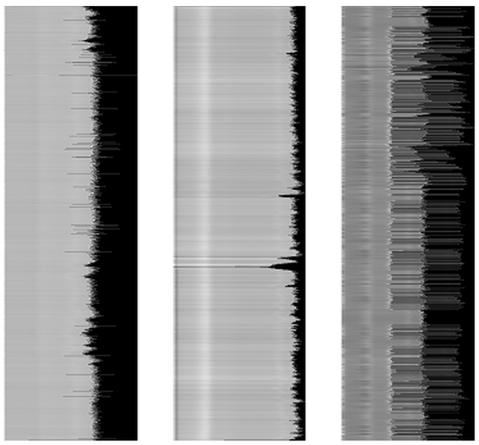


Figure 8. Histograms of decrypted 100, 117, and 119 data records of MIT-BIH arrhythmia database with key $K_1(s_1=0.6; r_0=3.997; r_1=3.99; r_2=3.96; r_3=3.77; r_4=3.99)$

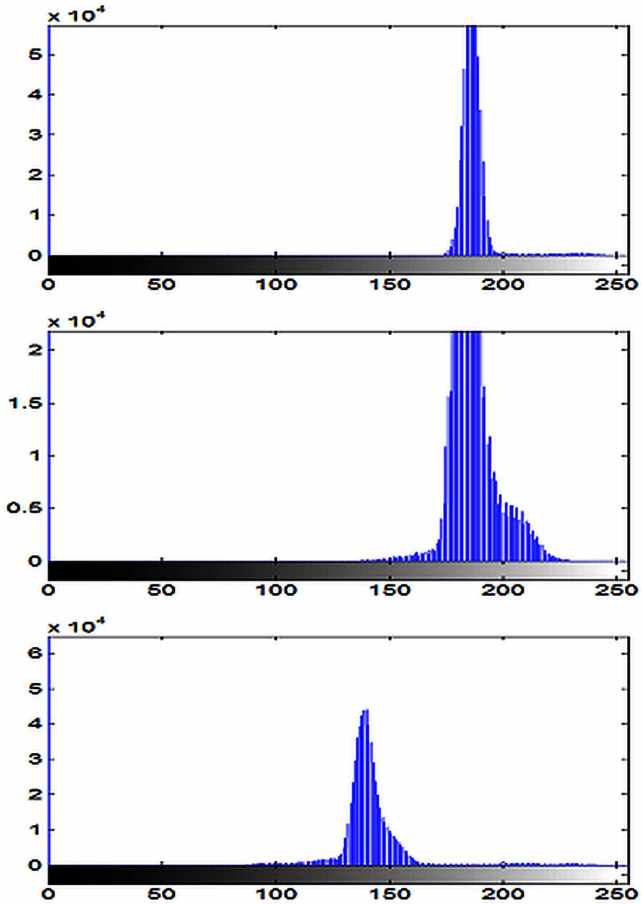


Figure 9. Decrypted ECG of complete data records 100, 117, and 119 of MIT-BIH arrhythmia database with wrong key K_2 (s_1=0.6; r_0=3.9970000001; r_1=3.99; r_2=3.96; r_3=3.77; r_4=3.99)

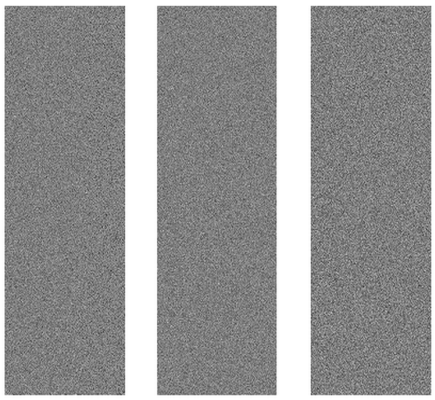
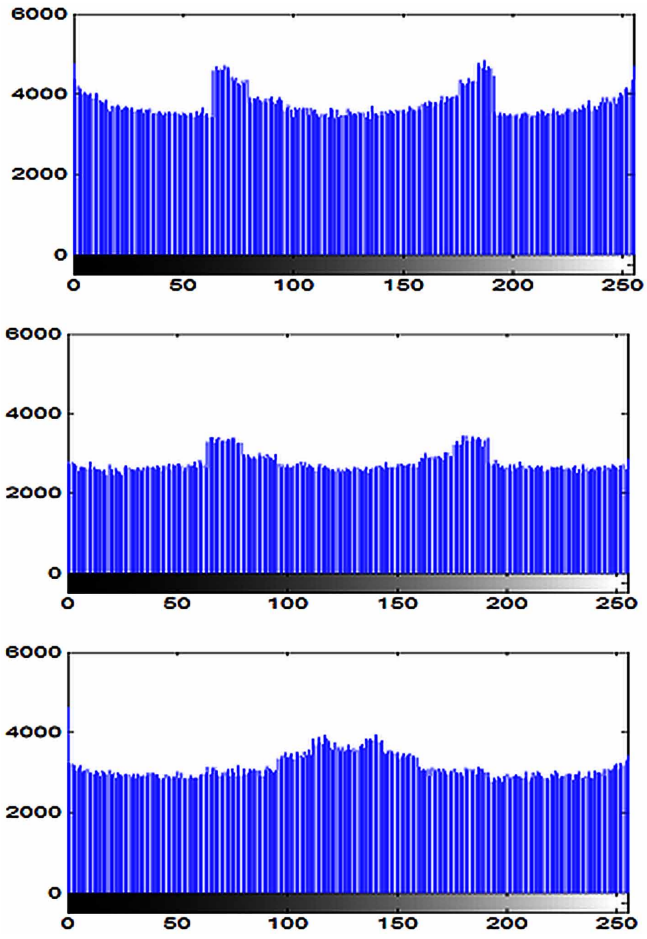


Figure 10. Histograms of decrypted 100, 117, and 119 data records of MIT-BIH arrhythmia database with wrong key K_2 (s_1=0.6; r_0=3.9970000001;r_1=3.99; r_2=3.96;r_3=3.77; r_4=3.99)



CONCLUSION

In view of E-health recognition and patient privacy, it is essential to encrypt biomedical signals. In particular, medical security is required to provide; confidentiality, integrity and authentication. In this chapter, we develop a chaos-based encryption system for applications to 2D ECG signals.

Excellent diffusion and confusion properties of proposed method can resist the chosen-plaintext attack. Particularly, encrypted signals of the proposed algorithm are random, non- repeated and unpredictable, even using the same set of security keys. The algorithm can also withstand the data loss and noise attacks. While arithmetic operations based encryption approaches have to deal round-off errors, our algorithm recover exact original information after an encryption/decryption procedure. The novelty of this method is that the reconstructed signal is an exact replica of the original one and has an excellent key sensitivity.

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Chapter 14
Mastering Electronic Health Record in Global Health Care

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ABSTRACT

This chapter describes the overview of electronic health record (EHR); the trends and issues with EHR; EHR and clinical decision support system (CDSS); the trust and privacy concerns of EHR systems; and the significance of EHR in global health care. EHR systems are very important in health care settings and have the potential to transform the health care system from a mostly paper-based industry to the one that utilizes the clinical data and other pieces of information to assist health care providers in delivering the higher quality of care to their patients. EHRs and their ability to electronically exchange health information can help health care providers effectively provide higher quality and safer care for patients while creating tangible enhancements in global health care.

INTRODUCTION

Electronic health record (EHR) contains a diverse set of information types, including patient demographics, symptoms, vital signs, laboratory tests, and treatments (Huang, Dong, & Duan, 2015). EHR is an important part of an efficient and sustainable health system (O'Sullivan, Billing, & Stokes, 2011). EHR systems promise to optimize the delivery of high-quality health care in health care settings (Halford, Obstfelder, & Lotherington, 2010). The integrated EHR that makes the patient's clinical data instantaneously available to all health care providers throughout a given episode of care, regardless of the service location or health care provider, holds great promise (Sherer, Meyerhoefer, Sheinberg, & Levick, 2015). Clinical decisions are taken based on medical records made electronically or by hand in paper, medical examinations, and physical evaluations having the close contact with the patient (Peixoto, Domingues, & Fernandes, 2016).

The rapid development in information technology (IT) through the utilization of data-intensive EHR can enhance the health care processes (Taweel, 2016). With the advent of EHR, patient health information has become more widely available to health care providers and has broadened its health care utilization

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beyond individual patient care (Caine & Tierney, 2015). EHR can contain the medical history and manage the medical treatment plans for patients in an effective manner (Amorim & Miranda, 2016). Use of the EHR can improve the quality of health information available to the medical team caring for a patient in any health care organization (Yontz, Zinn, & Schumacher, 2015). Xhafa et al. (2015) indicated that with the development of cloud computing, EHR system has appeared in the pattern of patient-centric perspective, in which patients can store their personal health records at a remote cloud computing server and selectively share them with physicians for convenient medical care.

This chapter aims to bridge the gap in the literature on the thorough literature consolidation of EHR. The extensive literature of EHR provides a contribution to practitioners and researchers by explaining the applications of EHR in order to maximize the health care impact of EHR in global health care.

BACKGROUND

In recent years, one of the most important applications of IT in the field of health care is EHR (Farzandipour, Sadoughi, Ahmadi, & Karimi, 2010). A growing capacity of IT in the collection, storage, and transmission of information has added a great deal of concerns since electronic records can be accessed by numerous consumers at various locations (Farzandipour, Ahmadi, Sadoughi, & Karimi, 2011). The digitization of health care typically has emphasized electronic records for patients (Raghupathi & Kesh, 2009). Advancements in information and communication technology (ICT) have led to the development of various forms of EHR to support general practitioners and health care providers in capturing, storing, and retrieving the routinely collected medical records and clinical information for the optimal primary care and translational research in modern health care (Bonney, 2016).

The increase in EHR implementation in all treatment venues has led to the greater demands for integration across health care practice settings with different work cultures (Sherer et al., 2015). EHR implementations may present challenges to patient safety and health care workflow (Colligan, Potts, Finn, & Sinkin, 2015). With growing adoption and use, EHR represents a rich source of clinical data that offers many benefits for secondary use in biomedical research (Rasmussen, 2014). The collected health care data plays a crucial role to ensure the effective statistical analysis in the health care organizations (Arfaoui & Akaichi, 2016). Wuyts et al. (2012) indicated that EHR systems are being developed to enable the electronic storing and sharing of medical data among health care practitioners. Patient records are the central parts of health care and hospitals (Bossen, 2011). EHR presents an opportunity to access the large stores of data for health care research (Griffith et al., 2015).

Many patients are often associated with various types of health-related records, needing care and attentions (Hamunyela & Iyamu, 2016). EHR includes demographics, medical history, medication and allergies, immunization status, laboratory test results, radiology images, and billing information (Bai, Dai, & Li, 2014). When EHR improvements are planned, it is important to recognize the diversified needs of the health care professionals who deliver care (Bramble et al., 2013). The coordination and communication tools provided by the EHR are the important source of various opportunities for the effective translation of clinical interventions (Fraser, Christiansen, Adsit, Baker, & Fiore, 2013). EHR includes sensitive health information and if it is integrated among health care providers, health care data can be accessible from different sources (Win & Fulcher, 2007).

ELECTRONIC HEALTH RECORD IN GLOBAL HEALTH CARE

This section emphasizes the overview of EHR; the trends and issues with EHR; EHR and CDSS; the trust and privacy concerns of EHR systems; and the significance of EHR in global health care.

Overview of Electronic Health Record

Electronic health record (EHR) systems are the primary methods of storing patient data (Blumenthal & Glaser, 2007) and cover several hospital-based departments toward enabling an analysis of the clinical process in the health care industry (Alpuim, Esteves, Pereira, & Santos, 2016). With advances in IT, the accuracy and security of EHR and personal information can be vastly improved (Passi & Zhao, 2015). EHR represents a rich source of clinical information, collected at minimal cost, in large numbers of people and with potential for linkage to other data sources (Weber, Mandl, & Kohane, 2014). The accessibility of health care data coupled with the effectively integrated analytic methods can provide health care organizations with the essential components of a solid framework for improving health care performance (Pate & Swofford, 2016).

EHR holds the potential to significantly improve the quality of care in the long-term care facilities (Cherry, Carter, Owen, & Lockhart, 2008) and reduces medical liability claims and potentially justifies premium credits from liability insurers (Victoroff, Drury, Campagna, & Morrato, 2013). EHR offers the opportunity to ascertain clinical outcomes at large scale and low cost, thus facilitating cohort studies, quality of care research, and clinical trials (Rubbo et al., 2015) and allows the health information to be rapidly gathered and presented to physicians (Weber, Bloom, Pierdon, & Wood, 2008). EHR enhances the patient-physician communication in health care settings (Migdal, Namavar, Mosley, & Afsar-manesh, 2014), improves the quality of care, allows for integrated information, and helps prevent the lost and duplicated records as well as occurrence of administrative errors (Al-Fedaghi, 2014).

DesRoches et al. (2008) indicated that four domains of functionality in EHR systems include recording patients' demographic and clinical data; viewing and managing results of laboratory tests and imaging data; managing order entry, including electronic prescriptions; and supporting clinical decisions, which includes drug interaction or contraindication warnings. Computerized physician order entry systems, which allow health care providers to directly enter all orders into the computer system, are dependent upon comprehensive EHR systems (Harrington, Kennerly, & Johnson, 2011). Peterson et al. (2011) stated that return on investment (ROI) concerns regarding EHR are a major barrier to the technology's adoption. In order to be able to utilize the EHR-related technology to provide better health care, physicians need to be able to activate their knowledge through it (Noteboom & Qureshi, 2014).

EHR includes the numerous combinations of health information technology (health IT) applications, ranging from a grouping of basic functionalities to a more comprehensive set of functions (Fareed, Bazzoli, Mick, & Harless, 2015). Understanding the impact of health IT on the patient-physician interaction is essential to design the effective EHR (Asan, Smith, & Montague, 2014). EHR training program effectively increases physicians' performance when applying the EHR (Clarke, Belden, & Kim, 2014). Recent developments in networking and computing technologies and the expansion of the EHR system have enabled the possibility of online collaboration among geographically distributed medical personnel (Maglogiannis, Delakouridis, & Kazatzopoulos, 2006). EHR has the potential to significantly benefit medical research through the reuse of patient data gathered during routine clinical care (Jensen, Jensen, & Brunak, 2012).

EHR has been used in the different types of research: to evaluate quality and performance of health care providers for managing patients, to monitor national trends in mortality and morbidity, along with intra and inter-country comparisons of health care policy (Chung et al., 2014) and to generate outcome data for prospective studies and clinical trials. The adoption of EHR is explained by the intention of the health care organization to improve organizational performance through the fit between its clinical or other activities and EHR system (Gan, 2015). For example, the low rates of obesity-related EHR functions highlight areas to improve the clinical health IT in primary care practice (Bronder, Dooyema, Onufrak, & Foltz, 2015).

The health care sector utilizes electronic technologies for medical information storage, treatment tools, and medical decision making among health care providers (Ben-Assuli, 2015). Health care focuses on diagnosis, such as treatment, and prevention of disease, illness, injury, and other physical and mental impairments in humans, which relies on technologies (Nemutanzhela & Iyamu, 2016). Business analytics can be used to validate causal relationships within traditional input, process, output, and outcome categories (Kasemsap, 2015a). Applying business analytics has the potential to facilitate better risk detection and support superior decision making in modern health care (Moghimi, Wickramasinghe, & Schaffer, 2016).

Trends and Issues with Electronic Health Record

Electronic medical record search engine (EMERSE) has been operational since 2005 and has undergone the multiple rounds of interface and architectural revisions based on end user feedback, usability testing, and the changing technology environment toward gaining the increased access to clinical data and enabling multiple secondary use purposes, such as quality assurance, population health management, and clinical and translational research (Hanauer, Mei, Law, Khanna, & Zheng, 2015). EMERSE was originally designed to work with the University of Michigan Health System's (UMHS) legacy homegrown EHR system, CareWeb, deployed in 1998. Regarding EMERSE, search engines, or information retrieval (IR) systems more generally, offer an effective, versatile, and scalable solution that can enhance the value of unstructured clinical data (Zalis & Harris, 2010).

Search engines help human reviewers quickly emphasize where information of interest is located, while leaving some difficult problems that computers are not yet capable of solving to human wisdom. The requirement for end user training is minimized as health care practitioners and researchers are already familiar with how search engines work through their day-to-day interactions with general-purpose web search engines (e.g., Google, Bing, and Yahoo!) and literature search tools, such as PubMed (Hanauer et al., 2015). EMERSE incorporates a medical spelling checker to alert users about potentially misspelled words in their search queries and offers an option for users to include potentially misspelled forms of the search terms in the search (Hanauer et al., 2015).

The impact of EHR technology on physicians' work can affect their acceptance and use of the technology (Hoonakker, Carayon, Walker, Brown, & Cartmill, 2013). Physicians have expressed the concerns regarding the changes in how they spend their time after EHR implementation (Carayon et al., 2015). EHR technology may create more or new work for physicians (Ash, Sittig, Dykstra, Campbell, & Guappone, 2009), such as looking for patient-related information, and reading charts and data (Overhage, Perkins, Tierney, & McDonald, 2001). Many studies have documented the additional time spent by physicians on the computer after implementation of computerized physician order entry (CPOE) in a pediatric emergency department (Yen et al., 2009), CPOE and electronic nursing documentation in an

emergency department (Asaro & Boxerman, 2008), and electronic medical record (EMR) in a hospital (Tierney, Miller, Overhage, & McDonald, 1993). Several studies rely on the subjective assessments of work time (Oxentenko, West, Popkave, Weinberger, & Kolars, 2010) or work sampling (Apkon & Singhaviranon, 2001). Continuous data collection on work activities (e.g., time studies and task analysis) are more precise methods for measuring physicians' time spent on various tasks (Lopetegui et al., 2014).

Patient care can be improved by the exchange of information (Ben-Assuli, 2015). Implementing EHR system requires an understanding of patient expectations for consent mechanisms and consideration of public awareness toward information sharing (Riordan et al., 2015). A number of benefits can be realized through the use of integrated records, including improved health outcomes, enhanced quality of clinical research, and effectiveness of medical care services (Chen et al., 2011). Reactions have focused on whether patients and the public are aware of the proposed changes and whether appropriate consent mechanisms are in place (Brown, Brown, & Korff, 2010). Informed consent is important in navigating the balance between the potential benefit and harm from information sharing for secondary purposes, while offering patients control over their personal data (Robling, 2004). There is little agreement about what constitutes meaningful and informed consent in the case of networked, integrated EHR, and what options should be available to individuals who wish to cancel any permission to use this data (Kaye, 2012). To achieve the informed consent processes, it is imperative that individuals understand what health information sharing entails (Parker, 2005).

Health care providers' positive attitudes about EHR are associated with their successful adoption (Bishop et al., 2015). Successful implementation and meaningful utilization of EHR are more likely when the system is more intuitive, when it is made to fit the clinical workflow and productivity, when continuous health education is provided, when clinicians are involved in defining their department-specific needs, when the design is novel and appropriate, where a realistic timetable is made utilizing an evaluation of the change-capability of the health care organization, and where effective knowledge governance practices are implemented (Goldberg, Kuzel, Feng, DeShazo, & Love, 2012).

Electronic Health Record and Clinical Decision Support System

Health care organizations experience a wide range of related approaches associated with decision support and analytics (Pate & Swofford, 2016). The highest functional level of EHR system is clinical decision support system (CDSS), which is expected to enhance patient health and health care (Rothman, Leonard, & Vigoda, 2012). CDSS is computer-based information system that is developed with the purpose of improving decision-making processes, providing the effective health information to the physicians and other health care providers with knowledge and specific health information (Guimarães, Coimbra, Frutuoso, & Abelha, 2016).

As the world of pathology and laboratory medicine has increasingly headed in the direction of automation, implementation of CDSS becomes a vital part of the health care systems (Nallas & Moon, 2016). CDSS is designed to help clinicians make decisions about patient diagnosis using technical devices (e.g., desktops, laptops, and mobile devices), to obtain medical information and establish alert systems to monitor medication (Moon & Galea, 2016). CDSS requires the well-designed EHR systems toward promoting the quality of care (Jonnagaddala, Dai, Ray, & Liaw, 2016).

In modern health care, CDSS is utilized in order to help health professionals take an evidence-based decision (Pereira, Portela, & Abelha, 2016). Decision support capabilities of EHR systems are an important aspect of health IT facilitated by the integration with CDSS (DesRoches et al., 2008). CDSS assists

health care professionals with decisions made in the clinical setting, such as decisions regarding patient transfer to or from an intensive care unit (ICU), use of ventilation and drugs, and discharge home (Hine, Farion, Michalowski, & Wilk, 2009). However, the barriers that have hindered the implementation of CDSS are that most systems are tightly integrated with a specific database as well as being costly to license (Mohktar, Lin, Redmond, Basilakis, & Lovell, 2013).

Trust and Privacy Concerns of Electronic Health Record Systems

EHR system is a store of electronically sustained information about an individual's lifetime health status and health care (Hajiheydari, Khakbaz, & Farhadi, 2013). Information privacy concerns are usually coupled with information security, which mainly involves unauthorized access to information by external entities (Gajanayake, Sahama, & Iannella, 2014). Fernández-Alemán et al. (2013) suggested using a cloud for security and protection of information. Haas et al. (2011) indicated that the basic goals of privacy (e.g., confidentiality, integrity, and availability) in the EHR systems must be preserved by entrusting the information to the third party designed to store the different pieces of information in separate systems. Health care organizations should monitor the level of security on a regular basis and keep patients' information secure (Ben-Assuli, 2015).

The rapid development of data collection and management technologies has led to the previously unknown challenges in that medical information is available on mobile devices, shared networks, and even sensors attached to the human body (Malin, El Emam, & O'Keefe, 2013). The vast majority of health care consumers are unaware or poorly informed about the current aspect of transforming paper-based medicine into a digital database (Angst, 2009). From the physicians' perspective, concerns regarding privacy and confidentiality are found to obstruct the physicians' acceptance and adoption of EHR (Chao, Hu, Ung, & Cai, 2013), thus showing how these issues can affect EHR utilization that extends beyond patients' reservations. The issues of data privacy, security, and integrity are diminished by an information accountability concept regarding EHR (Osop & Sahama, 2016).

The implementation of health care-related data security requires a good understanding of the stakeholders involved and requires the technical aspect of clinical information security, including security requirements, access control, and disclosure control in health care settings (Park & Moon, 2016). Health care providers must be able to distinguish patient-generated data imported into their EHR from clinician-generated data, because providers may not trust the validity or accuracy of all data generated by patients (Sujansky & Kunz, 2015). Clinical documentation accuracy is improved by EHR systems and the greater relevance of care data is electronically delivered (Rothman et al., 2012). Health care-related privacy addresses the question of who has access to personal information and under what condition (Omidoyin, Opeke, & Osagbemi, 2016). Processes and technologies that meet data privacy and regulatory requirements, and satisfy other organizational governance stipulations, are necessary prerequisites to gaining acceptance of the reuse of EHR for research (Geissbuhler et al., 2013).

Regarding health IT perspectives (e.g., EHR and telemedicine), the need for the increased trust by clients with potentially little knowledge of any security scheme is paramount in modern health care (Liu, Caelli, & Chen, 2013). Patient trust is considered as the major barrier to the adoption of EHR (Rauer, 2012). Trust in government leads to the support for the federal and state governmental encouragement of the adoption of EHR among physicians and insurance companies (Herian, Shank, & Abdel-Monem, 2014). To achieve a completely operational EHR platform, security, and privacy problems have to be resolved,

due to the importance of the health care data included within EHR (Tejero & de la Torre, 2012). The security of EHR systems is crucial for their growing acceptance in global health care (Almulhem, 2012).

Significance of Electronic Health Record in Global Health Care

With the integration of EHR, health data has become easily accessible and abounded (Wells et al., 2015). The proliferation of computerized databases and indexing technology for electronic records have initiated several health care opportunities and have brought various advantages (Menon, Jiang, Kim, Vaidya, & Ohno-Machado, 2014). EHR enhances the quality of care, thus allowing the rapid access to the comprehensive medical history of patients (Comandé, Nocco, & Peigné, 2015). While EHR data will increase in terms of volume, it is important for health care investigators to spend time understanding the data, including verifying format and quality (Murray, 2014). EHR implementation offers the data-mining opportunities to improve the operational, financial, and clinical processes (Rothman et al., 2012). Data mining is the process of applying the computational methods in showing unknown data formats in large data sets (Kasemsap, 2015b).

Electronic health data is very important, and can be used by health care providers for research and evidence-based practice (Kowitlawakul, Chan, Pulcini, & Wang, 2015). Data quality affects the usability of data in EHR systems (Hammond, Bailey, Boucher, Spohr, & Whitaker, 2010). In health care, data must be accurate and relevant, and the data collectors must ensure data quality (Hammond et al., 2010). Because accuracy is required for interoperability, total quality management (TQM) of EHR systems can be a major factor affecting the interoperability of health care data among health care institutions (Purcell, 2014). TQM is a dynamic process and demands a continuous change in an organization (Kasemsap, 2015c). In order to facilitate quality performance and achieve the effectiveness of the whole quality management system, researchers and managers should develop and maintain their organization's TQM practices related to quality performance in modern organizations (Kasemsap, 2015d).

EHR in its ideal pattern for patient care is a longitudinal record of patient health information generated by multiple encounters in any care delivery setting (De Moor et al., 2015). EHR significantly improves the quality of care received by patients and allows for cost savings throughout the health care delivery process (Cabrnoch & Hasić, 2011). Assessing patients' preferences for access to their EHRs and applying them in clinical practice requires the technical, clinical, and bioethical expertise, to make effective choices to overcome the technical challenges (Leventhal, Cummins, Schwartz, Martin, & Tierney, 2015). Ethics should guide the design of EHR, and the principles of EHR-related bioethics can play an important role in global health care (Meslin & Schwartz, 2015). Training priorities and practice guidelines should address the ethical data management and optimal utilization of EHR for clinical services (Mooranian, Emmerton, & Hattingh, 2013).

FUTURE RESEARCH DIRECTIONS

When health care providers have access to the complete and accurate information, patients receive better medical care. EHR can help health care organizations improve the ability to analyze diseases and reduce medical errors. EHR function helps health care providers identify and work with patients to manage the combination of risk factors toward improving patient outcomes and reducing medical er-

rors in global health care. With the advent of Web 2.0 technologies, social media enables the creation of knowledge value chain to customize information and delivery for a technological business growth (Kasemsap, 2014a). Cloud computing includes network access to storage, processing power, development platforms, and software (Kasemsap, 2015e). The relationships among EHR, social media, cloud computing, patient outcomes, and quality of care are considerably important in global health care and should be further studied.

The need to simplify and eliminate wasteful activities in hospital processes is a prerequisite to implementing an EHR system that will generate positive outcomes on patient care quality. The implementation of instantly accessible patient records is only a piece of the infrastructure necessary for excellent health care processes across the continuum of care. Organizations should focus on developing the management practices of Lean Production in order to achieve better organizational performance (Kasemsap, 2014b). Six Sigma is a customer-centric method which reduces process variation and optimizes development (Kasemsap, 2016). Lean Six Sigma achieves the best results when it is deployed with sound organizational strategy aligned with the goals, and has a strong understanding of a hospital's culture. The application of Lean Six Sigma in EHR systems will be the beneficial topic for future research direction.

CONCLUSION

This chapter explained the overview of EHR; the trends and issues with EHR; EHR and CDSS; the trust and privacy concerns of EHR systems; and the significance of EHR in global health care. EHR is viewed as an effective way to save money and improve health care quality, make clinical processes safe, and optimize operational health care efficiencies by streamlining the access to patient information throughout the health care system. EHR systems have the potential to transform the health care system from a mostly paper-based industry to the one that utilizes the clinical data and other pieces of information to assist health care providers in delivering the higher quality of care to their patients.

Clinical outcomes of EHR systems include improvements in the quality of care, a reduction in medical errors, and other improvements in patient-level measures that describe the appropriateness of care. Organizational outcomes of EHR systems include such items as financial and operational performance, as well as satisfaction among patients and clinicians who use EHR. In addition, societal outcomes of EHR systems include being better able to conduct research and achieving improved population health. EHRs and their ability to electronically exchange health information can help health care providers effectively provide higher quality and safer care for patients while creating tangible enhancements in global health care. Privacy and security of patient data must be recognized concerning EHR application toward increasing patients' trust in health care settings.

The benefits of EHR include better health care by improving all aspects of patient care, including safety, effectiveness, patient-centeredness, communication, education, timeliness, efficiency, and equity; better health by encouraging healthier lifestyles in the entire population, including increased physical activity, better nutrition, avoidance of behavioral risks, and wider use of preventative care; and the improved efficiencies and lower health care costs by promoting preventative medicine and improved coordination of health care services, as well as by reducing waste and redundant tests; and better clinical decision making by integrating patient information from multiple sources.

EHR contains fewer errors than paper record, according to experts. Communication between physicians can be greatly improved with the use of EHR, allowing each party full access to a patient's medical

history rather than a snapshot-type overview from a current visit. EHR makes it easier for physicians to follow up with patients and track continuing care, both under their supervision and that of the patient's other physicians. Reducing medical errors through applying EHR is of tremendous benefit to both physician and patient. The EHR system of information eliminates the medical problem of lost and misplaced patient files while eliminating medical data errors that can occur from transcription.

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KEY TERMS AND DEFINITIONS

Electronic Health Record: The health-related information captured through electronic method, and which may or may not have a paper record to back it up.

Health Care: The act of taking necessary medical procedures to improve a person's well-being.

Information: The data that is specific and organized for a purpose.

Information Technology: The set of tools, processes, and associated equipment employed to collect, process, and present the information.

Patient: A person who is receiving medical care.

Physician: A medical doctor, especially one who has general health care skill.

Record: The document that memorializes and provides the objective evidence of activities performed, events occurred, and results achieved.

Chapter 15
The Development of a Secure Hospital Messaging and Communication Platform

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ABSTRACT

Pagers and phone conversations have been the stalwarts of hospital communication. With good reason - they are simple, reliable and relatively inexpensive. However, with the increasing complexity of patient care, the need for greater speed and the general inexorable progress of health technology, hospital communication systems appear to be increasingly inefficient, non-secure, and inadequate. Thus, this study is proposed to answer the key research question: How can ICT (information communication technology) solutions ameliorate the current challenges regarding communication inefficiencies within healthcare? To answer this question, the study will design and develop a bespoke ICT solution for a specific context using three strong theories; communication theory, activity theory and agency theory to make a robust body of knowledge for the proposed solution. Further, it will serve to establish proof of concept, usability and feasibility of the proffered solution. The study participants will be selected from medical and nursing staff.

INTRODUCTION

The penetration rate of mobile devices such as smartphone and tablet computers has increased globally and will continue to increase in the future. The number of global smartphone subscribers is expected to reach 3.5 billion by 2019 (“Forrester Research,” 2016). Due to the attractive features such as cost-effective sensors and wireless communication capabilities mobile devices have received great attention in the healthcare context. Kang et al. (2010) have notion that the ability to monitor patients’ health remotely is making mobile devices popular in the health domain. Mobile devices such as smartphone can

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measure heart rate, count the steps walked, and can tell calories consumed and utilized (Yu Rang, Yura, Guna, Jae Ho, & Soo-Yong, 2015). Mobile devices are being used in health care in different ways. For instance, patients are using mobile devices for consultation with doctors (Korzep, 2010). On the other hand, doctors are using mobile technology for real time monitoring/tele monitoring of patients (Slaper & Conkol, 2014; Zangbar et al., 2014). Therefore, mobile devices are changing the way healthcare is delivered and are offering mobility, flexibility, convenience and real time communication in healthcare.

The concept of using mobile devices in healthcare can be viewed as follows: any equipment (with different sensors) which can be worn as wrist band, implanted in the body or embedded with the living species, measuring different physical changes of the patients, monitoring physical activities, analyzing, alerting and communicating with healthcare professionals and patients from remote places (Dwivedi, Shareef, Simintiras, Lal, & Weerakkody, in press). The use of mobile devices in healthcare is benefiting the healthcare domain in many ways such as reducing cost and traveling time for patients and healthcare professionals. Hence, the concept of using mobile devices in healthcare is more beneficial than traditional healthcare services where patients have to wait in long queues and doctors remained overburdened.

The use of mobile devices in healthcare has enhanced the scope of health care services and in the near future will make health services more flexible (Agosti, Graziano, Artiaco, & Sorrentino, 2009; Ben-Zeev et al., 2013; I.-L. Wu, Li, & Fu, 2011). For example, Rana, Hume, Reilly, and Soar (2015) proposes an ensemble sensing network named w-health (wireless health) which can combine smart phone, smart watch and smart glass in one network and can be used in telehealth in the near future. Andersen, Lindgaard, Prgomet, Creswick, and Westbrook (2009) think nurses and clinician tasks performed during ward rounds, require highly mobile computing devices. With a clinical alert system, a message can be sent to doctors or nurses mobile device and they can talk while they walk. Further, use of mobile devices such as smartphones, pagers, tablets and Wi-Fi phones can speed up admit and discharge process, response quickly to patients, promote direct communication between clinicians and can communicate test results efficiently. However, the Academy of Australian Technology, Science and Engineering (ATSE) report says that assistive technologies such as mobile devices could play a vital role in reducing health care cost when they are socially accepted and widely adopted. Although, globally mobile devices are benefiting the healthcare system and widely used in healthcare however, their adoption is slow in the Australian healthcare system. Mobile devices such as tablets are used by doctors for only a small portion of clinical tasks such as sending reminders to the patients for next consultation. The Australian health department is in favor of using mobile devices (HCSC 2014). However, the majority of consultations are conducted face-to-face even after implementation of videoconferencing in primary care in Australia (Smith, Armfield, Croll &Gray 2012). An extensive systematic literature review reveals most of the mobile devices projects in the Australian healthcare system are implemented on a pilot basis. Hence, the uptake of mobile devices and their further use in the Australian healthcare is unknown.

Therefore, the objectives of this chapter are:

- To understand the perception of healthcare professionals about the use of the mobile devices in the Australian healthcare environment.
- To contribute to the knowledge of the adoption of mobile devices in the healthcare context.

The overall aim of this chapter is to develop a conceptual framework for the adoption of mobile devices in the Australian healthcare environment.

BACKGROUND

Literature review reveals factors influencing adoption of mobile devices can be studied both at hospital level and individual level (Andersen et al., 2009; Brown III, Yen, Rojas, & Schnall, 2013; Kay, 2011; Rana et al., 2015; Shareef, Kumar, & Kumar, 2014; West, 2012; I.-L. Wu et al., 2011). This chapter is mainly focused on the individual user's (healthcare professionals) level of adoption of mobile devices in the Australian healthcare context because healthcare professionals such as doctors and nurses are one of the key users to use technology in healthcare. From literature it appears that even after implementation of mobile devices in the Australian healthcare system they are not used up to their full potential. Therefore, understanding the factors influencing adoption of mobile devices at the healthcare professional's level may increase the use of mobile devices in healthcare. The increased use of mobile devices can ensure the long term profitability and reduction in healthcare cost (Boulos, Wheeler, Tavares, & Jones, 2011; Lim et al., 2011; Xue et al., 2012). Hence, the conceptual framework in this chapter is developed from the healthcare professional's perspective.

Use of mobile devices in healthcare is a new concept globally including Australia (Dwivedi et al., in press). Therefore, an extensive literature review is conducted for the adoption of various kinds of Health Information Technology in the healthcare domain. Literature review conducted for the purpose of this chapter resulted many factors influencing adoption of various technologies in the healthcare environment (Baig, 2010; Brewster, Mountain, Wessels, Kelly, & Hawley, 2014; Furukawa, Raghu, Spaulding, & Vinze, 2008; M. P. Gagnon et al., 2012). However, all factors given in reviewing the literature cannot be considered important to understand the adoption of mobile devices in the Australian healthcare environment because of the cultural differences (Michael J. Ackerman, Rosemarie Filart, Lawrence P. Burgess, Insup Lee, & Poropatich, 2010; Peddle, 2007; Tiong, Hafeez-Baig, Gururajan, & Soar, 2006). Further, some factors for the adoption of technology in healthcare are given from other perspectives such as organizational perspective and not from the healthcare professionals' perspectives. To understand factors in this study the authors have given importance to three dimension: technology (mobile device), context (healthcare) and individual (healthcare professionals) (N. K. Bradford, Young, Armfield, Herbert, & Smith, 2014).

First Component: Technology is considered important to design the conceptual framework in this chapter because the healthcare domain is concerned with the health of a person and technology used should have good supporting features. Ben-Zeev et al. (2013) developed a smartphone system for self-management of Schizophrenia named FOCUS and (during first testing of system) found that individuals were facing problems in using mobile devices in healthcare. The problems were: with abbreviations, large amount of text, difficult wording, font size, smaller touch space, small diameter of the buttons and smaller touch sensitivity. This means mobile devices used should have favoring features with the healthcare domain which healthcare professional can easily understand and operate. Further, health care professionals are responsible for the life of the patient and the technology used should be secure (Bønes, Hasvold, Henriksen, & Strandenæs, 2007). Therefore, technology context is considered important and the factor considered in technology component are: features of mobile devices and security issues.

The Second Component: Context (environment) is considered important to design the conceptual framework because uses of mobile devices have different influence on different domains. To choose this component mobile devices uses are linked with the healthcare context. In this component

the main emphasis is given on how the use of mobile devices bring changes in clinical processes and healthcare professionals style of working. Healthcare professionals like the technology that can do clinical work efficiently and is compatible with the clinical work process. Mobile devices have potential to do clinical tasks efficiently. So the use of mobile devices in clinical context is considered important and factors considered in 'context' component are: advantages, complexity and compatibility.

The Third Component: Healthcare professionals are considered important to design the conceptual framework because they are the main users of the technology in the healthcare system. If heath care professionals consider that the use of mobile devices in healthcare is advantageous their intention will be strong to adopt mobile devices (I.-L. Wu et al., 2011). The factors considered in the individual component are: self-efficacy, individual readiness, social influences, intention, age, gender

Theory of planned behavior (TPB) and diffusion of innovation theory (DOI) are used as an underlying theory for developing the conceptual framework in this chapter. Several researchers have used various theories and models such as Technology Acceptance model (TAM), Theory of Reasoned Action (TRA), Theory of Planned Behavior (TPB), Diffusion of Innovation Theory (DOI), Unified Theory of Technology Acceptance and Utilization (UTAUT) to understand individual adoption of technology behavior (Daim, Basoglu, & Topacan, 2013; Deng, Mo, & Liu, 2013; Dwivedi et al., in press; Saad, Alias, & Ismail, 2013; Sanders et al., 2012). TAM is the most widely used model in literature to understand adoption of technology behavior. However, TAM is not suitable to understand adoption behavior in this research because TAM does not include the influence of social norm. The influence of social norms is important in this research context and can be explained using TRA. However, TRA does not include the basic predictors that is perceived usefulness and perceived ease of use from TAM. The basic predictors of TAM and TRA are included in the TPB. Therefore, TPB is the first underlying theory in this research. Further, Wu, Li and Fu (2011) explains psychological state is critical to determine individual behavior for the adoption of technology. TAM and DOI can easy explain the psychological state of the individual behaviour. However, TAM and DOI are extremely similar in some constructs and also supplements each other. While relative advantages is similar to perceived usefulness, complexity is similar to perceived ease of use (Wu, Wang & Lin 2007). Therefore, Both TAM and DOI can explain the psychological state of the individual behaviour without TAM. However, TAM cannot explain the compatibility factor which cannot be ignored in this research context because if technology used in healthcare is not compatible with the healthcare process then it is useless. For example, if a doctor is treating patients in emergency and technology used in that treatment is causing any inconvenience for it may divert doctor attention and may leads to wrong treatment. Therefore, compatibility of the technology with the healthcare process is important. Hence, DOI theory can explain the second component that is 'context' in this research (Ghodeswar & Vaidyanathan, 2007). Therefore, the second underlying theory in this research is DOI.

Note: The third component: technology in this research is a component which is derived from literature review on adoption of various kinds of technologies in the healthcare and not from any adoption theory or model.

MAIN FOCUS OF THE ARTICLE

Through the extensive literature review, it is found that there is limited research for the adoption of mobile devices (by healthcare professional) in the Australian healthcare context. From literature, it also appears that some healthcare facilities are already using mobile health services but their scope is limited to that environment. A major implication of such narrow adoption is lack of understanding of how mobile devices are adopted in the healthcare environment. Further, it appears from literature that even after implementation of technology in the Australian health organizations the adoption is not as much as expected. For example, although in July 2011, the Australian government has introduced funding for video-consultations in primary care yet, the adoption is not as much as expected (Smith et al. 2014).The majority of consultations in the Australia are conducted face to face compared with video consultation (Smith et al. 2012). Therefore, this study is focused on:

- Understanding factors influencing adoption of the mobile devices in the Australian healthcare environment.
- Developing a conceptual framework which can support adoption of mobile devices in the healthcare domain.

The various constructs used in the conceptual framework developed in this chapter and their operationalization is given in the next section.

DISCUSSION ON SOLUTIONS

The conceptual framework in this chapter is developed in two steps.

Step 1: Thorough Study of the Literature to Understand Factors Influencing Adoption of Various Kinds of Technology in the Healthcare Environment

In this phase various factors influencing adoption of technology are identified. This step provides a broad view of all the factors which can influence adoption of technology in the healthcare environment. Factors identified in this step are related to adoption of technologies such as electronic health records, wireless technology, health information technology, telehealth, home tele monitoring, eHealth mobile computing and mobile health (Daim et al., 2013; Deng et al., 2013; Heidarian & Mason, 2013; Singh, Lichter, Danzo, Taylor, & Rosenthal, 2012; Wang, Redington, Steinmetz, & Lindeman, 2010; Zinszer, Tamblyn, Bates, & Buckeridge, 2013). In step1 it is identified that some factors for the adoption of technology in the healthcare appears to be individual factors and some of them appears to be organizational factors. The list of the factors for the adoption of various technologies in the healthcare environment is given in the appendix 1.

Step 2: Selection of Appropriate Factor for Understanding Adoption of the Mobile Devices in the Australian Healthcare from the Healthcare Professionals' Perspective

To select the most appropriate factors the authors have given emphasis to understand technology, health environment and healthcare professionals' components. To understand the factors from technology aspect the authors have tried to understand the factors from the previous articles which were focused on mobile computing, mobile wireless devices, and wireless devices (M.-P. Gagnon, Ngangue, Payne-Gagnon, & Desmartis, 2016; Goswami & Chandra, 2013; I.-L. Wu et al., 2011; J.-H. Wu, Wang, & Lin, 2007; Yangil & Chen, 2007). To understand the Australian health context, the authors have tried to read and critically analyze the research articles based on use of mobile devices or mHealth from 2007-2016. A systematic literature review to understand the use of mobile devices in the Australian health domain is given in in Appendix 2. To understand the factors from the healthcare professionals' perspective the authors have emphasized on various theories/model and literature based on understanding individual behavior for the use of technology in healthcare.

It was a difficult decision to choose which factors can be selected and which can be discarded. Therefore, each construct is operationalized to understand the meaning of the construct. Construct operationalization is a process of achieving clear and practical meaning of the constructs to the chosen context. It includes an agreed definition of the constructs from literature, clear meaning of the constructs that is also suitable for the research and identifying key concept properties describing constructs (Ayers & Olander, 2013; Bhattacherjee, Hikmet, Menachemi, Kayhan, & Brooks, 2007). Operationalization of constructs is also helpful to understand constructs and apply them in a particular research context. Therefore, each construct considered for the development of conceptual framework in this research is operationalized below:

1. **Intention:** Intention in this research refers to the measure of the likelihood to use mobile devices in the healthcare process. User intention is a good indicator of how a system will be accepted. Intention to adopt mobile devices in healthcare may depend upon many factors. Therefore, intention to adopt mobile devices is a dependent variable and all the other factors explained below are independent variables.
2. **Readiness:** Readiness refers to the individual propensity to embrace and use mobile devices in health care. Individual readiness to adopt technology is influenced by the individual's positive and negative feelings. Positive feelings allow individuals to adopt technology while negative feelings distract from adopting technology. Parasuraman (2000) has considered positive feelings as 'optimism', one of the contributors of technology readiness. Optimism as 'a positive view of using technology and a belief that it offers people increased control, flexibility and efficiency in their lives. This clearly shows that individual readiness/ attitude to adopt technology is positively influenced by advantages provided by technology. On the other hand, negative feelings which create inconvenience make individuals less confident to adopt technology (Caison, Bulman, Pai, & Neville, 2008). In Australia, mobile devices use in healthcare is still in its infancy. Thus, healthcare professionals' readiness may be weak or strong depending on whether health professionals perceive disadvantages or advantages of mobile devices. Therefore, it can be concluded that induvial intention to adopt mobile devices in the healthcare may be influenced by readiness for the adoption of

Figure 1. Conceptual framework for adoption of mobile devices in the Australian healthcare context

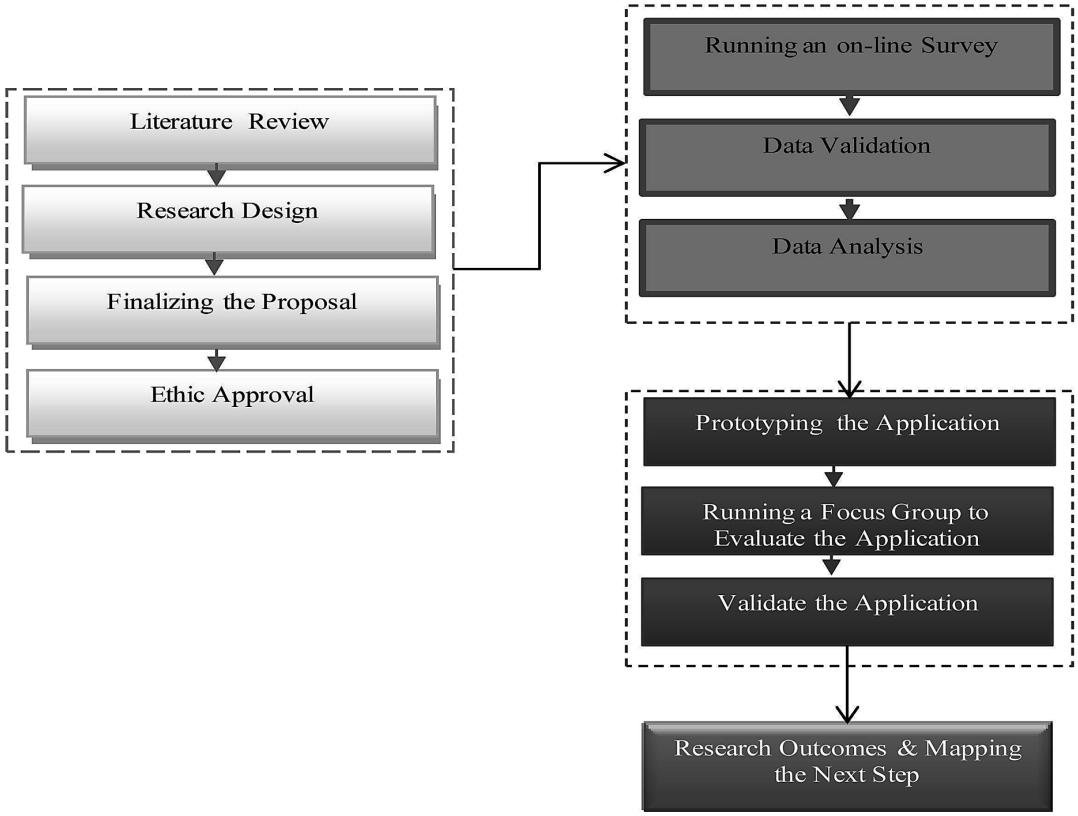

Figure 2.

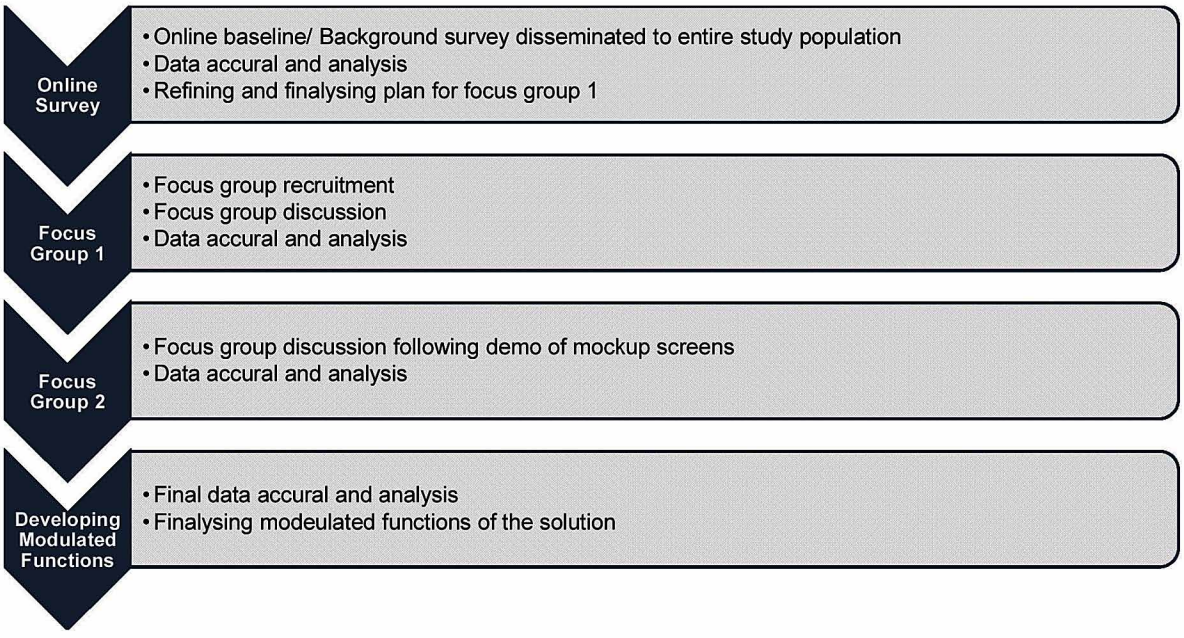

Figure 3.



mobile devices which may further be influenced by the advantages and disadvantages of using the mobile devices in the healthcare domain.

3. **Advantages:** Advantages refer to the benefits of mobile devices in the healthcare processes. Advantages of technology can be measured using various parameters such as cost, features and compatibility. Benefits offered by technology positively impact individuals to adopt technology (Wang et al., 2010; I.-L. Wu et al., 2011). Previous research studies explain the benefits of using technology in healthcare and their positive influence on individual perception (Daim et al., 2013; M. P. Gagnon et al., 2012; D. Kim, 2009). The Australian healthcare domain is under tremendous pressure due to rising healthcare costs, shortage of qualified staff and a growing demand of services (AIHW, 2014; Croll, Norton, Gray, Bryett, & Smith, 2012). Mobile devices such as smart phone in the Australian health context can help in promoting and facilitating health services, quality of life and reducing healthcare cost (Gee, 2015). Therefore, the various benefits of using mobile devices in the Australian healthcare context may influence healthcare professionals' intention for the use of mobile devices in the healthcare environment.
4. **Safety Issues:** Safety issues in this research refer to individual understanding of patient's privacy and confidentiality while using mobile devices for healthcare purpose. In health domain where patients' data is transferred from one point to another its integrity, safety, security, privacy and confidentiality needs to be maintained. While using mobile devices in healthcare safety of data being transferred is very important (M.-P. Gagnon et al., 2016; Michael J. Ackerman et al., 2010; Peddle, 2007). For example, if a patient is in emergency unit and patient's data gets modified intentionally or unintentionally then patient will get wrong treatment which can decrease his/her chances of recovering from the disease quickly (Cinque, Coronato, & Testa, 2013). Further, use of mobile devices could also create another security risks such as malware, spear phishing and losing equipment risk (Testa, Cinque, Coronato, & De Pietro, 2015) and these risk cannot be avoided in any country's health context unless a strong security measures are not available. Hence, the use of mobile devices in healthcare is at the same time a great opportunity and a great risk (disadvantage)

in the health domain. Therefore, it is important to study security factor while understanding adoption of mobile devices in healthcare.

5. **Features:** Features refer to the functional features such as battery life, screen size of mobile devices which may influence healthcare professionals for the adoption of mobile devices. In the healthcare the most important concern is a person's health and adopted technology should have good supporting features with healthcare process (I.-L. Wu et al., 2011). Zhang et al. (2014) have idea that adoption of technology in healthcare depend on performance of technology and technology features are responsible for performance of technology. (Ghodeswar & Vaidyanathan, 2007) Therefore, whatever technology is used it should have good supporting features in healthcare (Massey, Khatri, & Montoya-Weiss, 2007). EMarketer 2012b cited in Ally and Gardiner (2012) support the notion that features of mobile devices such as touch screen, voice and user interface influence adoption of mobile devices in the market. Further, each healthcare domain is responsible for the life of people and if technology features create any kind of inconvenience with the health care process, then technology is useless in the health environment. Hence, it is important to consider the impact of functional features for the adoption of mobile devices in the Australian healthcare context.
6. **Self-Efficacy:** Bandura have introduced the concept of self-efficacy, which is defined as the expression of self-ability and confidence in successfully reaching goals in certain circumstances (Bandura 1997). Many researchers have used self-efficacy as a variable for information system adoption, and they have de-fined it as the degree of perceiving the need for a certain ability, technique, or piece of knowledge when an individual attempt to use a certain information technology system. Self-efficacy has been considered as an important factor for the adoption of mobile banking and smartphones (Luarn & Lin 2005; D. 1989). Many researchers have demonstrated self- efficacy as an important construct for the adoption of technology (Lim et al., 2011; J.-H. Wu et al., 2007; Yangil & Chen, 2007). Mobile devices are a new technology in the healthcare and in the Australian healthcare it is in its infancy stage. Therefore, some of the individuals may not be confident to use the new technology and hence their intention may be influenced by the self-efficacy to use mobile devices. However, if training is provided to the individual their confident level to use technology is increased.
7. **Training:** Training in this research refers to the hospital's support to update the healthcare professionals about the use of mobile devices in healthcare. Training is useful for the employees (Zolfo et al., 2010). Zolfo et al. (2010) in their research resulted that providing training to health worker is useful in scaling up the HIV/AIDS care in resource-limited settings. Providing training to use mobile devices in healthcare is also important because there is a difference between health professionals and the typical technology users. Health professional work is critical and time sensitive and if mistake is done it may cost the life of a patient. Further, in the Australian health system is facing shortage of staff. Therefore, proving training may reduce the complexity level of healthcare professionals to operate the mobile devices in the health domain and can bring productivity and efficiency even with the limited staff.
8. **Complexity:** Complexity refers to the degree to which healthcare professionals may experience difficulties in using mobile devices for health care services. Rogers (2003, p. 257) states complexity as the degree to which an innovation is perceived as relatively difficult to understand and use. In the context of adoption of mobile devices in healthcare, if an individual has to struggle with the use of technology in the health process, then the individual's intention for the adoption of mobile devices will be weak. However, complexity can be reducing by providing training to the health

professionals. Many researchers proposed complexity as one of the major factors for adoption of technology in healthcare, with antonyms like simple/ easy to use/perceived easiness, perceived ease of use (Daim et al., 2013). Complexity can be an important factor for adoption of mobile devices in the healthcare environments because if HCPs find it difficult to operate mobile devices in healthcare process the intention for the adoption will be low. In the Australian health environment use of mobile devices in on a pilot basis and the future of the pilot projects is unknown. Therefore, it is important to understand the complexity construct to expand the mobile health on large scale in Australia. Thus, complexity influences adoption of mobile devices and is included in the conceptual framework.

9. **Social Influences:** Social influences are defined as the influences of people (who are in the social circle such as colleagues of healthcare professionals) on healthcare professionals for the adoption of mobile devices in healthcare services. In the theory of reasoned action (TRA), TAM2, TPB, C-TAM-TPB the term social norm is used and has the same meaning as social influences. Social influences are the influences of peers on the individual (Morris, Venkatesh, & Ackerman, 2005). Social influences have a great influence on individual adoption of innovation (Rogers, 2003) and is therefore, considered one of the essential constructs in adoption of mobile devices in the Australian healthcare context.
10. **Compatibility:** Compatibility refers to the degree to which mobile devices are perceived as consistent with the existing healthcare process and needs of the healthcare professionals. Literature reveals HCPs show less interest for the adoption of new technology (Rogers, 2003; I.-L. Wu et al., 2011). However, if the technology is compatible with healthcare professional's work process, they like to adopt it (Xue et al., 2012). Additionally, in the health care environment new technology is adopted if it supports the existing system and adds newness to the system and mobile devices have that potential. Therefore, compatibility construct is added in the conceptual framework.
11. **Age:** Age in this research is defined as how old a health professional is who is working in the Australian healthcare. Age is also one of the important factors that affects the adoption of information systems. Several researchers found young people more actively use mobile telecommunications (Brown, Cajee, Davies, & Stroebel, 2003; Nikou, 2015). However, elderly people are resistant to technology change. Skiba (2015) says that '60- plus crowd' crowd is not technology averse. Further, most of the old people are dominated by various kinds of physical problems such as poor eyesight (Leventhal, 2008; Zhang et al., 2014). If a person has poor eyesight he/she will more likely to prefer mobile devices with the bigger screen size (Boulos et al., 2011). Caison et al. (2008) results shows that young male medical students have more curiosity for using technology. Therefore, researcher expect that age would be a significant factor in the adoption of mobile devices among the Australian healthcare professionals.
12. **Gender:** Gender in this research is defined as whether a healthcare professional working in the Australian health domain is male, female or other. Gender difference is also considered one of the factor for understanding the adoption of mobile devices in the Australian healthcare domain. Imhof, Vollmeyer, and Beierlein (2007) explains male computer users use computer more frequently for games, music and video players, or Internet shopping than their female counterparts. Lim et al. (2011) think women who do not have prior experience with technology may feel more uncomfortable in using technology. Further, previous literature indicates that men are task oriented and like to finish their office work efficiently and timely and if technology is compatible with their style of working and can help to finish their office work timely their intention to use technology is strong

(Roberts & Bell, 2000). In the healthcare domain, healthcare professionals need to interact with various patients and their family members and friends to explain the disease condition of a patient. Therefore, gender difference could play a role for the use of mobile devices in the health domain.

13. **Other Factors:** Other factors refer to the factors which can be further added in the conceptual framework developed in this chapter. Other factors may be organizational factors, cultural differences and government policies and procedure to implement mobile devices in the healthcare system. These factors are not included yet in the conceptual framework because every country has its own health system. Others factors mentioned above may be influencing or may not be influencing in the Australian healthcare context. These factors may be added in the conceptual framework further by conducting exploratory study.

FUTURE RESEARCH DIRECTIONS

This research can provide avenues for future researchers for conducting further research. Future research can be conducted for the adoption of mobile devices in the Australian healthcare domain from other perspectives such as patients and management perspective. Also, the conceptual framework developed in this research can further be extended by conducting exploratory study to find out the other factors in the Australian health context.

CONCLUSION

This chapter concludes that there are many factors, which are influencing healthcare professionals for the adoption mobile devices in the Australian healthcare environment. The main factors which may influence healthcare professionals in the Australian healthcare context for the adoption of mobile devices proposed from literature are: intention, individual readiness, advantages, safety issues, features, self-efficacy, complexity, training, compatibility, social influences, age and gender. Other factors in the conceptual framework developed in this chapter can be added depending on the Australian health context.

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APPENDIX 1: LIST OF FACTORS

1. (J.-H. Wu et al., 2007)
    1.1. Compatibility
    1.2. Perceived usefulness
    1.3. Perceived ease of
    1.4. MHS self-efficacy
2. (S. Kim & Garrison, 2008)
3. Cognitive Influence Process
    3.1. Job relevance
    3.2. Perceived ease of use
    3.3. Perceived usefulness
4. Technological Influence Process
    4.1. Ubiquity
    4.2. Reachability
5. (Furukawa et al., 2008)
    5.1. Technology
    5.2. Geographic location
    5.3. Patient safety
6. (Michael J. Ackerman et al., 2010)
    6.1. Lack of technology integration
    6.2. Interoperability,
    6.3. Standardization
    6.4. Limited financing
    6.5. Lack of data standards
    6.6. Cultural barriers
    6.7. Usability
    6.8. Ease of use
    6.9. Security
    6.10. Privacy
    6.11. Trust
7. (Wang et al., 2010)
    7.1. Cognitive, physical limitation
    7.2. Health status
    7.3. Disease conditions
    7.4. Technology literacy
    7.5. Perceived Usefulness of technology
8. (I.-L. Wu et al., 2011)
    8.1. Personal innovativeness
    8.2. Availability

9. (Kluge, 2011)
    9.1. Liability
    9.2. Interoperability
    9.3. Legacy
10. (Singh et al., 2012)
    10.1. Financial constraints
    10.2. Return on investment issues
    10.3. Initial data entry labour intensive
    10.4. Initial loss of productivity
    10.5. Training burden for physicians
11. (Davis, 1985; M. P. Gagnon et al., 2012)
    11.1. Perceived usefulness
    11.2. Perceived ease of use
12. (Goswami & Chandra, 2013)
    12.1. User interface clarity
    12.2. Usage friendliness
    12.3. Social influence
    12.4. Support of product and service providers
    12.5. Learning predispositions
13. (Heidarian & Mason, 2013)
    13.1. Technology updates
    13.2. Cost
    13.3. Lack of time
    13.4. Equipment integration
14. (Zinszer et al., 2013)
    14.1. Lack of national vision
    14.2. Lack of leadership
    14.3. Insufficient investment
    14.4. Poor conceptualization of the priority areas
15. (Daim et al., 2013)
    15.1. Usefulness
    15.2. Quality of Services
    15.3. Compatibility with User's Life Style
    15.4. Quality of Support
    15.5. Quality of Information
    15.6. Image of Technology
    15.7. Usages Time
    15.8. Accessibility
    15.9. Easy to Use

16. (Goswami & Chandra, 2013)
    - 16.1. Interface clarity
    - 16.2. User friendliness
    - 16.3. Social influences
    - 16.4. Support of product and services provided
    - 16.5. Learning predisposition
17. (Deng et al., 2013)
    - 17.1. Physical condition
    - 17.2. Resistance to change
    - 17.3. Technology anxiety
    - 17.4. Self-actualization needs
18. (Cimperman, Brenčič, Trkman, & Stanonik, 2013)
    - 18.1. Security
    - 18.2. Usability
19. (Brewster et al., 2014)
    - 19.1. Staff-Patient interaction
    - 19.2. Credibility
    - 19.3. Negative impact of service change
    - 19.4. Autonomy
    - 19.5. Technical issues
20. (Daniel Castro, Ben miller, & Nager, 2014)
    - 20.1. Standard of care
    - 20.2. State licensing policies
    - 20.3. Compatibility
    - 20.4. Interoperability
21. (N. K. Bradford et al., 2014)
    - 21.1. Technical (setting up equipment, username and password)
    - 21.2. Individual (culture, linguistic and social variations)
    - 21.3. Service factors (Lack of staff)
22. (M.-P. Gagnon et al., 2016)
    - 22.1. Perceived usefulness
    - 22.2. Ease of use
    - 22.3. design and technical concerns
    - 22.4. Cost
    - 22.5. Time
    - 22.6. Privacy and security issues
    - 22.7. Familiarity with the technology
    - 22.8. Risk-benefit assessment
    - 22.9. Interaction with others (colleagues, patients, and management).

APPENDIX 2

Table 1. A systematic literature review to understand the use of mobile devices in the Australian health context

Title and Authorship	Research Design	Results
Intelligent human activity recognition scheme for eHealth applications (Chetty & Yamin, 2015)	A Samsung Galaxy S2 smartphone was used for quantitative data collection, which contains an accelerometer and a gyroscope for measuring 3-axial linear acceleration and angular velocity respectively at a constant rate of 50Hz, which is sufficient for capturing human body motion.	For single model experiments, we found optimal attribute selection Techniques based on information theory based ranking leads to better performance. For multimodal experiments, a combination of supervised and unsupervised yields best performance.
'TXT2BFiT' a mobile phone-based healthy lifestyle program for preventing unhealthy weight gain in young adults: study protocol for a randomized controlled trial (Lana Hebden et al., 2013)	Nine month two-arm parallel-group randomized controlled trial in Sydney, New South Wales, Australia is conducted. Participants are recruited from primary medical care clinic using random sampling.	The results of this study are not given in the paper. The results may be found in the further publications
Integrating mobile-phone based assessment for psychosis into people's everyday lives and clinical care: a qualitative study (Palmier-Claus et al., 2013)	Qualitative interviews were conducted in order to explore participants' perceptions and experiences of the devices. 24 community based individuals with non-affective psychosis completed a randomised repeated-measure cross-over design study, where they filled in self-report questions about their symptoms via text-messages on their own phone, or via a purpose designed software application for Android smartphones, for six days.	Three themes emerged from the data are: i) the appeal of usability and familiarity, ii) acceptability, validity and integration into domestic routines, and iii) perceived impact on clinical care. The mobile-phone assessment procedure itself may needto be tailored to the individual, potentially through machine learning, in order to maximise compliance
A Comparison of the Reliability of Smartphone Apps for Opioid Conversion (Haffey, Brady, & Maxwell, 2013)	Between 28 January and 5 February 2012, the major online app stores (Android 'Google Play' store, iOS 'App Store', BlackBerry 'Blackberry App World', Windows Phone 'Marketplace', Symbian 'Ovi (Nokia)' store and Bada 'Samsung Apps' store) are searched using relevant terms (opioid, morphine, medical calculator, conversion) to identify apps that had opioid dose/formulation conversion capabilities.	We have demonstrated that opioid calculator conversion outputs are highly variable between apps. Evidence of medical involvement in app creation or referencing of primary sources is lacking in many cases, and a statistically significant difference was found in conversion outputs of hydromorphone in those apps with and without stated medical involvement Despite large developments in Internet technology and growth in the knowledge of how to develop more effective web-based interventions, overall website quality was low and the majority of freely available physical activity websites lack the components associated with behavior change.
The effectiveness of a suicide prevention app for indigenous Australian youths: study protocol for a randomized controlled trial (Shand, Ridanir, Tighe, & Christensen, 2013)	A Pilot study will be conducted in this research. Use of the app (that is, login and logout times, activities completed, time spent in each section, answers to self-Assessment questions) will be tracked within the device, and downloaded to secure servers whenever internet connectivity is established. The app will require a security pin for access and any data stored on the device will be encrypted and hidden within the app coding. Answers to self-assessment questions will be coded so that they are unintelligible to anyone not connected with the study.	The primary outcome measure is a reduction in frequency and intensity of suicidal thoughts. Secondary outcome measures are the reduction of depression, anxiety and impulsivity. .
Telehealth and ubiquitous computing for bandwidth-constrained rural and remote areas (Steele & Lo, 2013)	review article	In this article, we review the benefits of ubiquitous computing for rural and remote telehealth including social media based preventative, peer support and public health communication, mobile phone platforms for the detection and notification of emergencies, wearable and ambient biosensors, the utilization of personal health records including in conjunction with mobile and sensor platforms, chronic condition care and management information systems, and mobile device–enabled video consultation.

continued on following page

Table 1. Continued

Title and Authorship	Research Design	Results
Obesity and outpatient rehabilitation using mobile technologies: the potential mHealth approach (Castelnuovo et al., 2014)	review article	To conclude, further studies should investigate both possible advantages and applications of Internet and mHealth technologies in the treatment of obesity. In spite of promising preliminary reports, the evidence-base for the effectiveness of mHealth applications is meagre and it remains too early to be able to recommend it for use in clinical settings
Safety for home care: the use of Internet video calls to double-check interventions (N. Bradford, Armfield, Young, Ehmer, & Smith, 2012) -RCH in Brisbane	This research is a trial research. The devices were taken on scheduled home visits to patient homes and video calls with a second clinician were conducted to double-check various items associated with the clinical care of the patient. Over a 14-month period, 88 video calls were conducted during which a total of 600 checks were completed. The items checked included medication names, doses, segmentations on syringes and details of ventilator settings.	The quality of the video call was acceptable on 97% of occasions. On three occasions (3%) it was not possible to establish a connection and the double check was not achieved. The use of Internet video calls is feasible for double-checking and has the potential to improve patient safety and reduce costs
Clinical use of Skype: a review of the evidence Base (Armfield, Gray, & Smith, 2012)	This articles is a literature review article. Five electronic databases were searched to identify relevant studies (CochraneLibrary, DARE,Medline,EMBASE,CINAHL). The search terms were: Internet; video; remote consultation; Skype; teleconsultation; telehealth; telemedicine.	One small (n=7) controlled clinical trial had assessed the effect of nursing communication using Skype on elderly patients with dementia and their careers. While there were many case reports and small studies, no firm evidence either in favour of, or against the use of Skype for clinical telehealth was found.
The smart therapist: A look to the future of smartphones and mHealth technologies in psychotherapy (Clough & Casey, 2015)	Review article.	Research indicates that consumers want to engage in mHealth interventions, although only a limited number of empirically supported options currently exist. Weakness Much of the research to date is lacking in methodological rigor, and reliance on standard research designs often used in other areas of psychological research may constrain development of interventions. Strength: The main areas of research identified included the use of SMS technologies, ecological momentary assessment, online and software application based interventions and the recent integration of sensor and data mining technologies.
Quantifying the body: monitoring and measuring health in the age of mHealth technologies (Lupton, 2013)	Review article.	Given that mobile digital technologies are so novel, research directed at how people actually use them for health purposes – how they 'domesticate' them and incorporate them into their everyday lives – has yet to be published. What types of people self-track? How do the devices they use come to acquire meaning in the context of everyday use? What are the social lives of these commodities? Aspects of how and to what extent these devices are incorporated in concepts of selfhood and embodiment also remain to be fully explored.
Testing the feasibility of a mobile technology intervention promoting healthy gestational weight gain in pregnant women (txt4two) - study protocol for a randomised controlled trial (Willcox et al., 2015)	txt4two is a parallel randomised control trial	Findings will inform the development of larger-scale Digitally based programmes to improve the delivery of healthy pregnancy nutrition, physical activity and healthy GWG. The findings of this trial will contribute to the literature on promotion of healthy lifestyles in pregnant women.
Iterative development of MobileMums: a physical activity intervention for women with young children (Fjeldsoe, Miller, O¿Brien, & Marshall, 2012)	Focus groups with women with young children to explore their perceptions of and needs for physical activity interventions were conducted. Women were recruited via posters and flyers displayed in general practice clinics, Playgroup locations, the public hospital antenatal clinic, and the public library of a community located in Queensland, Australia. To be eligible to participate, women had to have at least one child aged less than 5 years, and be able to speak and understand English. In pre-testing To be eligible to participate, women had to have at least one child aged less than 5 years, and be able to speak and understand English.	Key findings identified throughout the development process that shaped the MobileMums program were the need for: behaviour change techniques to be grounded in Social Cognitive Theory; tailored SMS content; two-way SMS interaction; rapport between SMS sender and recipient; an automated software platform to generate and send SMS; and, flexibility in location of a face-to-face delivered component.

continued on following page

Table 1. Continued

Title and Authorship	Research Design	Results
A mobile health intervention for weight management among young adults: a pilot randomised controlled trial (L. Hebden et al., 2014)	This was a prospective randomised controlled trial, conducted from July to the end of December, 2011. In total, 192 gender-specific SMS text messages were developed (24 SMS for each of four behaviours and two genders). Text messages were tailored to the processes of change identified in the Transtheoretil Model (Prochaska et al., 1992), and moved from addressing cognitive to behavioural processes to facilitate movement through stages of change. Four smartphone applications were developed by the investigators (one per behaviour). Briefly, each application enabled users to record their behaviour (e.g. daily minutes of physical activities performed, daily servings of fruit and vegetables, or weekly frequency, and energy and fat content, of take-away meals) and to then receive instantaneous tailored motivational advice, as well as feedback in reference to population health guidelines	All analyses were conducted using SAS, version 9.2 Data were analysed according to the intention-to-treat principle with baseline values imputed for missing follow-up data. Descriptive statistics were used to summarise baseline differences in participant characteristics between intervention and control groups. Changes within groups pre- to post-intervention were tested using paired sample t-tests (continuous normal data), Wilcoxon signed ranks Z-tests (ordinal data; i.e. fruit and vegetable servings) or Pearson chi-square tests (categorical data). The effect of the mHealth intervention on primary and secondary outcomes was analysed using analysis-of-covariance models for quantitative outcomes and logistic regression models for dichotomous outcomes
Effects of mental health self-efficacy on outcomes of a mobile phone and web intervention for mild-to-moderate depression, anxiety and stress: Secondary analysis of a randomised controlled trial (Clarke et al., 2014)	Randomized controlled trial is conducted in this research.	Mental health self-efficacy influences symptom outcomes of a self-guided mobile phone and web-based psychotherapeutic intervention and may itself be a worthwhile target to increase the effectiveness and efficiency of online treatment programs.
A framework for cloud-based healthcare services to monitor non communicable diseases patient (Al-Qurishi et al., 2015)	A framework is proposed in this research.	Analysis is conducted using AHP techniques.
Electronic psychosocial assessment tool: Concept development and identification of barriers to successful implementation (S. Bradford & Rickwood, 2014)	Interview is conducted in this research. At the beginning of each interview, participants are informed of the purpose of the study.	By engaging the stakeholders in this early process researchers were able to identify a range of software functionalities that are likely to improve the applicability for users, as well as identify possible barriers to implementation.
An empirical study to determine factors that motivate and limit the implementation of ICT in healthcare environments (Gururajan & Hafeez-Baig, 2014)	Mix methodology is used in this research. 80 staff are interviewed. Once the initial motivators were identified, a focus group is conducted.	This research paper provides some initial findings of the factors that motivate and limit ICT implementation in healthcare organisations. A list of themes which can influence the ICT implementation in a healthcare environment was identified. Some of the themes were already identified in the literature review; however this research also identified new themes, in the form of internal and external factors, which contribute to the general research domain.
Adoption phenomena for wireless handheld devices in the healthcare environment (Gururajan & Hafeez-Baig, 2014)	Survey	All the three constructs, CP, SD and Comp for the adoption of wireless handheld devices represent good measurements for the intention-to-use these devices in the healthcare setting. Whereas SD is strongly influenced by CP and Comp as determinants for their intention, in spite of the direct effects of CP and Comp on the intention.
Use of information and communication technology to provide health information: what do older migrants know, and what do they need to know? (Goodall, Ward, & Newman, 2010)	Qualitative study (Focus group discussion) method is used in this research	

continued on following page

Table 1. Continued

Title and Authorship	Research Design	Results
What's in a message? Delivering sexual health promotion to young people in Australia via text messaging (Gold, Lim, Hellard, Hocking, & Keogh, 2010)	Eight gender-segregated focus groups were held with 21 males and 22 females in August 2008.	Text messages were viewed as an acceptable and 'personal' means of health promotion, with participants particularly valuing the informal language. There was a preference for messages that were positive, relevant and short and for messages to cover a variety of topics. Participants were more likely to remember and share messages that were funny, rhymed and/or tied into particular annual events. The message broadcasting, generally fortnightly on Friday afternoons, was viewed as appropriate. Participants said the messages provided new information, a reminder of existing information and reduced apprehension about testing for sexually transmitted infections.

Chapter 16
Emerging Technologies and ICT Solutions in Healthcare

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ABSTRACT

The reaction of a human body under stress, on the onset of a disease or on being physically challenged is reflected by the fine changes in the human physiological parameters and hence is required to be repeatedly measured. The acquisition of data if done in real time enhances the sense of connectedness with the health care providers by sharing raw or interpreted physiological data. Emerging ICT tools in healthcare sector help in creating modular, software-defined test systems with improved throughput and flexibility for lesser overall costs. They also assist in designing advanced algorithms and developing prototype on off-the shelf hardware in a remarkable time frame. This chapter thus focuses on design and development of a system to acquire vital human physiological parameters like ECG, EMG and Carotid pulse waveform using latest technologically advanced ICT tools.

INTRODUCTION

The enhanced standard of living across the globe has resulted in better life expectancy in developing countries as well. The change is rapid and endlessly being challenged with the obligation of providing superior health care monitoring and attention either at health care centers or at remote locations. The reaction of a human body under stress, on the onset of a disease or on being physically challenged is reflected by the fine changes in the human physiological parameters and hence is required to be repeatedly measured. The applications could be varied and many requiring either need base or continuous measurement and analysis. The analysis may again be done at the point of measurement or away based on the situation or requirement. Quite clearly this opens a plethora of applications like monitoring patients at hospitals or remotely, to judge performance of sports men or women, evaluate the best of breed men posted at challenging high altitudes or while operating modern day equipment like jet planes and space ships or being cautious about the environment around the people involved in mining deep below the Earth's crust etc. Continuous monitoring of human physiology is of utmost importance in Biological

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feedback systems as well, which provides the patients with on-line information on the functional status of their internal organs and systems.

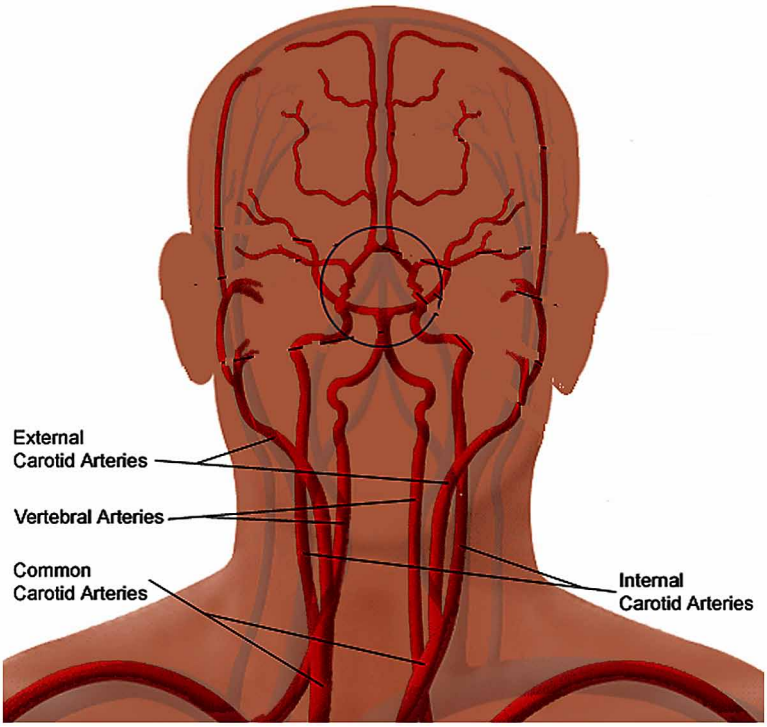
The challenges faced are further multiplied by growing masses and incessant strain on state resources to provide quality health care. Accordingly, importance of development of simple, low cost, reliable, portable and expandable devices to detect, measure, transmit and automatically analyse the output enabling diagnostic and therapeutic decisions are the need of the hour. The implication and potential of these health monitoring technologies are paramount as they enable early detection of health deterioration and notify subtle changes in the physiological parameters. The acquisition of data if done in real time enhances the sense of connectedness with the health care providers by sharing raw or interpreted physiological data.

Thus, it is evident that safety, cost, quality and access are the major parameters on which the health care systems can be gauged objectively. However, reduced development time is also significant to ascertain an early position in an extremely competitive market. Emerging ICT tools in healthcare sector help in creating modular, software-defined test systems with improved throughput and flexibility for lesser overall costs. They also assist in designing advanced algorithms and developing prototype on off-the shelf hardware in a remarkable time frame. By tightly integrating hardware, software, validation, and reporting tools, vendors like National Instruments and Mathwork provide the best solution for rapidly developing and testing complex medical devices. Various systems used presently to detect, transmit and analyze human physiological parameters have addressed a wide variety of clinical and technical issues. Although enormous research efforts have been made in the fields of human physiological signal monitoring and signal feature extraction, most of them are truly not affordable and reachable to the masses. There is a further scope for improvement, especially in terms of noise sensitivity, universal connectivity, response time and on-line processing. Advancement in computer based portable data acquisition (DAQ) hardware and software could facilitate development of monitoring instruments which are not only simple but also provide compatibility at a much lesser cost. This chapter thus focuses on design and development of a system to acquire vital human physiological parameters like ECG, EMG and Carotid pulse waveform using latest technologically advanced ICT tools.

BACKGROUND

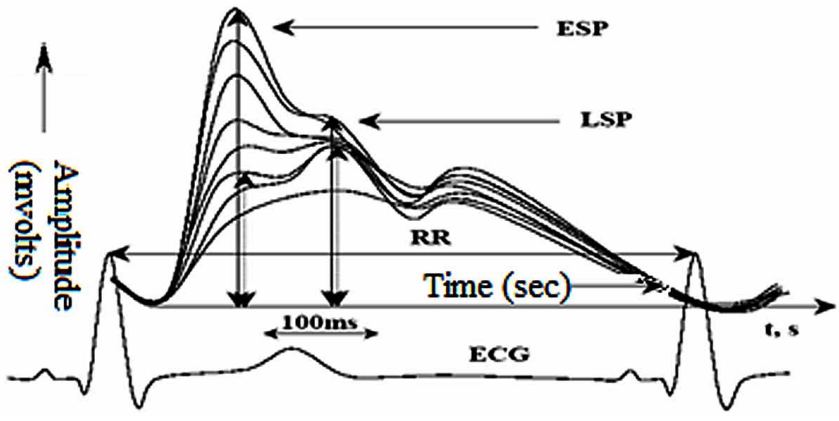
Detection and analysis of carotid pulse waveform for its amplitude, periodicity and shape is done for the assessment of various physiological parameters, especially the cardiac functions of an individual (Karnath, & Thornton, 2002; Stanford Hospitals & Clinics, n.d). Schematic representation of carotid arteries is shown in Figure 1. The common carotid artery branches off from the aorta in pair and supplies oxygenated blood from the heart to the head and the brain through the neck. It gets further bifurcated in the neck into left and right external carotid arteries and left and right internal carotid arteries. External and internal carotid artery, one each is situated on either side of the neck. It is very easy to detect a pulse over the carotid artery on both sides of the neck. Physicians therefore often use the carotid artery to detect a pulse in patients who are in shock. Plaque deposition due to cholesterol, calcium, cellular wastes etc. on the inner walls of the carotid artery may narrow it down. This can lead to serious carotid artery diseases like Stenosis where reduced amount of oxygen rich blood reaches the brain. Severe blockage in the carotid artery may even lead to a stroke (Stanford Hospitals & Clinics, n.d). Blood flow measurements through these arteries are therefore an area of research where the pressure waveforms generated due to pulsation of carotid arteries needs to be critically analyzed.

Figure 1.



Carotid pulse has a smooth rapid upstroke that arises due to ejection of blood from the left ventricle to the aorta followed by a less rapid down stroke. During systole, two positive deflections are seen. The peak is called the percussion wave, and the secondary wave is known as the tidal wave. This is followed by a dicrotic notch caused by the closing of the aortic valve. Figure 2 depicts a detailed carotid pulse waveform indicating early systolic peak (ESP) and late systolic peak (LSP), in direct correlation with the ECG wave (Stankus, & Alonderis, n. d.).

Figure 2.



Of all the methods used to acquire and monitor the Carotid pulse wave, arterial catheter is the gold standard but is an invasive process. Focusing the research on non-invasive procedures to measure the carotid wave, various methods have been developed. Earlier used one of the non-invasive technique involves the theory of fluid volume displacement in a capsule put over the artery (Freis, & Kyle, 1968). An automated carotid pulse assessment involves Doppler–Ultrasound based approach for in-vivo measurements during cardiac arrest. An array of three custom designed Piezo-electric sensors, pre-amplifiers, DAQ cards, filter and CW waveform generator are used for obtaining the carotid data in this work (Alfred, Solal, Raju, & Avati, 2008).

A simple and cost effective piezoelectric sensor arrangement is discussed here that has the possibility to improve the system portability, sensitivity and ease of interface with the computer for acquiring the carotid pulse contour in real time on freely available virtual scope. Sound card of the computer is used as the interfacing unit which amplifies and converts the analog input signal into digital, so additional amplifier, analog to digital convertors (ADC) and data acquisition (DAQ) boards are not required. MATLAB is then explored to quantify the posture related changes in the stored carotid data and is also used to further clean the stored Carotid signal using software digital filters.

Another physiological parameter Electromyography (EMG) quantifies the electrical impulse generated by muscles at rest or during contraction. Brain initiates a signal and sends it to the motor neurons to contract a muscle. Raw EMG signal is an electrical potential that changes over time and is oscillating in nature with an amplitude range between 0.5 to 10 m-volts. The spectrum of an EMG signal lies in the range 0.05 to 500 Hz. EMG signal can be measured either directly using invasive electrode or on the surface of a muscle using surface EMG method. Invasive EMG gives precise muscle information, but is unrealistic because needle electrodes need to be inserted into the muscle fibre of the subject. Surface EMG on the other hand, are noisier and less accurate, because MUAP captured is affected by body tissues like fat and skin. EMG sensors that acquire muscle details also pick up other electrical events such as activity from adjacent muscles, skin movement over muscles and EM noise. EMG measurement therefore requires multiple stage amplification, analog filtering and software digital filtering.

EMG detection and processing has a wide application in fields of Neuro-muscular physiology, Biomechanics, physical healing in case of improper muscle movements and postural control etc. EMG signal detection and analysis is utilized in various clinical and biomedical applications including generation of control signal for prosthetic tools. However, better solution to obtain noise free signal and compact detection and wireless communication technologies are continuously being upgraded. Advancement in digital signal processing and miniaturization of instrumentation has enabled the development of enhanced EMG detection and analysis methods (Reaz, Hussain, & Yasin, 2006; Zeng, Powers, & Hongwei, 1999). Surface EMG thus acquired is further decomposed (Luca et al., 2006; Nawab, Wotiz, & Luca, 2008) into motor unit action potentials (MUAP) using Template matching (Lefever, & Luca, 2008) and Neural Networks.

Application of EMG signal detection and analysis is enormous. Surface EMG provides an efficient control of robotic manipulator using MATLAB and DSP system (Lopez, Sciascio, Soria, & Valentinuzzi, 2009). It is practically possible to control virtual devices through non-invasively acquired EMG, thus replicating joysticks and keyboards (Wheeler, 2003). Fuzzy classifiers are utilized to control hand prosthesis (Zecca et al. 2006). Looking at the vast application of EMG acquisition, a real time, cost effective, non-invasive, compact physiological signal monitor with simple computer interface and algorithm to minimize artefacts needs to be developed. An attempt has been made in this chapter to non-invasively acquire and wirelessly transmit surface EMG signal during various levels of bicep muscle contractions. Also the algorithm developed is tested for a dual channel application where the correspondence of rec-

tus abdominis muscle contractions is established with Carotid artery pulsation. Stand-alone MATLAB executable file is further developed to give a compact, cost efficient solution to physiological signal monitoring.

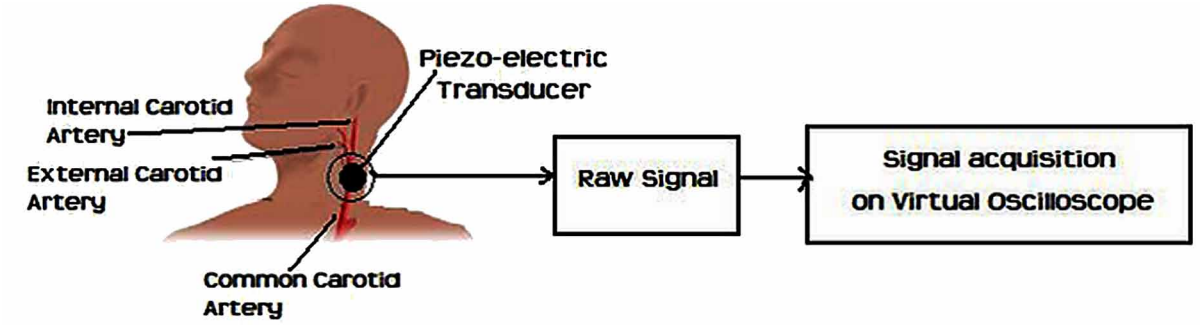
ECG system on the other hand is an ideal instrument for patient monitoring and supervision. An extensive range of human physiological conditions can be inferred from the PQRST waves obtained from an ECG instrument. Although ECG instruments were quite bulky, miniaturization in recent years has enabled development of wearable versions that collect and process ECG data. Subtle changes in the physiological signals of an individual are easily monitored using wearable health checking systems. Looking at the recent trends in bio medical applications, a major advancement can be noted in ECG monitoring devices. This ranges from simple and portable Holter instruments to sophisticate and costly implantable gadgets. The Holter monitors have been used only to collect data in ambulatory patients. Processing and analysis are then performed offline on recorded data (Jovanov, Gelabert, Adhami, Wheelock, & Adams, 1999). Systems with multiple sensors have too many wires between the sensors and the monitoring device, which limit the patient's activity and comfort level. Available systems also lack universal connectivity of interfacing to any output display device through common communication ports. There is a requirement of data acquisition circuits with analog to digital converters as the interface between the Instrument and the Computer. Various ECG instruments have addressed a wide variety of clinical and technical issues. However, there is still scope for improvement in them particularly in the area of their susceptibility to noise, fifty hertz power line interference, lack of universal connectivity, low cost wireless transmission and off-line processing.

Further to this, real time embedded systems created using digital signal processors have a significant progressive role in processing of multi-parametric bio-signals. The decreasing cost of this technology has resulted in its commercial availability and provides high speed, accuracy, noise immunity, low power consumption, programmability and size reduction. The analysis however is done generally on stored data and there is a need of additional data acquisition unit that makes the system expensive. This chapter implements the design of an intelligent general purpose low cost dsPIC digital signal controller DM330011 (by Microchip) based system for continuous monitoring and automatic analysis of ECG signal. The purpose of this work is to understand how modern ECG is derived and displayed and to ascertain standards that will improve the precision and utility of the ECG in practice. Emphasis is placed on compact and enhanced signal acquisition system and computer-based signal processing, which provide automated measurements that lead to computer-generated diagnostic inferences. The final system results in an inexpensive stand-alone solution to real time implementation of medical monitors.

Detection and Analysis of Carotid Pulse Waves

Block diagram of the sensor system for recording the Carotid pulse wave on a computer in real time is sketched in Figure 3. The measurement scheme consists of a pressure sensitive sensor and a mono jack is used as the interfacing connector between the sensor and the sound card of the computer. The sound port connector is used to input the analog voltage obtained from the transducer to the computer which then serves as the host for displaying the acquired physiological signal. Universal Real-Time Software Oscilloscope GUI DLL Library named Sound-Scope is used for data acquisition. This software is used for linking to real-time controlling programs as longer delays in transmission of data to the oscilloscope do not occur. Data can be obtained in this virtual oscilloscope via various communication ports like serial port (RS232, 422, 485), SSI, USB, Ethernet and also through a data acquisition card with analog-to-digital converters. The oscilloscope also permits data to be received from the sound card of the computer.

Figure 3. Basic block diagram for recording carotid pulse wave

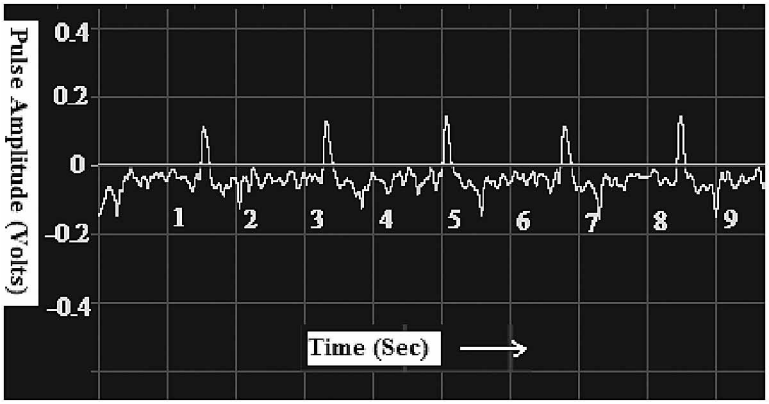


To record the carotid pulse waveform, the transducer was placed gently over the carotid artery after palpating it by fingers. The electrical signal generated by transducer is interfaced with the computer using a mono duplication chord through the sound port. The result is displayed, analyzed and stored in the computer. The subject is in a relaxed sitting on a chair position initially. In the second stage, the subject is made to sit on the floor and then suddenly stand up, and the changes that occurred were recorded. This is a non-invasive method and there is generally no discomfort in using the transducer on the skin. The study was done on healthy male and female volunteers of age group between 35- 55 years in sitting and active standing postures. The stored recordings were then analyzed for changes in amplitudes and periodicity of the carotid pulse waveform under different postures.

The analog voltage produced at the output of the sensor quantifies the pulsation of the carotid artery. The pressure pulse waveform obtained for various subjects are shown in Figure 4 till 6. The stark simplicity of the acquisition system may not be giving a very typical Carotid waveform but can be effectively used for purposes like RR interval calculations. The positive peak seen on the contour represents the increase in the arterial pressure due to ventricular contraction during systole. The variation in the amplitude and shape of the carotid contour is thus due to altered heart contractions.

Measurement made on healthy human subjects optimizes the simple electronic arrangement of carotid data acquisition. Table 1 analyses the acquired carotid pulse waveform in sitting on floor and active

Figure 4.



standing postures. RR period and Pulse amplitudes are quantified from the recordings by visual inspection. Reduced RR interval in active standing position is an indication of higher heart rate. An increase in amplitude of pulse pressure can also be observed in Figure 6, when the subject stands up. Differences in amplitude and periodicity of these waveforms may be due to diverse physiological parameters of an individual like age, gender, height, obesity, blood pressure etc (Stanford Hospitals & Clinics, n.d). Easy acquisition of carotid data can help in critical situations to measure pulse in patients who are in shock and so do not have a noticeable pulse in other peripheral arteries of the body.

Digital filters are programmed in MATLAB to remove the artifacts in the stored carotid data offline. Zero Phase digital filters, band-pass type are used to improve the raw carotid signal. This filter

Table 1. Carotid waveform analysis in different postures

Subject No.	RR Interval (Sec)		Pulse Amplitude (Volts)	
	Sitting on Floor	Active Standing	Sitting on Floor	Active Standing
1	1.65	1.20	0.020	0.025
2	1.40	1.10	0.018	0.020
3	1.50	1.30	0.019	0.021
4	1.90	1.40	0.017	0.020
5	1.65	1.30	0.022	0.025
6	1.60	1.10	0.020	0.025
7	1.70	1.50	0.017	0.022
8	1.75	1.50	0.015	0.020
9	1.80	1.40	0.014	0.018
10	1.65	1.40	0.020	0.023
11	1.55	1.35	0.019	0.022

Figure 5.

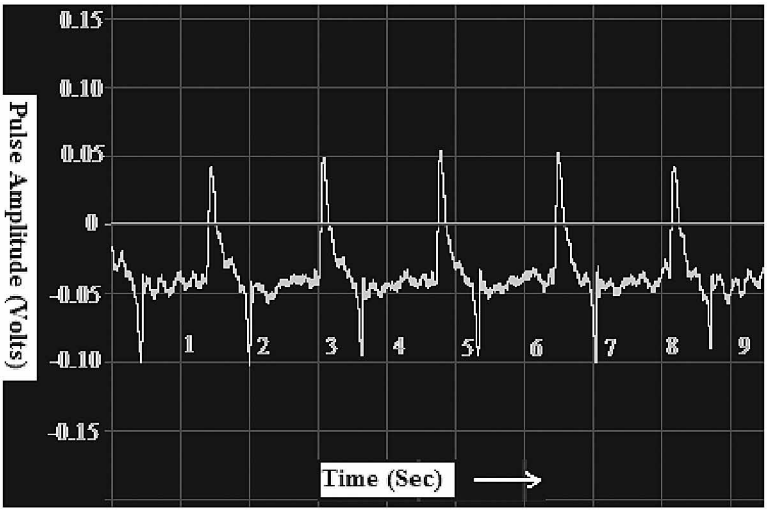
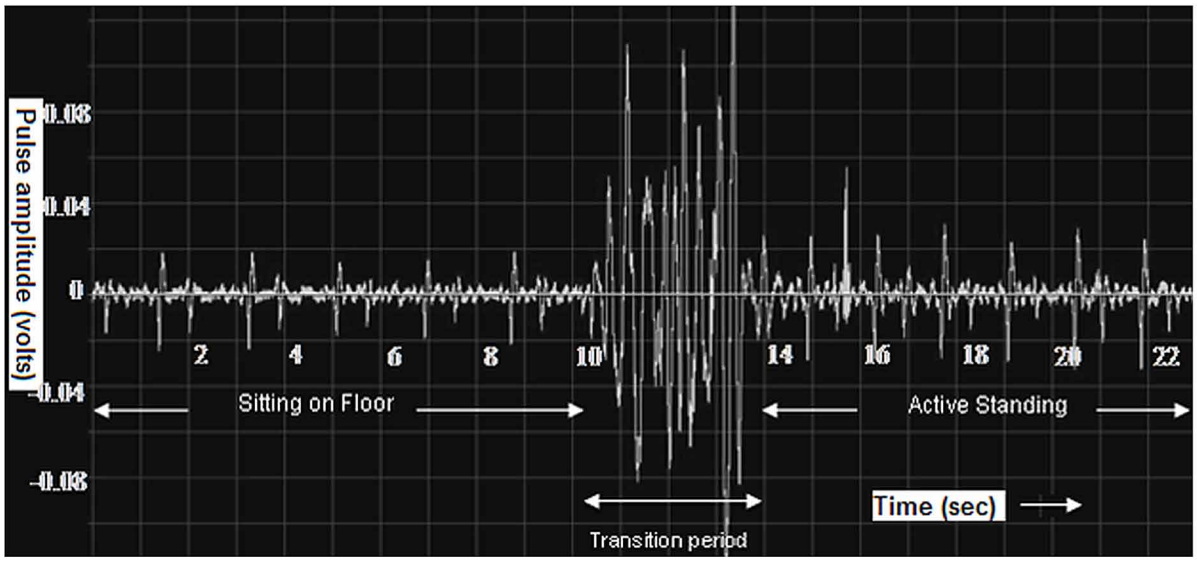


Figure 6.



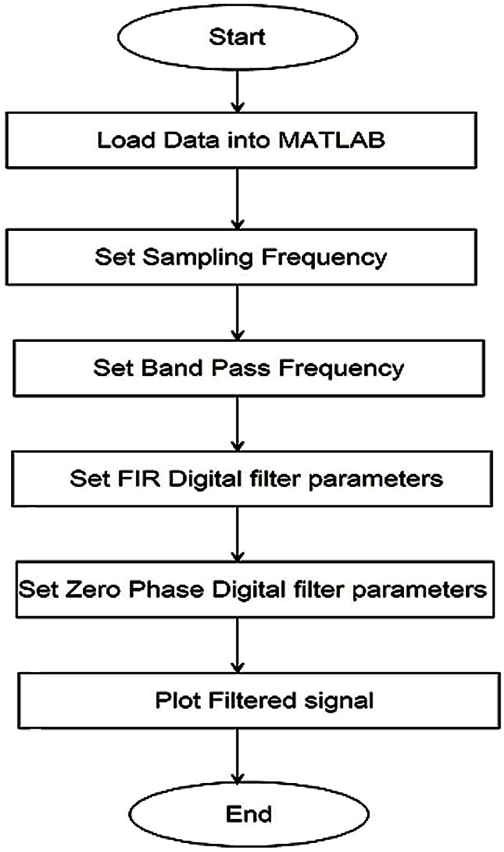
is a combination of a low pass and a high pass filter which filters the acquired signal in forward and reverse directions resulting in zero-phase distortions and helps in removing the noise which arises due to high & low frequency interferences and also because the sensor-body interface is not stationary in time (Tenedero, Rava, & Sison, 2002). The pass – band of the filter is 0.05 Hz to 50 Hz which adequately covers normal to normally excited heart beat intervals and can be used for carotid recordings. The flow chart for off-line filtering of carotid data is shown in Figure 7. The raw carotid signal is fetched into MATLAB workspace. Zero-phase digital filtering is then done in both the forward and reverse directions using 'filtfilt' command. As can be clearly seen in Figure 8, the noise picked up during the recording is filtered to a great extent using MATLAB based Digital filter algorithm. X-axis records the number of samples. The sampling rate being 8000 samples/sec, the results obtained thus show 12.5 seconds of data.

EMG Signal Acquisition and Digital Processing

The functional block diagram of Laptop based simple portable system for real time wireless acquisition of human EMG signal is shown in Figure 9 (Carr, & Brown, 1998). Instrumentation includes reusable surface Ag-AgCl electrodes, Amplifier and Filter section made of TL-084C operational amplifier followed by a commercially available Wireless Microphone FM Transceiver system, mono duplication chord, 9V and 1.5 V batteries and HP pavilion Laptop. The Ag-AgCl sensor used is made of silver and is coated with chloride ions that help in transducing the bio-potential into a measurable voltage signal. An electrolytic gel (Ag-AgCl) is used on the skin to reduce skin impedance for better current flow. A dual channel recording system is further developed, to simultaneously acquire human rectus abdominal muscle contractions and Carotid pulse wave. Functional block diagram of computer based dual channel system to simultaneously record EMG signal and Carotid artery pulsation is shown in Figure 10.

Analog outputs from EMG amplifier system and Carotid pulse acquisition arrangement are fed to the stereo input jack interfaced to the Laptop through the sound port. Visualization and digital process-

Figure 7.



ing of the simultaneously acquired EMG signal and Carotid pulse is done using MATLAB programme. Figure 11 shows the flow chart of virtual oscilloscope in MATLAB for online dual channel acquisition and filtration of both the bio-signals. After creating the analog input object, two channels are added to acquire both signals at the sound port. Once the data is collected, it is segregated for EMG and Carotid signals. The pass –band range of the FIR filter set is 0.05 Hz to 50 Hz which adequately covers Carotid signals and is set 1 Hz to 200 Hz for the EMG signal. Both the filtered signals are simultaneously plotted. Figure 12 is the snap shot of simultaneously acquired rectus abdominal muscle EMG and the Carotid artery pulsation. Channel one acquires EMG signal and channel two acquires corresponding Carotid pulse wave. Raised pressure in abdominal cavity causes a back pressure on the abdominal aorta and through left ventricle into the Carotid Artery. Raised amplitude levels in Carotid pulsation are evident corresponding to abdominal contractions in these snap shots. This indicates that a direct correlation exists between the rectus muscle contraction and the Carotid artery pulsation.

The user friendly programming and versatile graphics of MATLAB effectively analyzes and filters real time simultaneously acquired EMG signal and Carotid pulse wave. One benefit of performing the digital processing on-line is that the information to be transmitted is reduced after noise removal and it also increases the possibility of acquiring more number of signals. In this work, FIR filters are designed to filter out noise from the acquired EMG signal and Carotid signal because FIR filters possess certain

Figure 8.

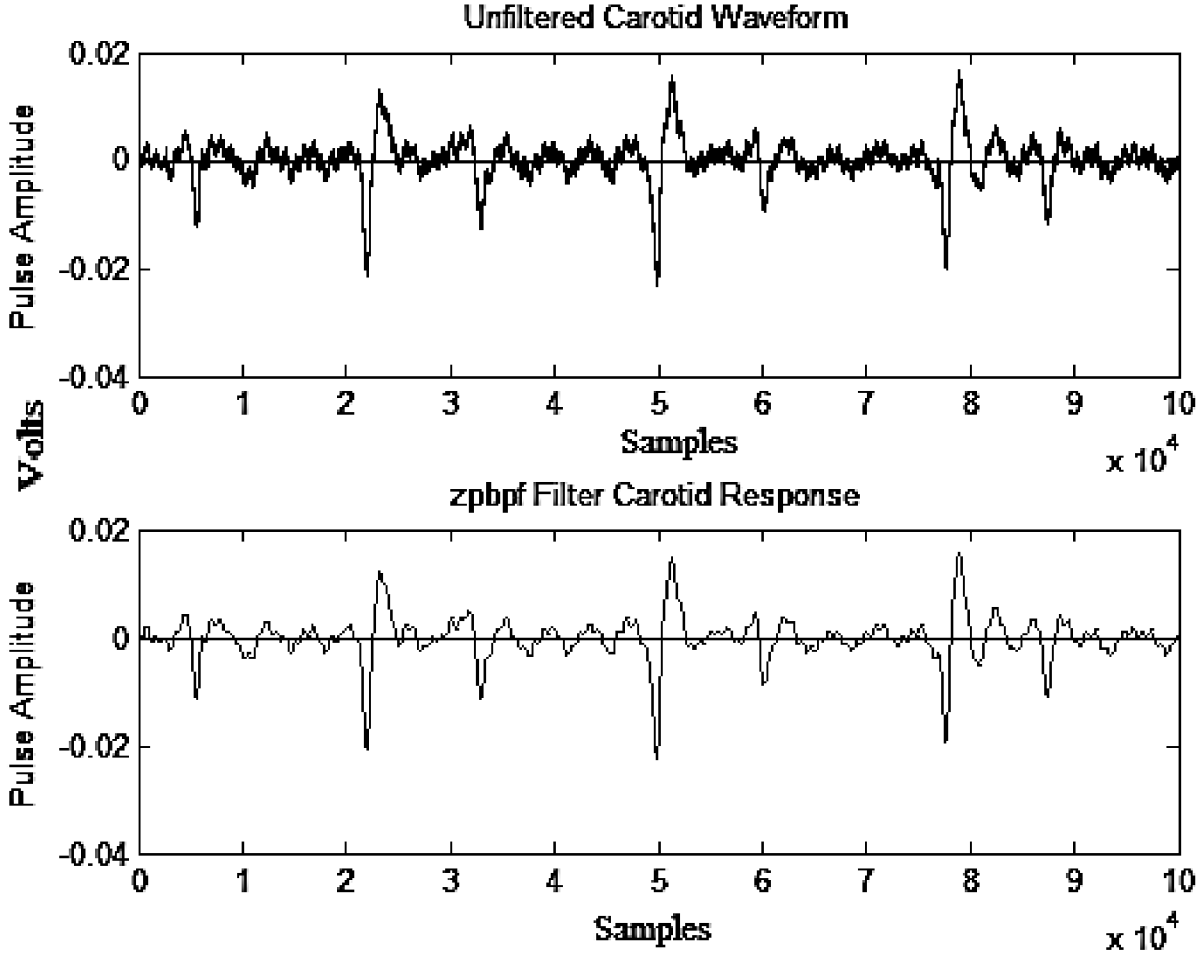


Figure 9.

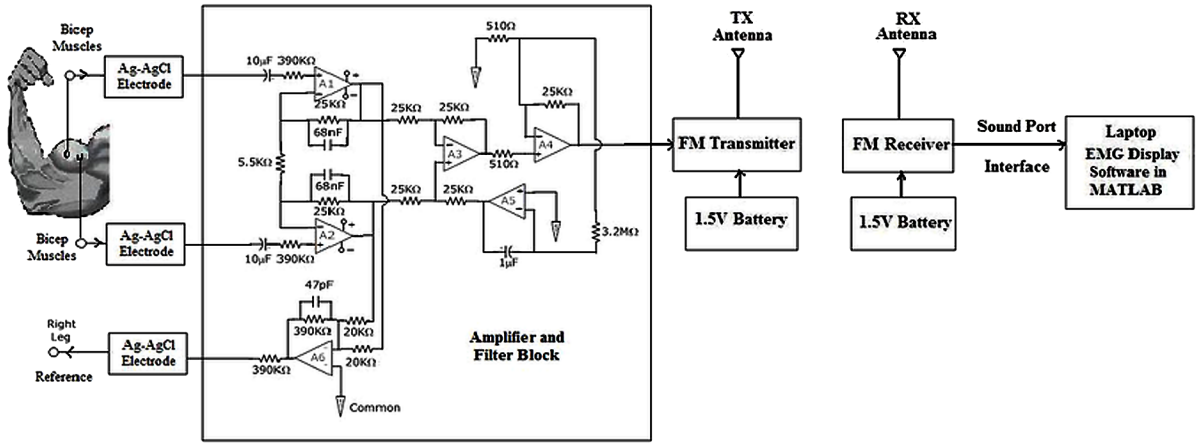


Figure 10.

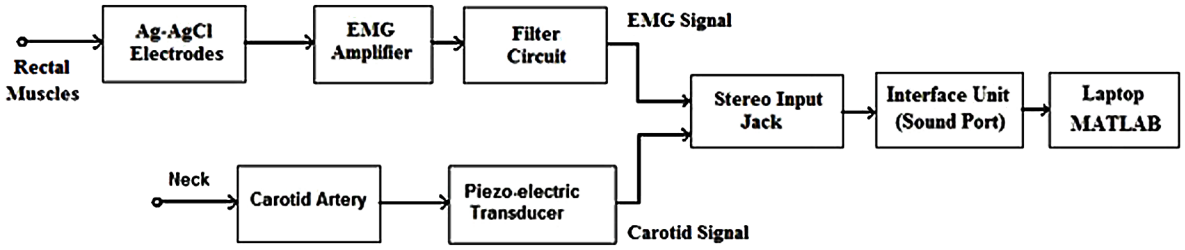


Figure 11.

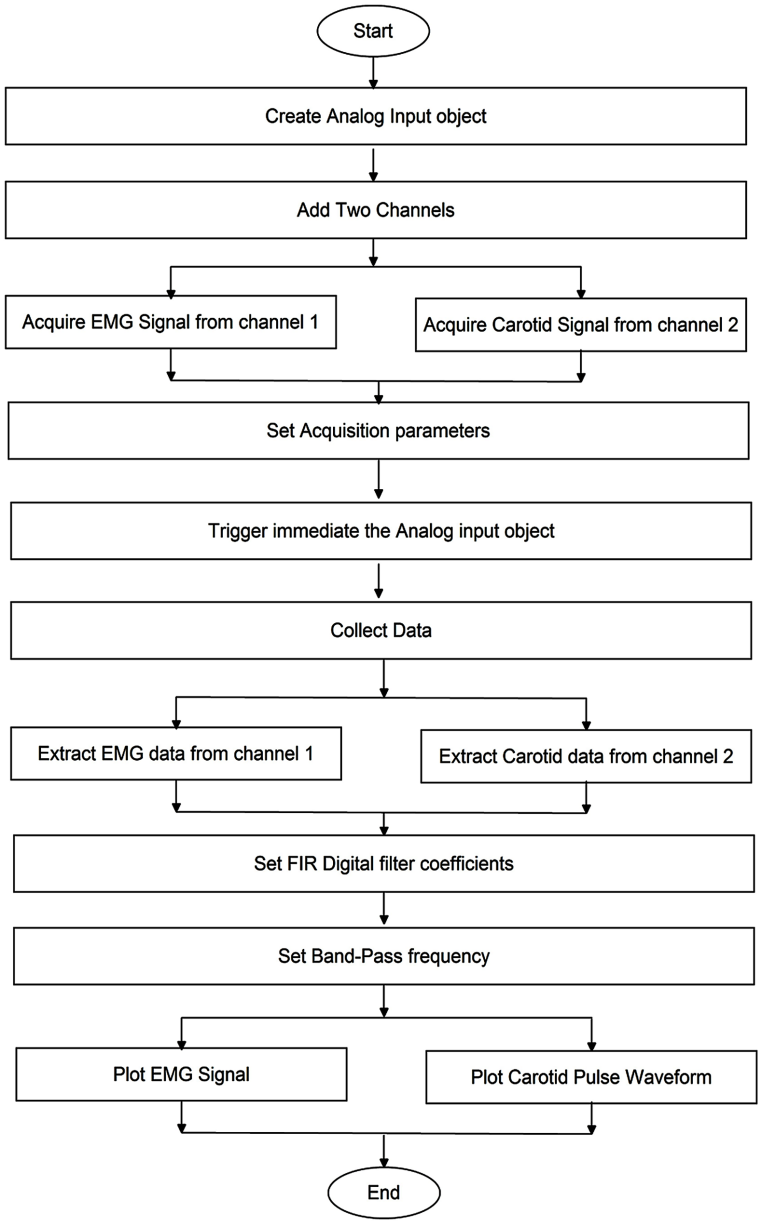
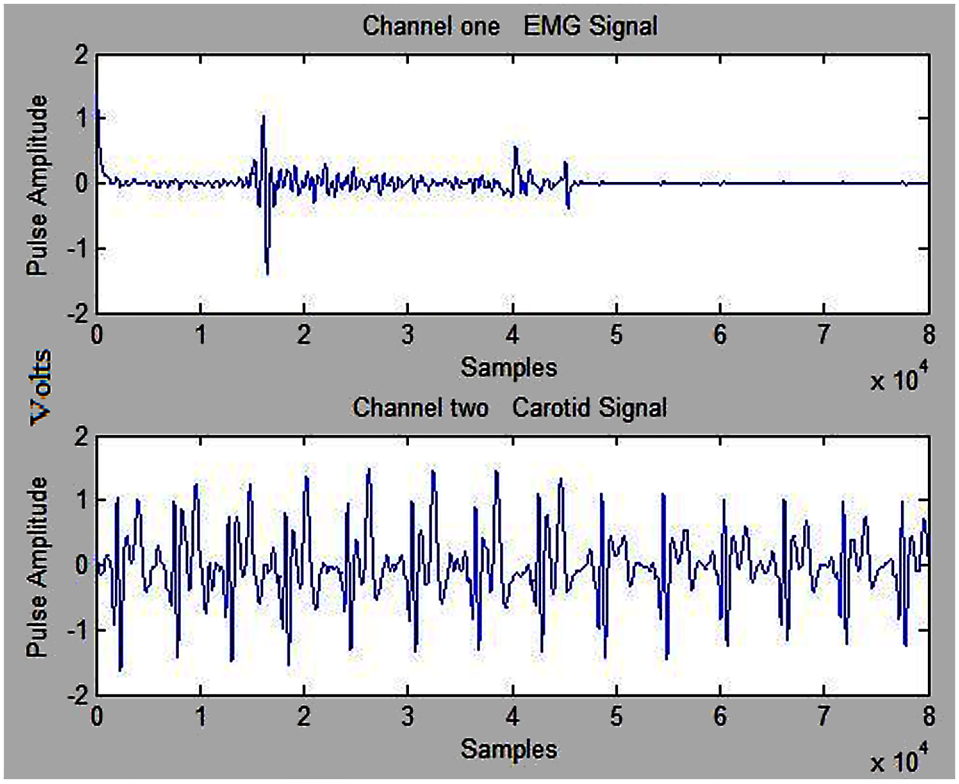


Figure 12.



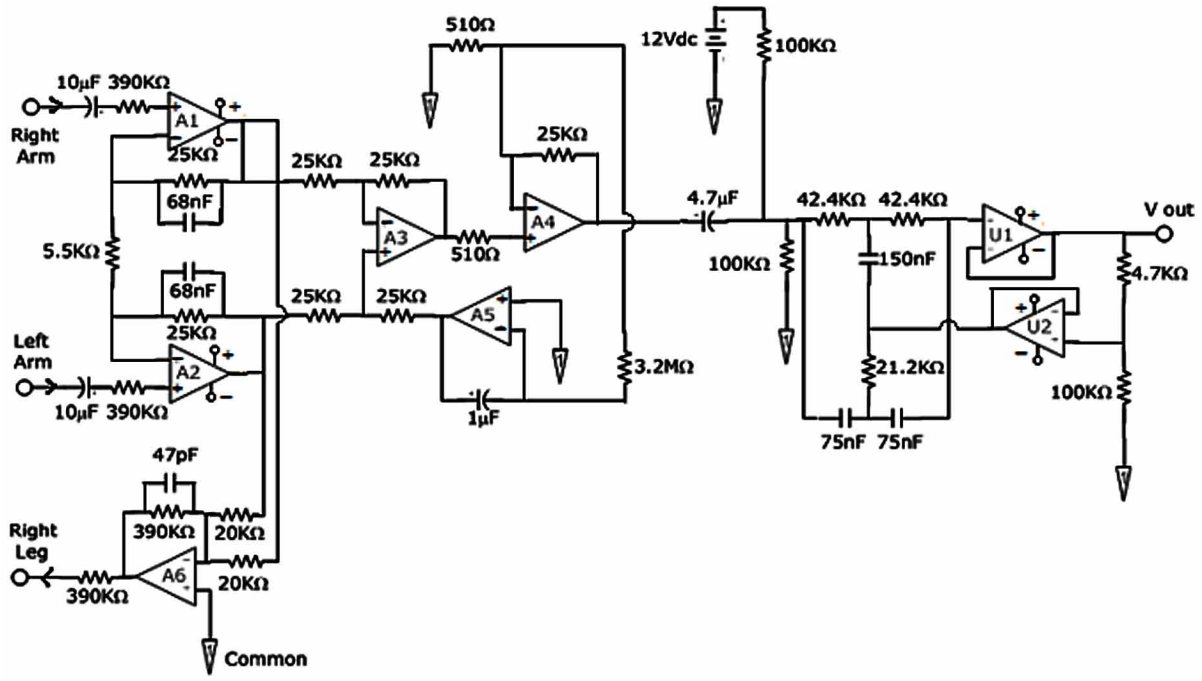
very desirable properties like they exhibit linear phase characteristics within the pass-band of the filter, are stable and realizable. Generally, signals are modified in amplitude and phase when passed through a filter. A filter that does not have linear phase property distorts the phase of the signal. A particular input signal has various frequency components that get delayed in appropriate fashion due to phase nonlinearity. This changes the harmonic relationship of the input signal and can distort the bio-signal (Johnson, 1992).

ECG Signal Acquisition and Digital Processing

Detailed circuit diagram of an enhanced system for ECG acquisition is shown in Figure 13. Multiple stage amplification, proper lead placement, right leg drive circuit, analog filter, hardware 50 Hz notch filter and MATLAB based virtual oscilloscope with digital filter program helped in obtaining human ECG signal.

The stages of the blood flow through the heart and the associated electrical activity are represented in the features of the ECG signal. The detection of heartbeats, also referred to as QRS complexes, has been an active research topic for several decades. However, the use of the ECG as an offline identification mechanism based on feature extraction is generally studied. In this work, online algorithm is developed using MATLAB to identify the QRS peaks. Figure 14 shows the flow chart for feature extraction in ECG signal and its frequency domain analysis. Spectral analysis of ECG gives additional information about human physiology. The algorithm developed successfully identifies the QRS peak and calculates the

Figure 13.



power spectral density (PSD) of the ECG signal as can be seen in the results of Figure 15. The software oscilloscope developed in MATLAB is successful in acquiring faithful rest ECG signal with identified RR peaks along with their spectral details. The ECG signal has very low amplitude (of the order of few m.volts) and lies in the frequency range 0.05 to 100 Hz. The software digital filter designed is tested with various lower and upper cut off frequencies.

Digital signal processors (DSP) have further enabled an automated approach to analysis of complex human biological signals, enhanced computational speeds, easy data acquisition and ability to handle huge amount of data. Digital Signal controller (DSC) is a hybrid solution that combines the processing power of a DSP and the utility of a Microcontroller which includes fast interrupt times, control of peripherals, general purpose I/O and can run compact code. Digital signal controllers developed by Texas Instruments (T.I) have been widely explored to give a system on chip solution to real time implementation and feature extraction of ECG signals. Digital heart rate monitors have been implemented by T.I using MSP430FG439 micro controllers and the results are displayed on a LCD. The RS232 port is utilized to interface data to the computer (Raju, 2007). A 300 MHz floating point DSP TMS320C6713 is used in a yet another application to give a solution to real time fetal ECG extraction. This scheme is simulated using code composer studio v3.1 including all its peripherals (Pani, Argiolas, & Raffo, 2008). MSP430F149 along with a fast 12 bit ADC provides a solution to remote home health care where the data is sent to a computer using RS232 interface. The ECG signal is acquired using custom designed amplifier, filter and protection circuits (Ho et al., 2005). Holter monitoring of bio-signals in real time has been made possible using TMS320C542 and Del Mar PWA amplifier Digicorder (Jovanov et al., 1999). Low cost DSP TMS320C31 is used in certain applications to build up a real R-R interval detection scheme using correlation technique (Buttfield, & Bolton, 2005).

Figure 14.

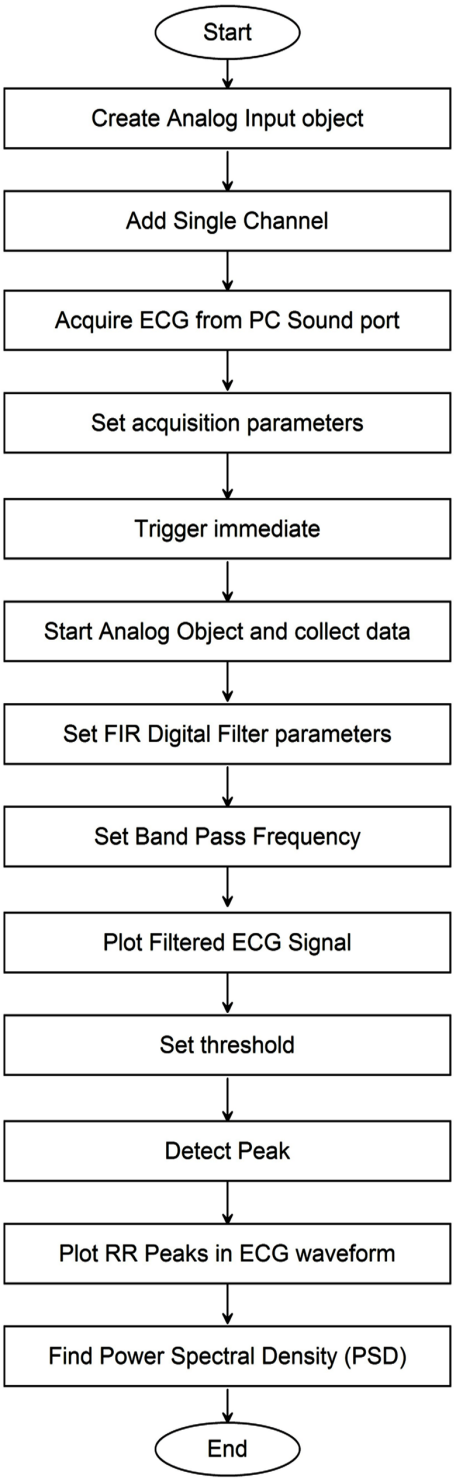
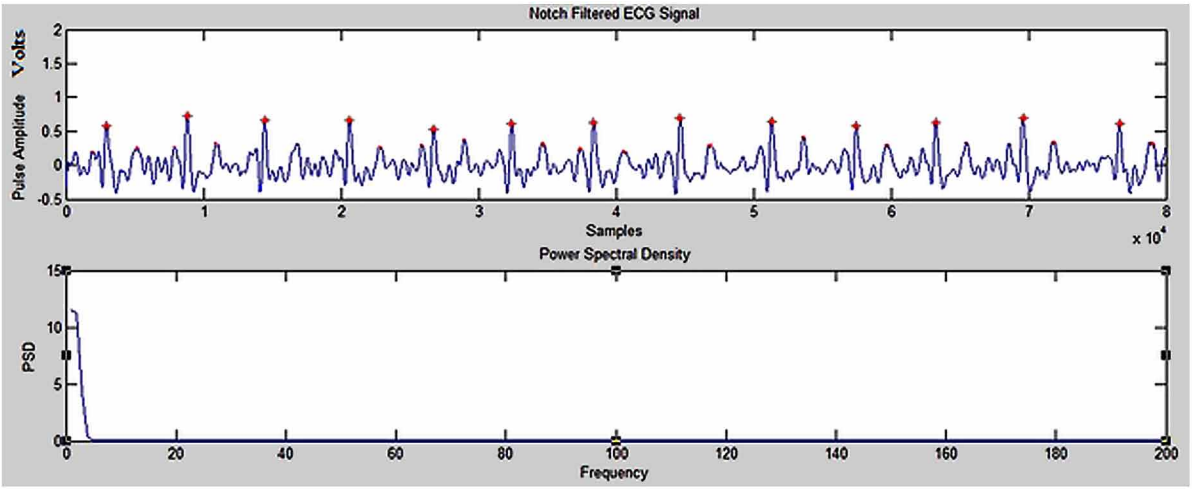

Start
Create Analog Input object
Add Single Channel
Acquire ECG from PC Sound port
Set acquisition parameters
Trigger immediate
Start Analog Object and collect data
Set FIR Digital Filter parameters
Set Band Pass Frequency
Plot Filtered ECG Signal
Set threshold
Detect Peak
Plot RR Peaks in ECG waveform
Find Power Spectral Density (PSD)
End

Figure 15.



This section implements the development of a Microchip dsPIC digital signal controller based cost effective real time system for acquisition and analysis of ECG. Functional block diagram of the Digital Signal Controller based real time system for acquisition of Human ECG Signal is sketched in Figure 16. The measurement system consists of an Ag-AgCl sensor to pick the human physiological signal, amplifier system, hardware band-pass filter, fifty hertz notch filter, Digital signal controller and a personal computer as the output display device.

The design is based on an intelligent MPLAB starter kit dsPIC digital signal controller DM 330011 board for continuous monitoring and automatic analysis of ECG which connects directly to the USB port on a computer. The starter kit demonstrates features of dsPIC 33FJ 256 GP 506 and is a general purpose fixed point Digital Signal Controller (DSC) with compatible interface options to PIC24 MCUs and dsPIC30F DSCs.

Functional block diagram for dsPIC33F DSC starter kit (Microchip MPLAB Starter Kit, n.d) is shown in Figure 17. Analog output signal obtained from the front end amplifier and filter system is routed

Figure 16.

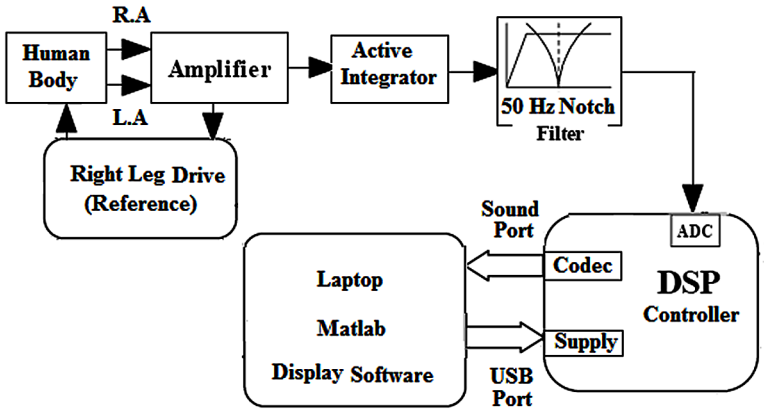
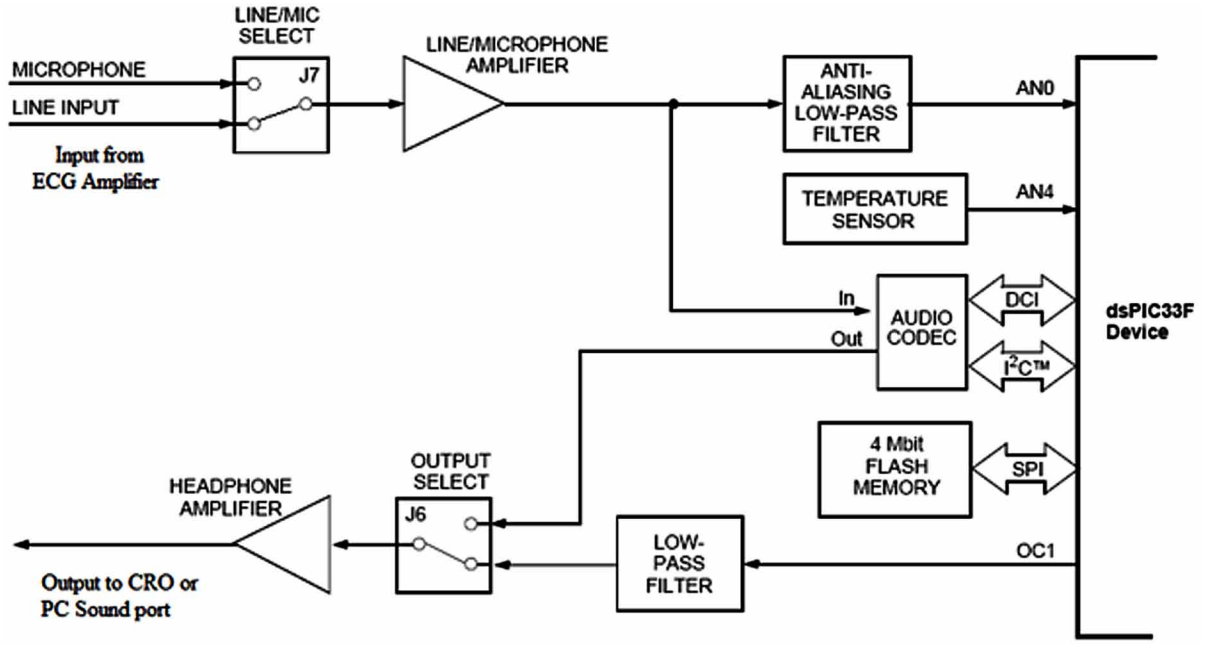


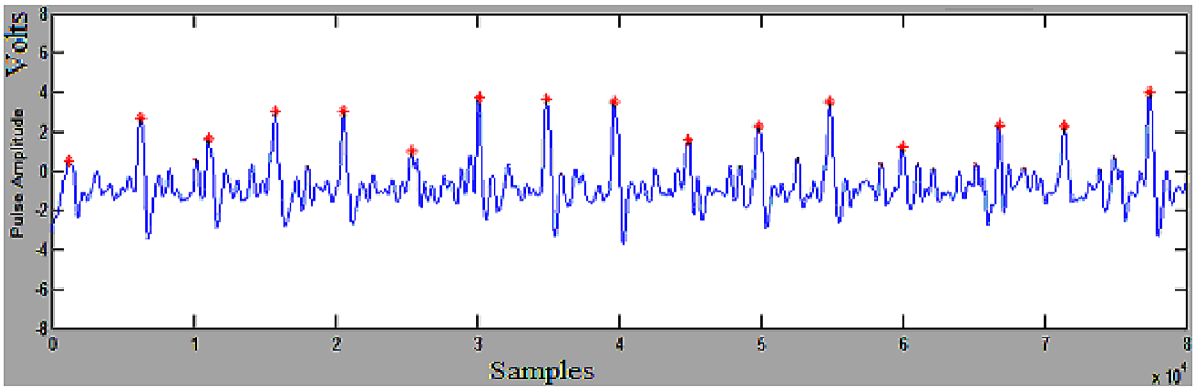
Figure 17.



through the line-in socket J7 to the 12 bit analog to digital converter (ADC) module in the on board kit for software processing as shown. This rules out the need of an extra ADC, thus reducing the size and the cost involved. The incoming bio-signal is amplified by a non-inverting AC amplifier (Line/Microphone Amplifier) and routed to the ADC module on the dsPIC33F device through an anti-aliasing filter. This sixth-order Sallen-Key low-pass filter has a cut-off frequency of 3300 Hz that suits bio-signal applications. The output of the anti-aliasing filter is connected to input AN0 of the ADC module on the device.

To record the input bio-signal in the serial Flash memory, switch S1 on the kit is pressed till the Red LED turns off (the serial Flash memory is being erased) and the Yellow LED turns on. Then switch S2 is pressed to playback and view the stored ECG signal samples. The application then uses the audio codec to play back the recorded signal (Microchip MPLAB Starter Kit, n. d.). The processed signal finally appears in an analog form at the output port socket J6 after passing through the Codec. The input to the audio codec is the output of the line-in pre-amplifier and the output is fed to the output amplifier. The codec interacts with the application program running on the dsPIC33F device. Audio output from the application program is sent to the codec via the Digital Converter Interface (DCI) module. The codec converts this digital signal to analog for the output amplifiers (Microchip MPLAB Starter Kit, n. d.). This output is interfaced directly to the sound port of the PC and the result is viewed on the virtual oscilloscope programmed in MATLAB. The Zero phase band-pass filter and peak detection algorithm tested and implemented in MATLAB are verified in the development software tool provided by dsPIC. Earlier used microcontroller system for the purpose lacked the complicated processing power requirements but the DSC kits used these days for medical monitoring have sufficient power for long-lasting use (Raskovic, Jovanov, & Kavi, 2001). The work done ensures sophisticated real time processing of bio-signals using MicroChip's DSC kits that requires less power, is compact in size and is cost effective. Peak detected ECG Signal as recorded in DSC DM330011 displayed in MATLAB virtual oscilloscope is in Figure 18.

Figure 18.



FUTURE RESEARCH DIRECTIONS

Apart from the challenges of hardware and software development, a suitable data format needs to be developed for these physiological parameters. With advancements in Information and Communication Technology (ICT), physicians can take advantage of web based applications like internet and access health information using Personal Digital Assistants (PDA) and smart phones. Thus, data format of biological signals compliant to web technologies needs to be explored for bio tele-monitoring applications. Future work extension lies in location tracking using wireless wide area network like GSM and GPRS to decrease the amount of time and cost required for medical response. These technologies need to be reliably explored first in intra hospital and subsequently in inter hospital networks. The benefits accrued would be countless and lead to a credible tele-home care monitoring systems. The research thus would be proactive enough and lead to timely preventive and diagnostic intervention. This would in the long run benefit the masses and ease the clinicians and medical care staff of the avoidable stress and delay in medical response.

CONCLUSION

This chapter thus focuses on design and development of a compact, portable and cost effective data acquisition system to acquire vital human physiological parameters like ECG, EMG and Carotid pulse waveform and also details the algorithm required for its rapid development using latest technologically advanced ICT tools. Real time embedded systems including DSP processors also have a considerable progressive role in signal processing the human biological signals. The ever decreasing price in the domain of embedded systems has resulted in its commercial feasibility and offers high speed, accuracy, noise immunity, low power consumption, programmability and size reduction. The only drawback is that the analysis is done generally on stored database which hinders the automated analysis in real time. This chapter aimed to explain in depth the design of an intelligent general purpose low cost dsPIC digital signal controller based system for continuous monitoring and automatic analysis of ECG signal in real time scenario. Overall, the work shall assist readers to understand how human physiological parameters are acquired and produced using modern technologies and to establish benchmark that will improve

the precision and utility of Healthcare devices in practice. It shall also provide an insight into design of compact and improved data acquisition system and computerized digital signal processing algorithms, which present automated results for diagnostic inferences.

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Chapter 17
Analyzing the Role of Health Information Technology in Global Health Care

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ABSTRACT

This chapter explains the perspectives on global health, the overview of health information technology (health IT), the applications of electronic health record (EHR), and the importance of health IT in global health care. Health IT is the area of IT involving the design, development, creation, utilization, and maintenance of information systems for the health care industry. Health IT makes it possible for health care providers to better manage patient care through the secure use and sharing of health information. Effective health IT can lower costs, improve efficiency, and reduce medical error, while providing better patient care and service. The chapter argues that utilizing health IT has the potential to enhance health care performance and reach strategic goals in global health care.

INTRODUCTION

The increasing adoption of the Internet-based technologies in modern health care has been very beneficial and has led to the innovative approach to health care practice (Spinelli & Benevolo, 2016). With the increasing development in the Internet, health information technology (health IT) can assist the health care professionals in managing clinical tasks and conducting research (Hsu et al., 2015). Health IT has the potential to improve the quality, efficiency, outcomes, patient safety, and reduce the cost of health care (Ahlan & Ahmad, 2014). Health IT has the potential to significantly improve the quality of health care (Dunnebeil, Sunyaev, Blohm, Leimeister, & Krcmar, 2012) and can be organized to increase the physical, social, and cognitive stimulation in health care settings (Goldwater & Harris, 2011). The impact of health IT on the quality of health care delivery is a topic of significant importance (Bardhan & Thouin, 2013) and is dependent on how it is used by nurses and health care providers (Spetz, Burgess, & Phibbs, 2014).

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With advances in health IT, the processing of health care procedures can be implemented more efficiently (Passi & Zhao, 2015). Health IT plays an essential role in the provision of health care (Koumaditis & Themistocleous, 2016). Health IT collects the data from the health care sector and other relevant sectors, analyzes the data, and converts the data into information for health-related decision making (Amorim & Miranda, 2016). Decision making is an integral aspect in health care routine that the ability to make the right decisions at crucial moments can lead to patient health improvements (Osop & Sahama, 2016). Therefore, the need for optimizing health IT is of great essence in the health care industry (Bonney, 2016).

Rapid increase of service demands in health care contexts today requires a robust framework enabled by health IT solutions as well as real-time service handling in order to ensure superior decision making and successful health care outcomes (Moghimi, Wickramasinghe, & Schaffer, 2016). Health IT gives patients and health care professionals electronic access to patient records and to health-related databases (Bai, Dai, & Li, 2014). In recent years, health care providers have begun to organize health IT solutions and the Internet to reach patients in the transformative ways (Tiago, Tiago, Amaral, & Silva, 2016). The strong influx of health IT puts the increased array on the heath care system and its various decision makers (Nedlund & Garpenby, 2014).

Health IT has the potential to improve both the quality and effectiveness of health care providers (Laflamme, Pietraszek, & Rajadhyax, 2010) and can enable the automation, integration, and the management of clinical and administrative functions in global health care (Yang, Kankanhalli, & Chandran, 2015). The health care facility must adapt to the continuous development in modern technologies in order to generate the health care-related knowledge by data and ensure quality treatment to patient (Peixoto, Domingues, & Fernandes, 2016). Advances in computer technology and capacity combined with lower start-up costs allow developing countries to achieve greater impact when they initiate health IT (Shih, Pan, & Tsai, 2009).

This chapter aims to bridge the gap in the literature on the thorough literature consolidation of health IT. The extensive literature of health IT provides a contribution to practitioners and researchers by describing the theory and applications of health IT in order to maximize the health care impact of health IT in global health care.

BACKGROUND

Over the years, IT and computer applications have been widespread among all fields, including health care (Alpuim, Esteves, Pereira, & Santos, 2016). Prior research dealing with the productivity impact of health IT has mostly focused on the impact of IT investments on hospital-level performance (Thouin, Hoffman, & Ford, 2008). In the hospital setting, two of the most important technologies are the computerized patient records and the medication administration systems (Coye & Bernstein, 2003). The Internet is increasingly utilized by individuals and health care administrators in the health care industry (Ybarra & Suman, 2006). Clinical information system improves hospital output in the short run while administrative system has a detrimental impact on hospital output in the long run (Menon, Yaylacicegi, & Cezar, 2009).

The critical enabler in the health care reforms is the adoption of health IT solution (Muhammad, Teoh, & Wickramasinghe, 2013). Health IT leads to the improvement of the health care facility both regionally and globally (Das, Maji, Dey, & Dey, 2014) and offers the great opportunities in long-term care (Rada, 2015). The application of health IT to support self-management extends the reach of the provider orga-

nization by linking patients to the exchange of health care information and facilitating self-management activities (Solomon, 2008). Interpersonal relationships and health care information are intertwined as the essential cornerstones of health care systems (Weiner & Biondich, 2006). Health care technologies tend to be characterized by their potential to make the valued contributions to the patient's health in the areas of relative unmet need, and have high acquisition costs and uncertainty within the evidence based on their actual impact on global health care (McCabe, Edlin, & Hall, 2013).

HEALTH INFORMATION TECHNOLOGY IN GLOBAL HEALTH CARE

This section highlights the perspectives on global health, the overview of health IT, the applications of EHR, and the importance of health IT in global health care.

Perspectives on Global Health

Koplan et al. (2009) defined global health as an area for study, research, and practice that places a priority on improving health and achieving health equity for all people worldwide. Kickbush (2006) recognized global health as those health issues that transcend national boundaries and governments and call for actions on the global forces that determine the health of people. Global health is viewed as health issues where the determinants circumvent, undermine or are oblivious to the territorial boundaries of states, and are beyond the capacity of individual countries to address through domestic institutions (HM Government, 2008). Global health builds on national public health efforts and institutions.

Health care is an integration of patients, health care providers, tools, and resources (LeRouge, Ma, Sneha, & Tolle, 2013) and is a domain in which the principles of information accountability can be effectively utilized (Gajanayake, Sahama, & Iannella, 2014). Health care has historically suffered from a tendency toward continued costs growth (Monguet et al., 2016). Macfarlane et al. (2008) described global health as being the worldwide improvement of health, reduction of disparities, and protection against global threats that disregard national borders. Hospitals and other health care providers are challenged by an ageing population with a rise in chronic diseases that have increased demand on constrained health care resources. There are the growing health information that overload physicians when facing urgent cases (Akaichi & Mhadhbi, 2016).

Health care has taken the center stage of attention in recent years (Nemutanzhela & Iyamu, 2016). Global health is concerned with all strategies for health improvement, whether population-wide or individually based health care actions, and across all sectors, not only the health care sector. While developed nations search for health care-related solutions to pay for the increasing financial burden of health care, developing nations provide a way forward in the deployment of innovative health care (George, 2016). Improving capacity without increasing resource consumption is necessary in health care settings (Institute of Medicine, 2001). Overcoming this challenge is critical for the sustainability of public health systems obliged to effectively deliver the health services (Godlee, 2013).

Overview of Health Information Technology

Health information technology (health IT) covers the interaction between patients and health-service providers, institution-to-institution data transmission, or peer-to-peer communication between patients

or health professionals (Chaltikyan, Avoyan, Hovhannisyan, Saghatelyan, & Aroyan, 2013). Health IT provides the important opportunities to improve patient safety, quality of care, and clinical effectiveness (Chaudhry et al., 2006) and offers various electronic methods of collecting, managing, and storing health data (Abernethy, Wheeler, & Bull, 2011). The achievement of high-quality health care through health IT is a broad goal for any health care organization (Pate, 2012). In developing countries, health IT is used to enable and support both clinical and administrative processes for health care services (Shaanika, 2016).

Health IT can be recognized as an important tool to provide the best possible health care (Akesson, Saveman, & Nilsson, 2007). The purpose of health IT should tend toward helping clinicians make best decisions for the clinical benefits of their patients, as well as for the cost-related benefits of health care organizations, communities, and societies (Shaha, 2016). The success of health IT depends on the ability to manage the iterative-incremental approach to technology and data standards, starting from small data sets with high impact on specific care and then gradually expanding toward more comprehensive data sets with an increased emphasis on secondary uses of data (Salzberg et al., 2012).

The utilization of health IT can either be enforced by health authorities or be achieved as a result of voluntarily adoption (Dunnebeil et al., 2012). The application of IT for the improved system performance can challenge the traditional autonomy of clinicians (Spurgeon, Clark, & Ham, 2011). Engagement of clinicians in the change management process required to implement the large-scale IT systems is a major component in achieving the improved patient outcomes at lower costs (Lega, Prenestini, & Spurgeon, 2013). Publications on health IT implementation are often based on case studies that report the before-and-after outcomes evaluation of health IT as an intervention (Rippen, Pan, Russell, Byrne, & Swift, 2013).

Technological innovation in modern health care requires the expertise in technical considerations and clinical practice (Cresswell & Sheikh, 2013). Clinical leaders who have technical informatics skills and previous experience with IT project management are likely to develop a vision that comprises a long-term commitment to the utilization of IT (Ingebrigtsen et al., 2014). Regarding project management, project-based organizations should concentrate on organizational learning culture to advocate the creation of knowledge to be practically fulfilled while executing the projects (Kasemsap, 2015). Organizational factors, such as the capacity for change, can have a major effect on the success of health IT (Avgar & Kuruvilla, 2011). Clinical leaders may experience strategic choices when technology is effectively adopted and their decisions affect health outcomes in health care setting (Avgar & Kuruvilla, 2011).

While earlier research primarily focused on the impact of health IT on hospital costs, scant attention has been paid toward analyzing their effect on the outcomes associated with health care process quality (Menachemi, Chukmaitov, Saunders, & Brooks, 2008). A recent study on health IT adoption patterns found that states with more patient safety initiatives exhibit the higher IT adoption rates (Furukawa, Raghu, Spaulding, & Vinze, 2008). Health IT has the potential to be a significant enabler in transforming the health care delivery system (Solomon, 2007). Health care delivery is a very special service process involving complex human activities and real-time decision making (Shen & Wang, 2015). Hikmet et al. (2008) stated that hospital size, geographic location, system membership, and tax status practically influence the adoption of health IT in hospitals.

Mouttham et al. (2012) indicated that electronic health systems, through their use of Internet and wireless technologies, offer the possibility of near real-time data integration to support the delivery and management of health care. The U.S. health care system is one of the world's most advanced systems (Doebbeling, Chou, & Tierney, 2006). Health IT perspectives (e.g., the use of clinical management system, electronic prescribing, and EHR) have been developed for health-related purposes in the West-

ern countries (Hsu et al., 2015). Devaraj and Kohli (2003) found that the health IT usage is related to a reduction in patient mortality rates and the greater hospital productivity measured as revenue generated per admission. Menon et al. (2000) provided the evidence of a positive impact of medical IT capital on hospital output as well as marginal hospital revenue based on hospital data from the State of Washington.

The increasing aging population, the prevalence of chronic diseases, and the rising costs have brought about the unique health care challenges to the global society (Scalvini et al., 2014). Fischer et al. (2014) stated that with the worldwide population growing in age, IT helps meet important needs to prepare and support patients and families for aging. The complexity of modern health care coupled with the current scarcity of good tools to support seniors and their families make IT a promising support for an aging population (Bookman & Kimbrel, 2011). Improvements in communication, information transfer, and clinical data sharing have potential to help seniors and their families manage their health at home (Lipsitz, 2012). Various patients monitoring systems utilize sensor network technology in order to collect the physiological data of a patient suffering from different diseases, such as cardiovascular disease (Kulkarni & Ozturk, 2011) and other diseases (Tura, Badanai, Longo, & Quareni, 2003).

Health IT preparedness assessment represents an important step in change management, and including this step in its planning stage can increase the positive chances of its implementation success (Li, Ray, Bakshi, Seale, & MacIntyre, 2013). Barriers to the adoption of health IT include costs and the lack of clinician involvement in implementation, planning, design, and installation of many health IT products (Stabile & Cooper, 2013). Cost is the primary barrier to adopting health IT systems (Wilson, 2009). One of the problems in health care in developing countries is the bad accessibility of medicine in pharmacies for patients (Edoh & Teege, 2011). Adopting information system in health care is not only a question of cost-benefit analysis, but also a complicated decision that depends on the social factors that are embedded in health care settings (Anderson, 2007).

Health IT can be used to better patient physician relationships as websites can be used to deliver information directly to health consumers (Lazakidou, Ilioudi, & Tsironi, 2012). Health IT makes part of day-to-day workflows in health care facilities and is used by physicians, nurses, and administrative teams (Peixoto, Abelha, Santos, & Machado, 2013). Nurses are the largest group of staff in hospitals, providing the majority of patient care at the bedside, and they are responsible for inpatient charts and the administration of medications (Waneka & Spetz, 2010). Regarding health IT, nurses utilize the electronic patient records and charting systems, clinical reminders, and electronic medication administration systems (Hamilton, Coyle, & Heinen, 2004). Health IT can improve the nurse–patient relationship and enhance the well-being for patient (Akesson et al., 2007).

The adoption of health IT and the integration of health care data and systems into efficient cross-institutional collaboration workflows of health care providers are the challenging problems for the health care domain (Ziminski, Demurjian, Sanzi, & Agresta, 2016). Other reasons given for barriers to health IT are privacy concerns, the extensive efforts required to implement the health IT project, and dissatisfaction with the performance of health IT. Careful attention should be paid to the social and cultural norms in health care organizations for successful implementation (Rivard, Lapointe, & Kappos, 2011). Implementing IT in the hospitals brings change into an established profession in the time-honored organizations (Safadi et al., 2015). Time required to learn something novel, the fear of potential lawsuits, the risk of data openings, the fear of automation, and the poor track record of health IT are the major obstacles that may arise when the computerization of patients' records is introduced (Kaplan & Harris-Salamone, 2009).

Applications of Electronic Health Record

Electronic health record (EHR) is the central component of the health IT infrastructure. The introduction of EHR in medical practice is considered as the best way to provide the beneficial document sharing in the health care settings (Piras & Zanutto, 2010). The widespread application of EHR in primary care exam rooms has changed the dynamics of patient–physician interaction (Saleem et al., 2013). The use of EHR leads to better adherence to guidelines, prevention of medical errors (Reis et al., 2013), completeness of medical records (Kumarapeli & de Lusignan, 2013), information exchange (Shiri, Iris, Pliskin, & Shmuel, 2013), patient safety, health care quality, decision making, medication management (Gagnon et al., 2014), and facilitation of patient access to medical records and communication through electronic messaging (White & Danis, 2013).

Electronic health communication has the potential to transform the health care system, and support the patient–physician interaction (Tabatabai, 2013). Physicians can engage patients in communication by using EHR in the visits (Asan, Young, Chewning, & Montague, 2015). Patient–physician communication is considered as the foundation of the health care visit (Clayton, Latimer, Dunn, & Haas, 2011). since it affects patient satisfaction (Hall, Harrigan, & Rosenthal, 1996), adherence to medical treatment (Schneider, Kaplan, Greenfield, Li, & Wilson, 2004), clinical outcomes (Stewart, 1995), and patient trust (Ong, de Haes, Hoos & Lammes, 1995). Regarding EHR, sharing a computer screen with the patient may help improve the real-time patient– physician communication (Piper & Hollan, 2013), facilitate more accurate documentation, enhance shared decision making (Almquist et al., 2009), increase shared understanding (Unruh, Skeels, Civan-Hartzler, & Pratt, 2010) and patient involvement (Frankel et al., 2005), and reduce patient alienation while a physician looks at the computer screen (White & Danis, 2013).

Rani et al. (2011) stated that EHR is a rich resource for various fields, such as epidemiological studies and medication safety. Bhavsar et al. (2014) indicated that enhancing medical workflow effectively promotes an EHR system's potential to improve the quality of health care, the patient experience, and the outcome of health care. Electronic prescribing reduces the risk of medication error in the Western medical practices (Jani, Barber, & Wong, 2010). Implementing EHR in hospitals should not to impose any additional requirement on the physicians toward minimizing the impact on physician-patient interaction (Baron, Fabens, Schiffman, & Wolf, 2005).

Increasing interest in the end users' reactions to health IT has elevated the importance of theories that predict and explain both health IT acceptance and health IT utilization in health care settings (Holden & Karsh, 2010). EHR has the potential to both make health information more accessible to patients and function as a decision-support system for patients toward managing chronic conditions (Price, Pak, Müller, & Stronge, 2013) and can transform the management of health information by providing the useful and cost-effective clinical management, the reminders for drug prescription, and the warning on cases, such as drug incompatibility and abnormal laboratory result in health care settings (Fraser et al., 2005).

EHR can offer an effective method to store the patient information and medical history (Jensen, Jensen, & Brunak, 2012). EHR with computerized physician order entry (CPOE), medication management, communication, and imaging systems are widely utilized in health care settings (Buntin, Burke, Hoaglin, & Blumenthal, 2011). EHR systems have the ability to provide clinical decision support through clinical decision support system (CDSS), the summarized data on clinical performance, and the information for population-based analyses of consumption rates (Vedel, Akhlaghpour, Vaghefi, Bergman, & Lapointe, 2013). CDSS is the important approach to a solution for improving patient safety together with CPOE (Moon & Galea, 2016). Emerging enterprise systems integrate clinical and administrative information

system, and provide new possibilities for better coordination between care processes and resource deployment (Pearlson & Saunders, 2009).

Importance of Health Information Technology in Global Health Care

Health IT has been shown to reduce the incidence of adverse events, the administration of wrong medications, the number of hospitalizations and health care spending (Whitten, Steinfield, & Hellmich, 2001). Safadi et al. (2015) indicated that the utilization of technology in the health care system is associated with many advantages, such as reducing the health care costs and improving the quality of health care. Health IT can enhance the nursing care by improving information access, providing automated surveillance for error detection and prevention, facilitating communication among health care providers, and standardizing practice patterns in the health care industry (Bakken, Cimino, & Hripcsak, 2004). Patient–physician communication through health IT is an essential element of patient-centered care (Asan et al., 2015). Health IT implementation can impact the nursing workload in both positive and negative ways, which may affect the results of health IT on patient care (Waneka & Spetz, 2010).

Many researchers in the health IT field have been attracted to develop computer applications that help in the diagnosis process in modern health care (Al-Khasawneh, 2015). Several studies have reported the evidence of the positive impact of health IT on health care quality, including the lower mortality rates (Amarasingham, Plantinga, Diener-West, Gaskin, & Rowe, 2009) and the higher vaccination rates (Dexter, Perkins, Maharry, Jones, & McDonald, 2004). Regarding health IT projects, many

health care organizations are engaging in projects to improve the flow of health information among different settings (Warholak, Murcko, McKee, & Urbine, 2011). Amarasingham et al. (2009) indicated that the greater automation of hospital information is related to the reduced rates of inpatient mortality, complications, costs, and length of stay, based on a study of older patients across a cross section of 72 hospitals in North Texas, United States.

Health IT that increases the availability of information at the point of care can improve health care (Marchibroda, 2008). Hospitals, physicians, and nurses can provide health care services either through office or home visits in collaboration with other health care providers including general practitioners with the utilization of health IT (Olaniran, 2016). The advantages of health IT include the improved legibility of documentation; the ability to integrate new scientific evidence into practice; the enhanced management and exchange of complex health information; the ability to standardize order sets, incorporate computerized physician order entry, and provide clinical decision support; and the ability to capture the health data for management, research, and quality reporting (Stabile & Cooper, 2013).

Health IT has been assigned a major role in improving the quality and safety of health care systems (Hart, 2013). The safety of health IT needs to be urgently addressed in health care settings (Coiera, Aarts, & Kulikowski, 2012). Health IT broadly includes computer hardware and software utilized by health professionals to support the health care (Magrabi et al., 2013). Evidence that problems with health IT can pose a risk to patient safety is emerging even though such systems are the important approaches to improving the safety and quality of health services (Magrabi, Ong, Runciman, & Coiera, 2012). Health IT problems can disrupt the clinical work contributing to the new types of medical errors leading to health care-related delays (Hanuscak, Szeinbach, Seoane-Vazquez, Reichert, & McCluskey, 2009). Safety issues involving IT are not unique to health care (Jackson, Thomas, & Millett, 2007), but the health care sector has lagged behind other industries in addressing the safety problems (Institute of Medicine, 2012).

FUTURE RESEARCH DIRECTIONS

The classification of the extensive literature in the domains of health IT in global health care will provide the potential opportunities for future research. Large amounts of heterogeneous medical data have become available in health care settings (e.g., health care organizations, health care providers, and physicians). Utilizing big data analytics, the medical data can be an enabling resource for deriving insights for improving care delivery and reducing waste. The enormity and complexity of these data sets present great challenges in analyses and subsequent applications to a practical clinical environment. Handling health care-related big data and big data analytics through health IT applications is certain to remain important topic for future research direction. Leaders of virtual teams should carry the responsibilities to satisfy their bosses, subordinates, and external customers in a complex environment that is highly dependent on IT perspectives (Kasemsap, 2016). Regarding the advances in the World Wide Web and health IT, managing virtual teams in health care systems should be further studied.

CONCLUSION

The perspectives on global health, the overview of health IT, the applications of EHR, and the importance of health IT in global health care are highlighted in this chapter. The adoption of health IT can enable care coordination to be more effective but only when the essential elements are addressed to reflect the team-based nature of care coordination as well as a focus on the individual's needs and preferences. Health IT makes heath care information accessible, actionable, customizable, and portable. Health IT makes it possible for health care providers to better manage patient care through the secure use and sharing of health information toward improving the quality of care and reducing medical errors in health care settings. Rapid access to health care information through health IT can create the efficiencies in care by eliminating redundancies.

Health IT systems make a substantial impact on medical quality and safety by integrating the relevant automated decision making and knowledge acquisition tools into the practices of health care providers, thus reducing the errors of omission resulting from gaps in the health care provider's knowledge or the failure to synthesize that knowledge in the health care practices. The potential advantages of widespread adoption of health IT in the health care systems make it vital to examine the scientific evidence that currently supports the relative costs and the benefits of health IT, and the barriers to implementing the various types of health IT systems. Utilizing health IT has the potential to enhance health care performance and reach strategic goals in global health care.

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KEY TERMS AND DEFINITIONS

Health Care: The activity or business of providing medical services.

Health Care Industry: The industry involving the providers of diagnostic, preventive, remedial, and therapeutic services, such as physicians, nurses, hospitals, and other voluntary organizations.

Health Care System: The combination of facilities, organizations, and trained personnel engaged in providing health care within a geographical area.

Hospital: A place where people who are ill or injured are treated and taken care of by physicians and nurses.

Information System: A combination of hardware, software, infrastructure, and trained personnel organized to facilitate planning, control, coordination, and decision making in an organization.

Information Technology: A set of tools, processes, and associated equipment employed to collect, process, and present the information.

Internet: The large system of connected computers around the world.

Chapter 18
Health Information System

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ABSTRACT

Information systems (IS) help in managing healthcare costs and in improving the quality of care. IS are uniquely positioned to capture, store, process, and communicate timely information to decision makers for better coordination of healthcare at both the individual and population levels. One of the most interesting aspects of HIS (Health Information System) is how to manage the relationship between healthcare providers and patients. The main focus of this Chapter is a brief overview of Health Information Systems and the description of the techniques that can be used to develop the health information systems. There are various emerging tools and technologies in creating and managing HIS like data mining and geographical information system. Developing HIS can improve access for geographically isolated communities; provide support for health care workers; aid in data sharing; provide visual tools linking population and environmental information with disease outbreaks.

The main objectives of this chapter are to present:

1. Concepts of health information system,
2. Tools and techniques used to develop the health information system,
3. Future research directions in this field.

INTRODUCTION

Healthcare is an information intensive industry (Rodrigues, 2010), where reliable and timely information is a critical resource for the planning and monitoring of health care services at organizational, regional, national and international levels.

The nature of healthcare industry has changed over time, from a relatively stable industry to a dynamic one. A Health Information System (HIS) is the combination of healthcare's business process and information systems to deliver better healthcare services.

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Rodrigues (2010) defines HIS as powerful ICT-based tools able to make health care delivery more effective and efficient. The data related to both clinical and administrative processes can be integrated with the data from other entities in order to be effective, and must be subject to strict rules in terms of confidentiality and security safeguards, especially for patient data.

Developing HIS is important because of (Haux 2006):

1. Increase of health care data;
2. The inclusion of patients and health consumers as HIS users, besides health care professionals and administrators;
3. The use of HIS data for health care planning as well as clinical and epidemiological research;
4. Focus on strategic health information management; and
5. The steady increase of new technologies, like including sensor-based technologies for health monitoring.

BACKGROUND

A number of health information systems are developed for patients with a health crisis or medical concern and for primary care providers.

Rahimi, Vimarlund & Timpka (2009) organized the knowledge gained in qualitative studies performed in association to HIS implementations and used this knowledge to outline an updated structure for implementation planning. Duan, Street & Xu (2011) suggested to use correlations among nursing diagnoses, outcomes and interventions to create a recommender system for constructing nursing care plans. Kuo & Chung (2012) integrated information technology and medical-related technologies to develop a healthcare information system for Comprehensive geriatric assessment (CGA).

Shoba (2013) developed a HIS that followed two tier architecture for e-doctor service where the consistent database were maintained by the hospital server to update the queries instantly by the user. Dirk, Klaus & Tobias (2014) described HIS prototype that addressed a common practical and manifested in the short interaction times between healthcare professionals and patients. Çeken (2014) proposed a healthcare information system framework which consists of wireless sensor and cellular networks, a MATLAB interface, a database, and a web based monitoring interface. Al-Sakran (2015) described the conceptual design of an e-healthcare system, which implements integration strategies and suitable technologies for a HIS.

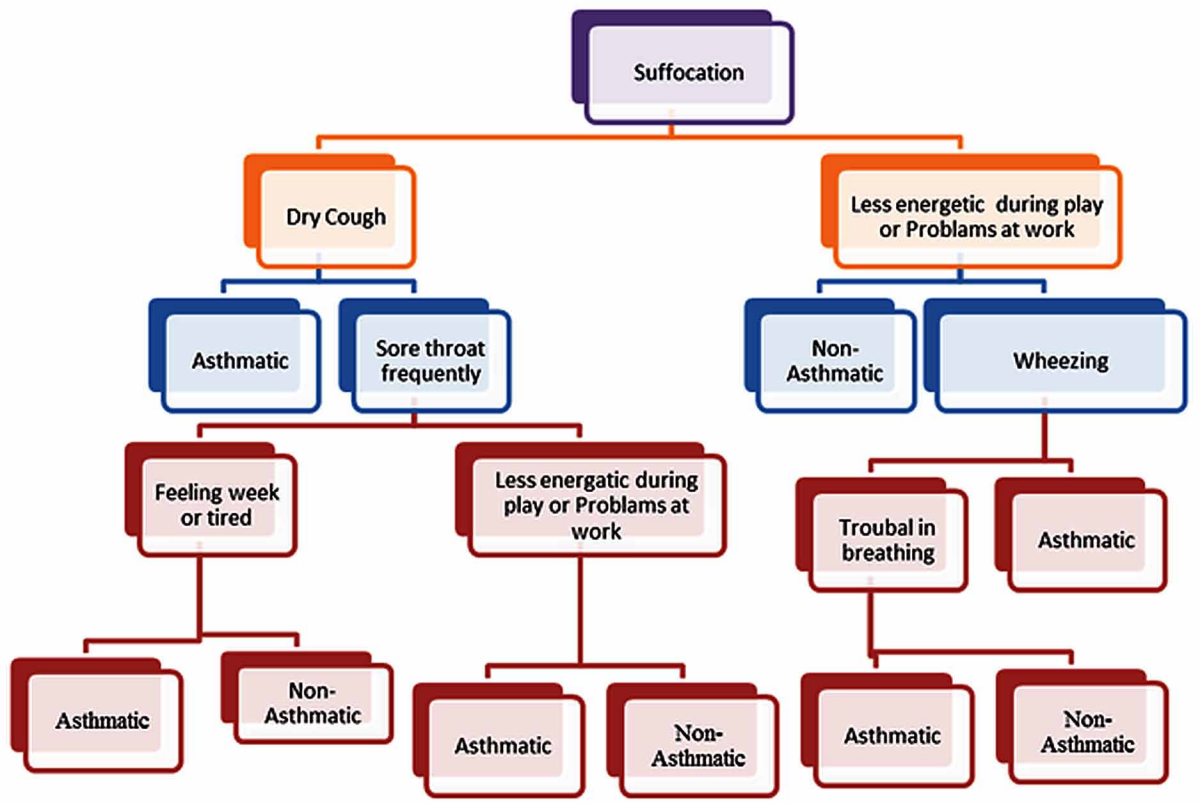
MAIN FOCUS OF THE CHAPTER

The main focus of this Chapter is a brief overview of Health Information Systems and the description of the techniques that can be used to develop the health information systems.

1. Components of Health Information Systems

- The HIS components can be divided into three categories (Figure 1): inputs, processes and outputs.
- The *inputs* category includes all HIS *resources*.
- The *processes* used by an HIS include Indicators, Data sources and Data management
- The HIS *outputs* is the information produced which needs to be relevant, accessible, and useful evidence for decision making.

Figure 1. Components of HIS



TOOL AND TECHNIQUES RELATED TO HIS

There are various emerging tools and technologies in creating and managing HIS like data mining, geographical information system, and World Wide Web.

1. Data Mining

The data generated by the health care organizations is very vast and complex due to which it becomes difficult to analyse it in order to make important decision regarding patient health. Data Mining is one of the most vital and motivating area of research with the objective of finding meaningful information from huge data sets. A survey on data mining techniques in health care can be found in Koh & Tan (2004), Durairaj & Ranjani (2013) and Tomar & Agarwal (2013).

The main aim of data mining technique is to identify valid, novel, potentially useful, and understandable correlations and patterns in data by combing through copious data sets to determine patterns that are too subtle or complex for humans to detect (Chung & Gray, 1999).

The Cross Industry Standard Process for Data Mining (CRISP-DM) provides a framework for carrying out Data Mining activities (Cunha, 2010). It divides the data mining task into 6 phases: business understanding, data understanding and preparation, modelling, evaluation, and deployment.

Data Mining Techniques

An overview of the data mining techniques with the description and application in health care is given in Table 1.

2. Geographic Information System

A Geographic Information System (GIS) helps visualizing, question, analysing, and interpreting data to understand relationships, patterns and trends. It offers tremendous benefits for the health care industry, like database management, planning, risk assessment, service area mapping, location identifications etc.

Table 1. Techniques of data mining

Technique	Description	Application in Health Care
Description and visualization	Contributes greatly towards understanding a data set, especially a large one, and detecting hidden patterns in data.	Detecting a restrictive pattern in occupational health settings (Mehrparvar et al., 2014); detecting abnormal patterns of daily activities (Zhao et al., 2014)
Classification	Predicts the target class for each data points	Predicting trends in patient condition and behaviour (Milovic & Milovic, 2012)
Classification Methods		
K-Nearest Neighbour	A classifier that discovers the unidentified data points using the previously known data points and classified data points.	Generating early warning system (Jen, Wang, Jiang, Chu & Chen, 2012)
Decision Tree	Every non-leaf node denotes a test on a particular attribute and every branch denotes an outcome of a test and every leaf node has a class label.	Determining asthma control level (Tyagi and Singh, 2014)
Support Vector Machine	Based on statistical learning theory, the classification creates a one or multiple hyper plane(s) in higher dimension space that is useful for classification or regression.	Health Monitoring System (Kim, Chong, Chon & Kim, 2013; Rejab, Nouira & Trabelsi, 2014)
Neural Network	An algorithm for classification based on biological nervous system having multiple neurons.	Chest disease diagnosis (Er, Yumusakc &Temurtas, 2010)
Bayesian Method	A classification method based on bays theory. It is a simple classifier which is achieved by using classification algorithm	Analysing risks associated with health (Liu & Lu, 2009)
Regression	Determines functions that explain the correlation among different variables	Analyzing costs in health care (Gregori et al., 2011)
Clustering	An unsupervised learning method different from classification. Large database are separated into the form of small different subgroup or cluster. Methods of clustering are Partitioned Clustering, Hierarchical Clustering and Density Base Clustering	Clustering of oral health risk behaviors (Park, Patton & Kim, 2010); Clustering of health behaviours (Griffin, Sherman, Jones, & Bayl-Smith, 2014)
Association	Used to find frequent pattern and some relationship among a set data items in the data repository.	Healthcare Fraud and Abuse (Rudman, Eberhardt, Pierce, & Hart-Hester, 2009); discovering relationships between various diseases and drugs (Soni & Vyas, 2010)
Association Methods		
Apriori Algorithm	Find the relationships among a set of data item in data repository.	Discover frequent diseases in medical data (Ilayaraja and Meyyappan, 2013)
Frequent Pattern Tree Algorithm	Identifies the frequent item set without generating candidate item set.	Identifying interesting patterns in medical (Noma & Ghani, 2012)
Estimation	Refers to the prediction of a target variable that is metric in nature	Predicting the length of stay (Kraft, Desouza, & Androwich, 2002)

GIS applications can be found in the review papers by Clarke, McLafferty & Tempalski (1996), Higgs (2004) and Fradelos, Papathanasiou, Mitsi, Tsaras, Kleisiaris and Kourkouta (2014).

GIS can be used to generate the kinds of spatial objects that arise in health research, and the variety of attributes that may be attached to those objects. Some of the classes of spatial data are:

- **Point Data:** Point data include, as objects, the residential locations of individuals, whose attributes might include presence or absence of a disease together with other features (age, gender, occupation, and so on) that is relevant to an understanding of that disease.
- **Area Data:** Analysis of area-based data represents a long-standing tradition in the geography of health. The zones are population census-based areal units, permitting a simple link between measures of disease risk and demographic or socioeconomic covariates.
- **Line Data:** Line data used in health applications include road network databases used to define travel times to centres of treatment. For example, to define a probabilistic catchment around a major hospital routing the emergency service vehicles in rural areas.
- **Spatially Continuous Data:** Spatially continuous or 'field' data arise mainly in the environmental sciences, where a continuous surface is sampled at discrete point locations.

An overview of the GIS techniques with the description and application in health care is given in Table 2.

Table 2. Techniques of GIS

Technique	Description	Application in Health Care
Point Data Analysis		
Clustering/ hot-spot analysis	Spatial cluster analysis plays an important role in quantifying geographic variation patterns.	Determine demand scenarios for public healthcare (Mokgalaka, Mans, Smit & McKelly (2013); clustering of disease (Abubakar, Honest, Abubakar, Hamiar, 2014)
K-function analysis	Ripley's K(t) function is a tool for analyzing completely mapped spatial point process data, i.e. data on the locations of events. These are usually recorded in two dimensions, but they may be locations along a line or in space	Visualization of disease surveillance data (Croner & Cola, 2001); mapping health risks (Zhang, Xiao, Shortridge and Wu, 2014)
Continuous (Surface) Data Analysis		
Spatial interpolation	Process of using points with known values to estimate values at other points	health-related indicator acquisition (Meng, Law and Thompson, 2010)
Kriging	Optimal interpolation based on regression against observed *z* values of surrounding data points, weighted according to spatial covariance values	Spatial Distributions of the Health Risk (Tyagi & Singh, 2013; Liu et al., 2015)
Network analysis	Analysing the ways to transport the goods on transportation routes Includes shortest route or closest facility	Determining vehicle-based ambulance routing systems Ganeshkumar & Ramesh, 2010) to evaluating ambulance sites and identify optimal locations (Jia et al., 2014)
Simulation	Can be done with area or point data	Fecht, Beale, & Briggs (2014)
Forecasting	Prediction based on space-time data	Air quality prediction (Nunes & Soares, 2005)
STAR model	To guide the design, evaluation, and ongoing improvement of a healthcare program	Skinner, Maley & Norman (2006)
Spatial Decision Support Systems	Integrated GIS with an array of analytic methods to support health care planning and assessment.	Early Warning and Response System (Platz et al., 2014); malaria elimination (Marston et al., 2014)

DISCUSSION

Overall, information and communication technologies have a potentially major role to play in health information systems. Technology in health care can improve access for geographically isolated communities; provide support for health care workers; aid in data sharing; provide visual tools linking population and environmental information with disease outbreaks; and is an electronic means for data capture, storage, interpretation and management.

FUTURE TRENDS IN HEALTH CARE INFORMATION SYSTEMS

The areas for further developments in HIS can be:

- **Evidence-Based Medicine (EBM):** The conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients. Recently, EBM has gained increasing attention as a tool to address the concerns about healthcare cost and quality—allowing earlier and more precise diagnoses, producing cheaper and more effective treatments, and minimizing the side effects associated to each treatment.
- **Health Care Analytics:** Makes extensive use of data, statistical and qualitative analysis, explanatory and predictive modelling. It is a technical application that retrospectively evaluates population data sets like records of patients in a large medical system, or claims data from an insured population) which can be used to supplement disease management or population health management.

A mixture of managerial skills, technological knowledge, commitment to innovate, and adequate resources is needed. Continuous innovation of HISs provides great results both in terms of efficiency and effectiveness in delivering care.

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KEY TERMS AND DEFINITIONS

Association: Is used to find frequent pattern and some relationship among a set data items in the data repository.

Classification: Predicts the target class for each data points.

Clustering: An unsupervised learning method different from classification. Large databases are separated into the form of small different subgroups or clusters. Methods of clustering are Partitioned Clustering, Hierarchical Clustering and Density Base Clustering.

Data Mining Technique: Identifies valid, novel, potentially useful, and understandable correlations and patterns in data by combing through copious data sets to determine patterns that are too subtle or complex for humans to detect.

Description and Visualization: Contributes greatly towards understanding a data set, especially a large one, and detecting hidden patterns in data.

Estimation: Refers to the prediction of a target variable that is metric in nature.

Geographic Information System: Helps visualizing, question, analysing, and interpreting data to understand relationships, patterns and trends. It offers tremendous benefits for the health care.

Health Information System: A powerful ICT-based tools able to make health care delivery more effective and efficient.

Chapter 19
Smart Technology for Non Invasive Biomedical Sensors to Measure Physiological Parameters

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ABSTRACT

Communication and Information technologies are transforming our lifestyles, social interactions, and workplaces. One of the promising applications of the information and communication technology is healthcare and wellness management. Advancement in electronic health care and mobile have made doctors and patients to involve the modern healthcare system by extending the capabilities of physiological monitoring devices. Various biomedical sensors are being used to measure the physiological parameters like pulse rate, blood glucose level, blood pressure etc., Among various bio-sensor, Researchers from different field of science are particularly and increasingly interested in Photoplethysmography (PPG) signals. This chapter addresses the importance of bio sensors and its principle, significance of remote monitoring of PPG signal using Radio Frequency (RF) and design challenges in RF connectivity. Also this chapter presents a reliable low power wireless transmission mechanism of biomedical signals which works on narrow band RF frequencies.

1. IMPORTANCE OF BIO SIGNALS

Bio signal can be defined as a description of a physiological phenomenon. Commonly used bio signals are Electroencephalogram (EEG), Electrocardiogram (ECG) Electromyogram (EMG) Mechanomyogram

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(MMG) Electrooculography (EOG), Galvanic skin response (GSR), Magneto encephalogram (MEG). Among these bio signals, ECG and PPG signals are widely used.

A *photoplethysmogram (PPG)* is an optically obtained using plethysmogram, a volumetric measurement of an organ. A PPG is often obtained by using a pulse oximeter which illuminates the skin and measures changes in light absorption. PPG technique allows us to study heart beat rate thereby increasing the reliability of clinical measurements. It is also used to evaluate the vascular blood flow resistance which is found to be an important physiological parameter for vascular diagnostics. PPG pulse wave analysis helps to study diabetes and arthritis which is unique for each individual and helps to get unique identification as biometric identification. It also helps to study large artery damage & an abnormality in the cardiovascular disease which is one of the common causes of high mortality rate. PPG analysis emphasizes the importance of early evaluation of the diseases (Tamura et.al., 2014).

Electrocardiogram (ECG) signals are used for diagnosis of heart diseases. Figure 1 shows the waveform of ECG signal. The QRS waveforms which are used to indicate electrical activity of heart over a period of time are called Electrocardiography (Kumar 2010).

The electrical activity of heart is found using electrodes placed in patient's body. Normally in a 12 lead ECG, ten electrodes are placed on the patient's limbs and on the surface of the chest (shown in Figure 2) and the magnitude of electrical activity from twelve leads are recorded over 10 seconds (Lee and Chung 2009, Engel 2010). This non-invasive procedure of obtaining magnitude and direction of electrical activity is called cardiac cycle.

Figure 1. ECG waveform

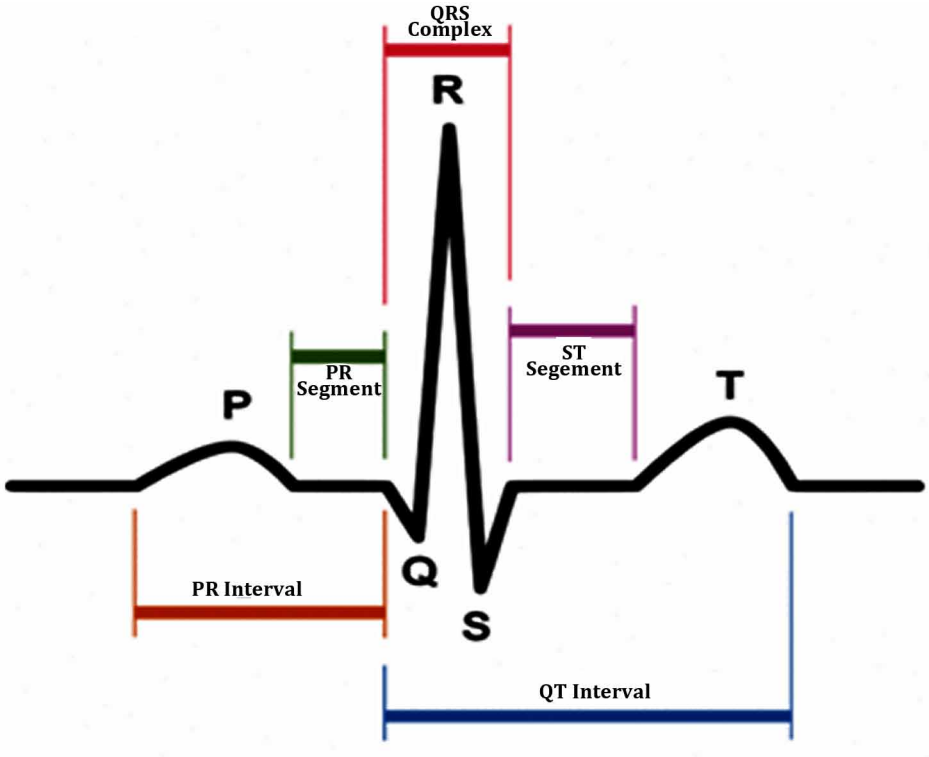
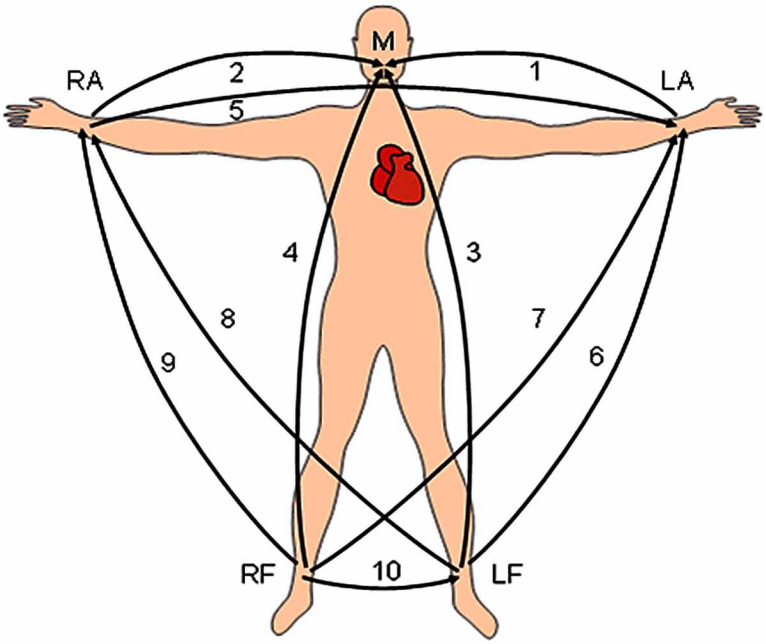


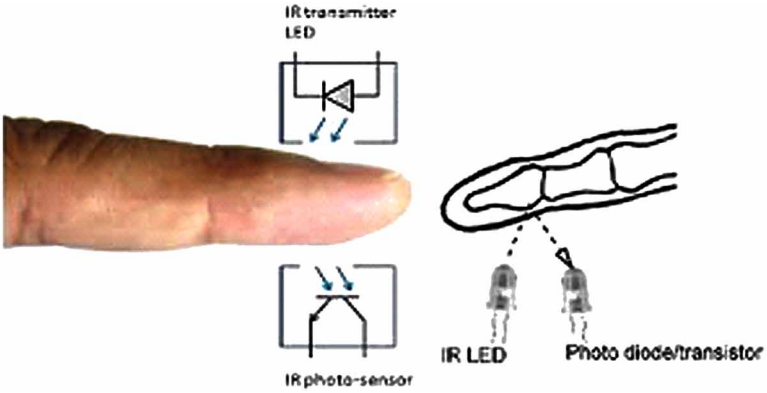
Figure 2. Placement of electrodes to measure ECG signal



2. PRINCIPLE BEHIND PPG SENSOR

The photoplethysmogram sensor consist of an infrared light source (typically a photodiode emitting light at a wavelength of around 900 nm) and a photo detector (phototransistor) as shown in Figure 3. The light source is used to illuminate the tissue (e.g. skin) and a photo detector is used to measure the small variations in light intensity associated with changes in the blood vessels volume. It gives a voltage signal, which is proportional to the amount of blood present in the blood vessels. This type of sensors gives only a relative measurement of the blood volumetric changes and it cannot quantify the amount of blood (Tamura 2014).

Figure 3. PPG sensor

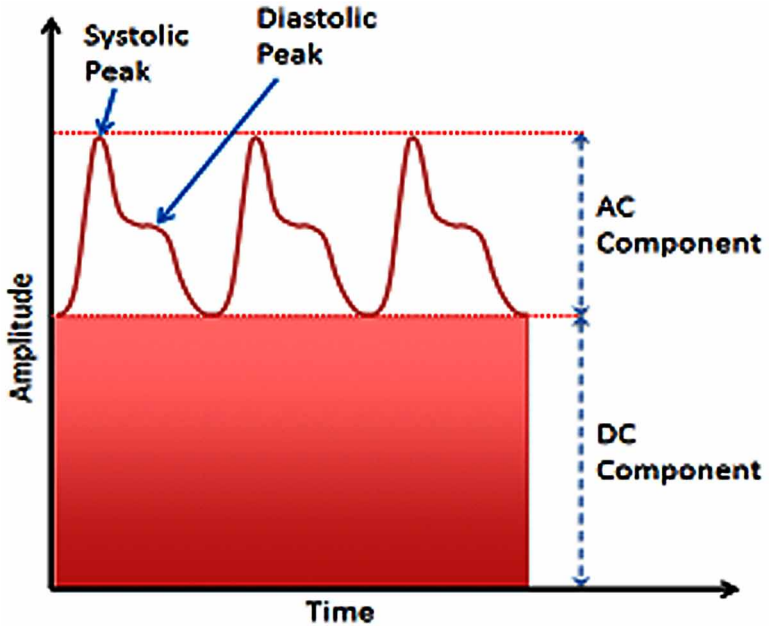


Most illuminated constituents, such as bone, muscle, venous blood, and various other cellular structures, absorb a constant amount of light, since their volumes and densities do not change over short periods of time. The volume of the arterial blood, however, is modulated by the beating of the heart. Each time the heart contracts, an additional bolus of blood are forced through the arterial pathways. With this variation in arterial volume comes a proportional variation in light absorption that can be measured by an optical sensor. An increase in arterial blood volume causes a corresponding decrease in the amount of light that reaches the photo detector. The amount of light absorbed by the tissues contains two significant aspects, as shown in Figure 4. The first is the constant absorbance, or DC component, influenced by the nonvascular tissues and residual arterial and venous blood volumes. The second is a modulated absorbance, or AC component, caused by the variations in arterial blood volume. Together, they affect the amount of light that illuminates the photo detector to produce a pulsatile waveform

3. SIGNIFICANCE OF REMOTE PATIENT MONITORING

Remote Patient Monitoring (RPM) allows the continuous remote monitoring of bio signals for elderly peoples, patients having seizures, cardiac diseases, with high blood pressure, high blood sugar etc., without disturbing their personal life. It helps in 24*7 monitoring of patients which helps the physicians for better diagnostics. It allows the patients to be monitored outside clinical setting, even allowing them at their own home. RPM helps in providing better monitoring for antenatal care and even post-operative monitoring. Wireless transmission of the bio-monitoring signals was performed by means of the Bluetooth technology and other technologies (Chen et.al., 2012), developed for cable replacement when connecting devices still maintain a high level of security. However, the wire connection between

Figure 4. PPG pulse waveform



the recording sites and the processing unit may disturb subject's daily activities (Vaidehi et.al., 2013). In order to have a continuous data acquisition and monitoring without any disturbances we use Radio Frequency (RF) connectivity based wireless transmission of PPG data (Perkins et.al., 2009). Through these data values we could calculate the Heart rate, Respiratory rate and can measure various other parameters (Klingeberg and Schilling 2012, Carlos et.al., 2013, Hadjidj et.al., 2013)

4. REMOTE MONITORING OF PPG SENSOR

Figure 5 shows the system to diagnose the physiological parameters from PPG signal through Wireless Transmission technology. First the Patient PPG signal is taken through the PPG sensor, which is connected to the Arduino UNO microcontroller through USB or UART. These read data are send through Wireless transceiver, here we use NRF24L01 RF Transceivers. At the other end we receive those data and is send to the Microcontroller through USB and the data are displayed in Serial Monitor of the Arduino IDE and further the Parameters are extracted in the LabVIEW Panel (Klingeberg and Schilling 2012).

The component in block diagram are discussed in Figure 5.

4.1 PPG Sensor

Figure 6 shows USB/ UART based SPO2 sensor probe. It is a Transmittance type sensor where a transmission mode PPG device uses the transmitted light to estimate the absorption. The transmission mode is capable of obtaining a relatively good signal, but the measurement site may be limited. In order to have effective reading from PPG sensor, the sensor must be located on the body at a site where transmitted light can be readily detected, such as the fingertip, nasal septum, cheek, tongue, or earlobe. Sensor placement on the nasal septum, cheek or tongue is only effective under anaesthesia. The fingertip and earlobe are the preferred monitoring positions. In addition, the fingertip and earlobe are more susceptible to environmental extremes, such as low ambient temperatures. This sensor can be connected directly to the PC and also to the Microcontroller Peripheral.

Figure 5. Block diagram for wireless transmission of PPG signal

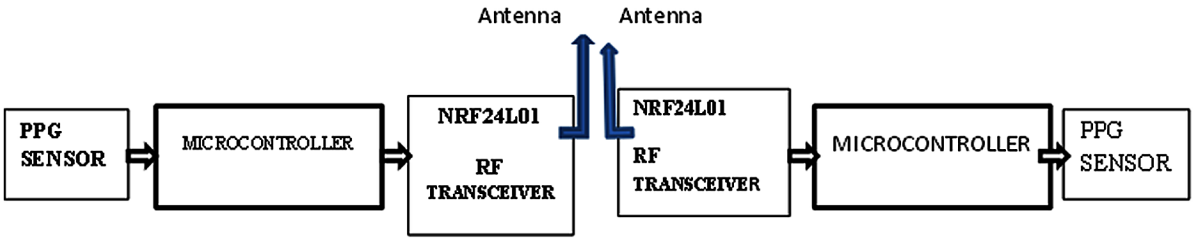


Figure 6. PPG sensor



4.2 Arduino Uno Microcontroller

Arduino/Genuino Uno shown in Figure 7 is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 pins can be used as PWM outputs), 6 analog inputs. I t works with 16 MHz quartz crystal and it can be connected to computer through USB. It can be powered with a AC-to-DC adapter or battery (Arduino, 2016).

Figure 7. Arduino board



4.3 Transceiver

The nRF24L01 is a transceiver designed for ultra-low power wireless applications is a single chip device operates under 2.4GHz with an embedded baseband protocol engine. It is configured and operated through a Serial Peripheral Interface (SPI.) The register map includes all the registers in the nRF24L01. nRF24L01 supports data rate up to 2Mbps. It consists of 4 modes of operation namely RX mode, TX mode, standby mode and Power Down mode.

The features of transceiver are (Nordic Semiconductor 2016)

- Worldwide 2.4GHz ISM band operation,
- Up to 2Mbps on air data rate,
- Ultra low power operation,
- 11.3mA TX at 0dBm output power,
- 12.3mA RX at 2Mbps air data rate,
- 900nA in power down,
- 22μA in standby-I,
- On chip voltage regulator,
- 1.9 to 3.6V supply range,
- ±60ppm 16MHz crystal,
- 5V tolerant inputs,
- Compact 20-pin 4x4mm QFN package.

Figure 8 shows the schematic of transceiver and Figure 9 shows the block diagram of nRF24L01 board (Nordic Semiconductor 2016).

The module has following pins connecting to a microcontroller:

1. **GND:** Ground.
2. **VCC:** 3.3V.
3. **CE:** Chip (RX/TX) Enable, high active. If high, module is either sending or listening.

Figure 8. nRF24L01 board and its schematics

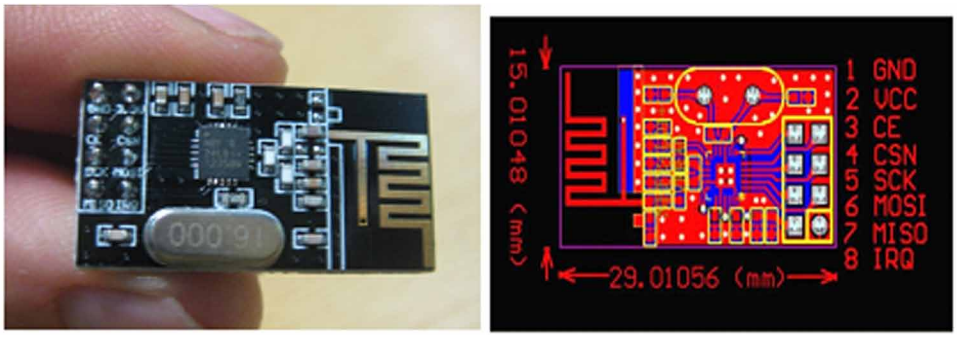
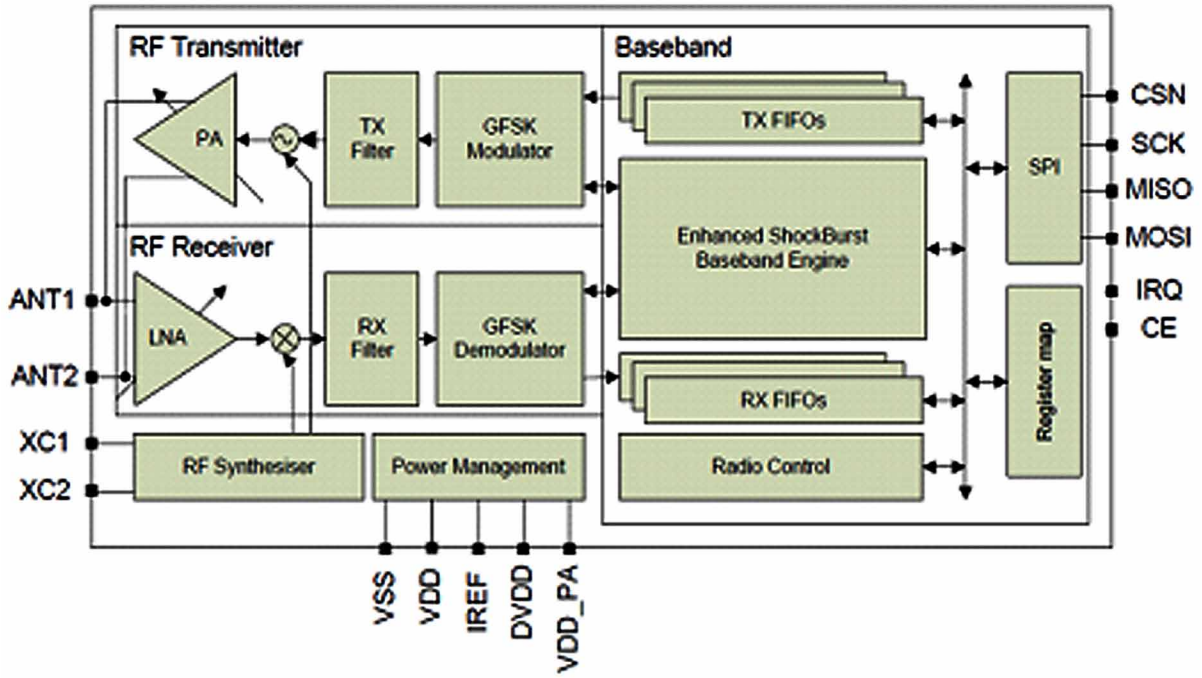


Figure 9. nRF24L01 block diagram



4. **CSN:** Chip Select Not, low active. If low, the chip responds to SPI commands. This is actually the 'real' chip select signal, and is easily confusing with CE which enables/disables the transceiver radio part.
5. **SCK:** SPI Shift Clock, up to 10 MHz.
6. **MOSI:** Master-Out-Slave-In, used to shift data from the microcontroller to the device.
7. **MISO:** Master-In-Slave-Out, used to shift data from the device to the microcontroller.
8. **IRQ:** Optional Interrupt Request pin. Signals RX/TX status like packet sent or received.

4.4 Microcontroller Interfacing Circuit with nrf24l01 Transceivers

Figure 10 shows how arduino interfacing with transceiver. Table 1 shows the pin connection between microcontroller and transceiver. The sensor data are given to the microcontroller through USB port and further it is transmitted to the the RF transceiver, i.e., NRF24L01.

4.5 Transmitter Program Flow Chart

Figure 11 shows the flow chart for Transmitter Program. First we have to initialize the header files for the microcontroller and RF Transceivers. Set the baud rate at 9600 to initialize the serial data read for PPG signal from PPG sensor. Give the *while condition* for serial read data *if yes*, then initialization, set the channel and set the payload size. Also set the RF as 2Mbps at 0dbm.

Figure 10. Microcontroller interfacing with nRF24L01 transceiver

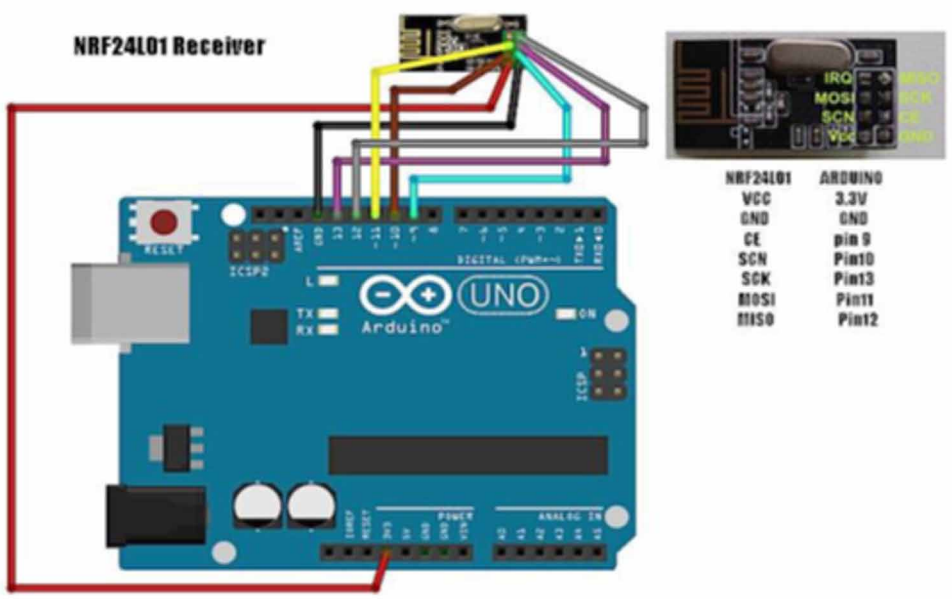


Table 1. Pin connection between microcontroller and transceiver

nRF24L01 Transceiver	Arduino UNO Microcontroller
VCC 3.3V	3.3V
GND	GND
CE Chip (RX/TX) Enable, high active. If high, module is either sending or listening.	Pin 9
CSN Chip Select Not, low active. If low, the chip responds to SPI commands. This is actually the 'real' chip select signal, and is easily confusing with CE which enables/disables the transceiver radio part.	Pin 10
SCK SPI Shift Clock, up to 10 MHz.	Pin 13
MOSI Master-Out-Slave-In, used to shift data from the microcontroller to the device.	Pin 11
MISO Master-In-Slave-Out, used to shift data from the device to the microcontroller.	Pin 12

In case *if failed*, give the error message as failed. Now write the Values through SPI write register. Once the buffer is full, check for the condition and transmits the signal with header. Repeat the process until the sufficient data was obtained.

In the receiver end, first we have to initialize the header files for Microcontroller and RF Transceivers. Set the Receiver address pipeline in which the received data was stored. Set the received data baud rate at 9600 and check for the *while condition*. If the condition is true then set initialization, channel and address. Then set the Payload size. If condition is false, then show the Error message as failed for each initializations. Now check for *iF condition loop* as whether Rx is powered up or not. If yes, then receive the Data Packets and start displaying it in the serial Monitor. If Error occurred in Rx Power up show the Error Message. Repeat the procedure until the data is received. Figure 12 shows the flowchart at the receiver end.

Figure 11. Flowchart at the transmitter end

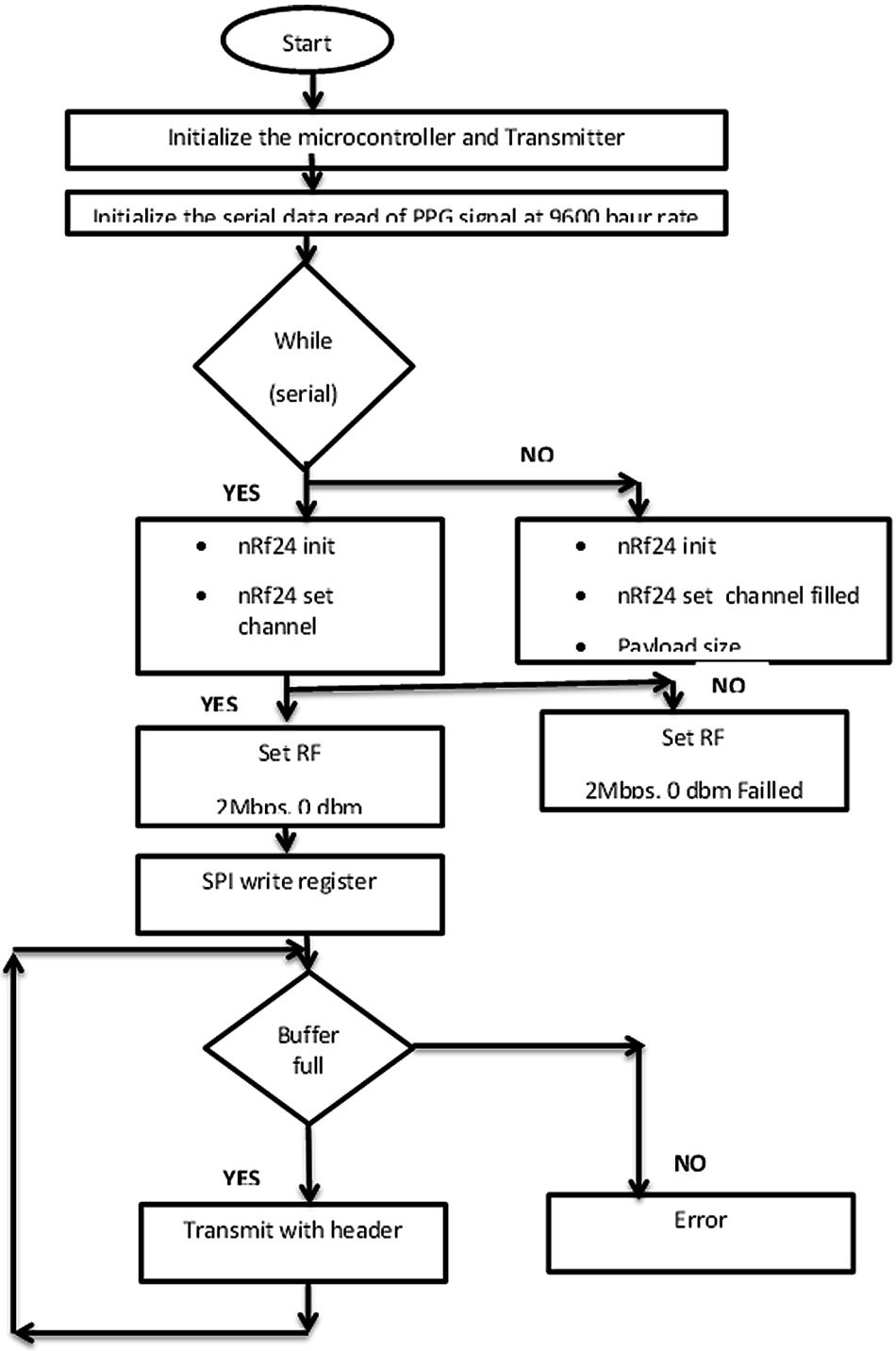
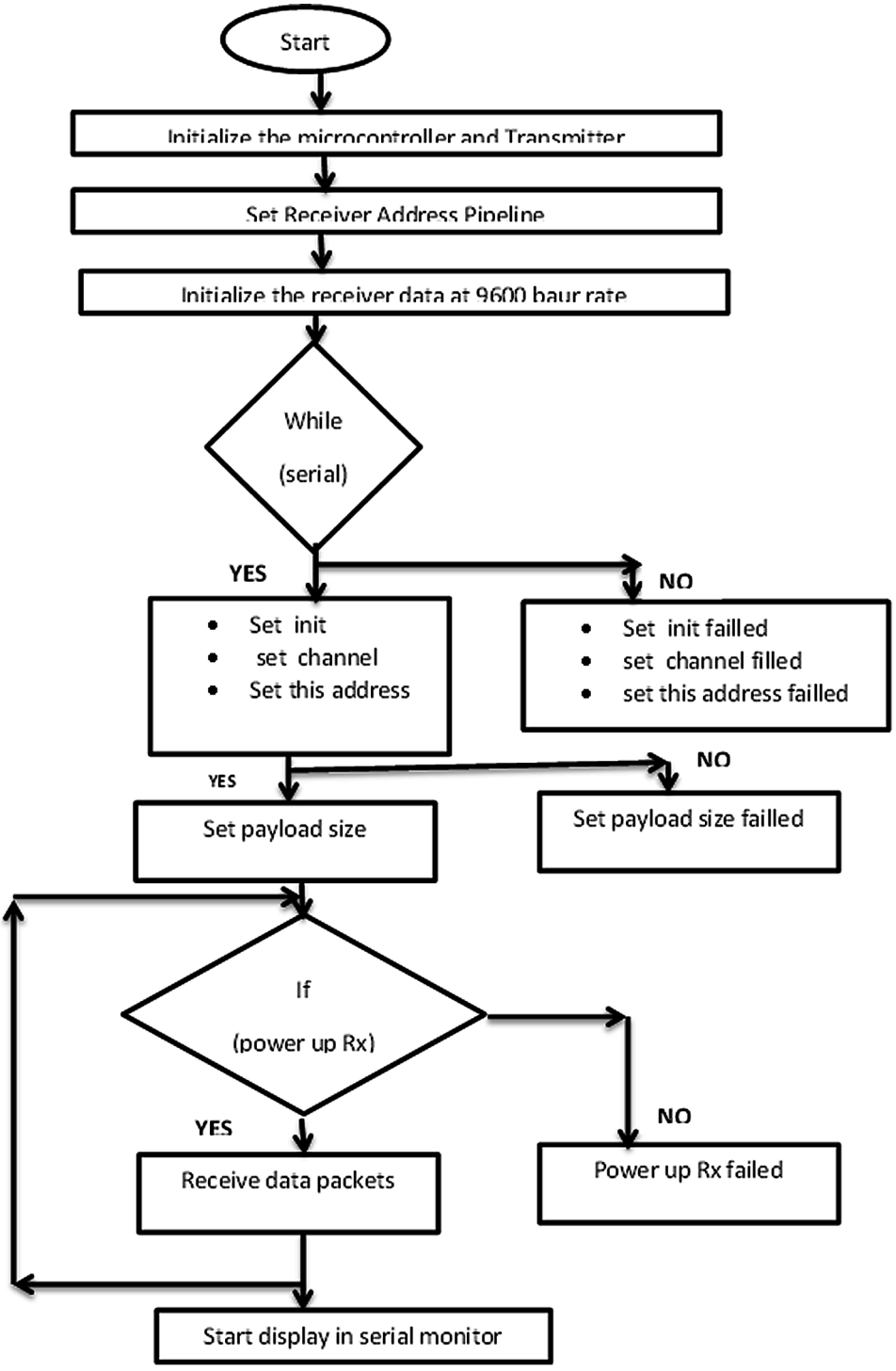


Figure 12. Flowchart at the receiver end



5. EXPERIMENTAL RESULTS OF REMOTE MONITORING OF PPG SIGNAL THROUGH RF CONNECTIVITY

Figure 13 shows the entire experimental setup for remote monitoring of PPG signal through RF connectivity. Figure 14 shows the transmitter section where PPG signals are taken and send through the wireless RF transceivers. For this unit, the power supply is given through an external unit to the Arduino UNO. From the microcontroller, it provides supply to the sensor and the sensor works. Hence the sensor reads and is passed to the microcontroller, from there the transceiver reads and sends through wireless method.

When the transceiver sends the data, it is received at the other end through receiver as shown in Figure 15.

This receiver receives the signal and sends it to the microcontroller. This microcontroller, i.e. Arduino UNO reads the signal are displayed in the serial Monitor shown in Figure 16.

Figure 13. Experimental setup of remote monitoring of PPG signal through RF connectivity

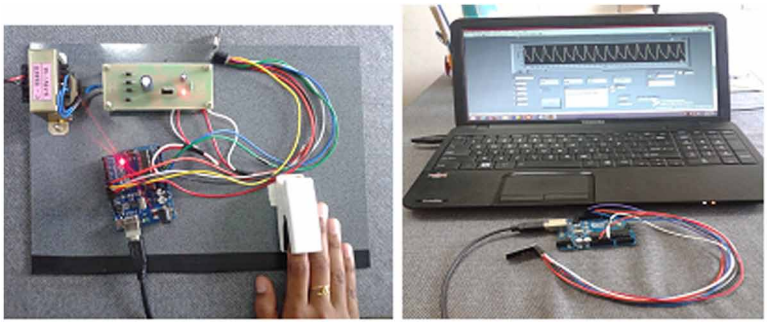


Figure 14. Transmitter section

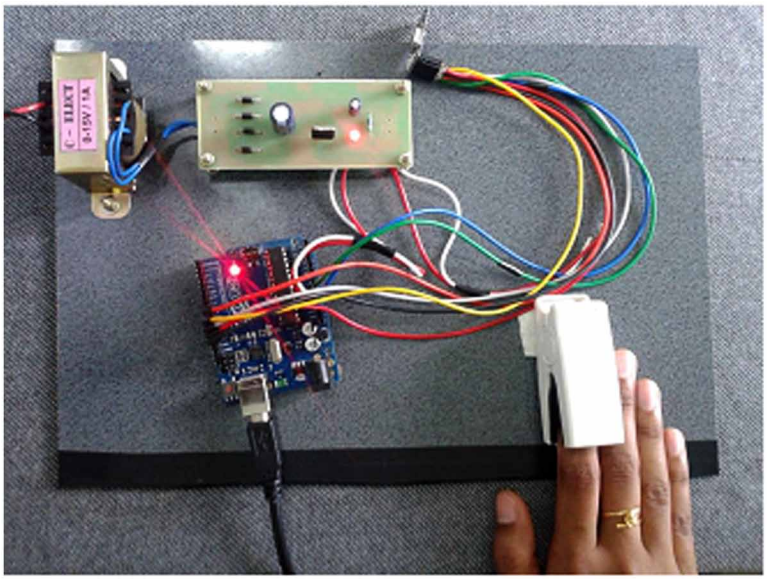


Figure 15. Receiver section

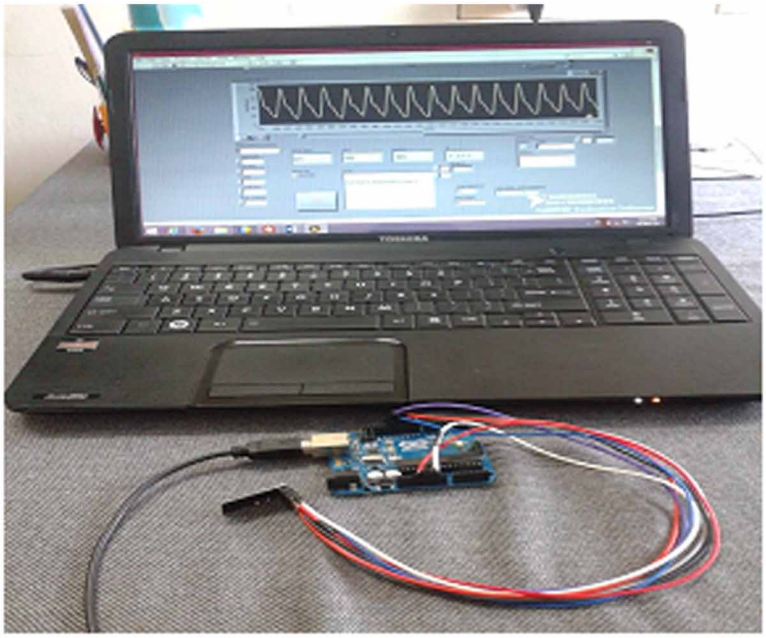


Figure 16. Data received shown in serial monitor of Arduino IDE

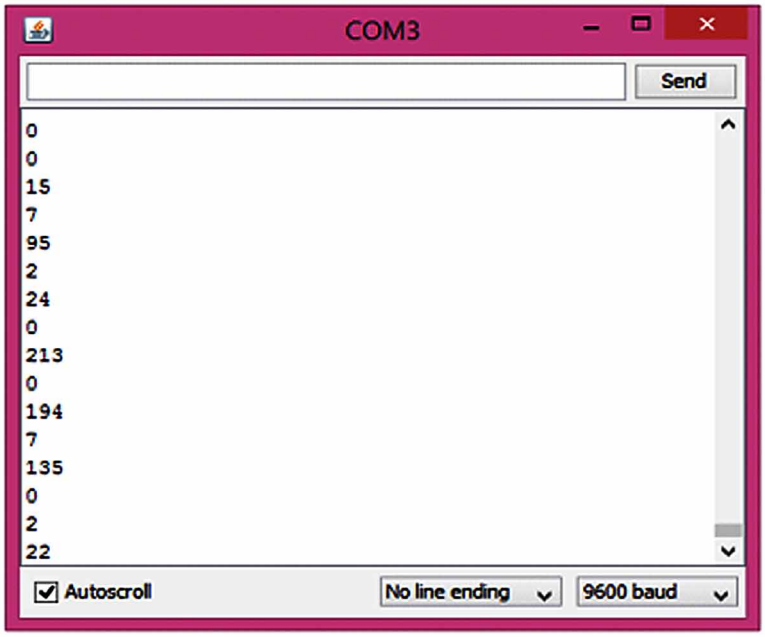
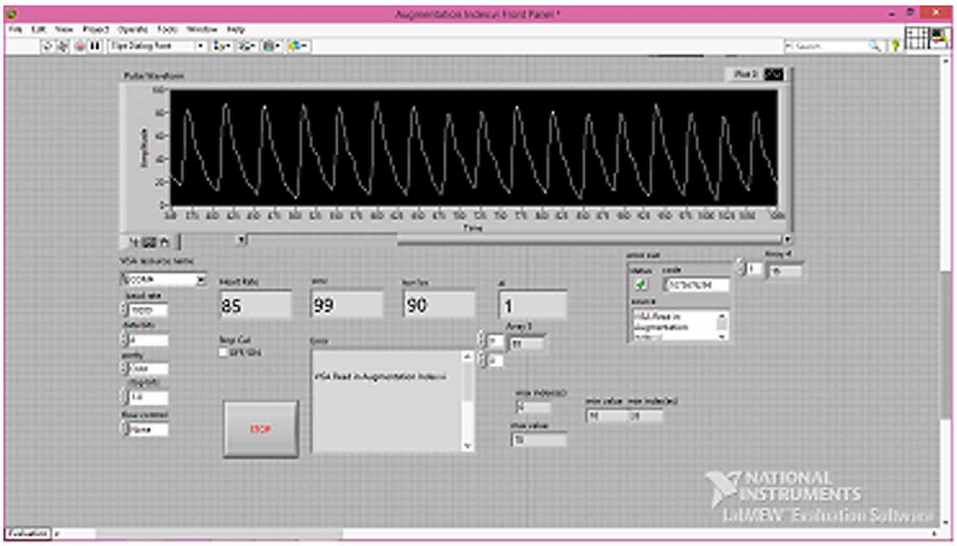


Figure 17. PPG signal in LabVIEW environment



The received data can also be read through VISA read of LabVIEW environment and are are displayed in the Waveform graphs shown in Figure 17. The data's which are read can also be displayed as shown in Figure 18.

From these we could calculate the Heart rate and SpO2 level of the patient.

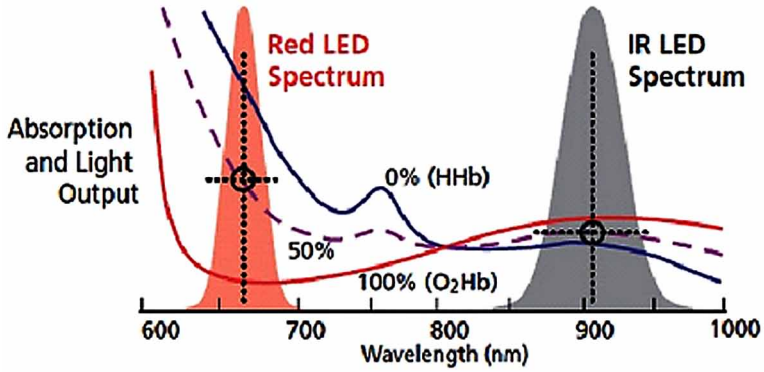
6. CALCULATION FOR SpO_2 LEVEL AND HAEMOGLOBIN

Light from LEDs at two different wavelengths is transmitted through the tissue bed and the Photo Detectors measures the unabsorbed light as shown in Figure 19. The method exploits the fact that deoxyhaemoglobin (Hb) has higher optical extinction in the red region (R) of spectrum than oxyhaemoglobin (HbO2) and lower optical absorption in the near infrared region (IR). These differences in the extinction

Figure 18. Data received in LabVIEW



Figure 19. Relative light absorption spectra of oxygenated and deoxygenated haemoglobin



coefficients can be used for the determination of the light absorbed by Hb and HbO2, and then used to calculate the N*ormalised Ratio*.

$R = V_{IR}/V_R$

$$SpO_2 = \frac{\varepsilon HbR - R\varepsilon HbIR}{\left(\varepsilon HbR - R\varepsilon HbIR\right) + \left(\varepsilon HbOR - R\varepsilon HbOIR\right)}$$

$$Hb_c = \frac{V_{IR}}{\left(\varepsilon HbIR\left(1 - SpO2\right) + \varepsilon HbIRSpO2\right)} T_F$$

- Є HbIR is the extinction coefficient of the hemoglobinn the infra-red region.
- Є HbOIR is the extinction coefficient of the hemoglobin in the red region.
- If male, then $T_{F=}$ -0.00031 + 0.03642 V_{IR}.
- else $T_{F=}$ -0.001641 + 0.049542 V_{IR}.

7. SUMMARY

In this chapter, the wireless communication of PPG signal, in order to get database anywhere within the hospital was done. This is especially helpful in monitoring the postoperative patient, though a separate person to watch them is not necessary. The doctor can view the patient details anywhere within the hospital. Also it is a continuous monitoring of the PPG signal for a long time, which shows the results of Heart Rate and SpO2. Since it a wireless communication, it doesn't cause any disturbances to the Patient. The output of this system is shown in LabVIEW environment, which is user friendly.

8. REMOTE PATIENT MONITORING (RPM) FOR ECG SIGNAL

RPM helps in providing better monitoring for antenatal care and even post-operative monitoring. While implementing RPM applications a lot of challenges such as low energy resources, limited bandwidth, unstable wireless links, low computational power and small memory has to be addressed. This proposed system presents a reliable low power wireless transmission mechanism for biomedical signals for RPM which works on licensed narrowband RF frequencies. This system provides the freedom of mobility to the patients and being at their own house instead of being strapped in hospital beds. ECG is one of the critical signal to be monitored for Cardiac patients, etc. This chapter proposes the monitoring of ECG over wireless transmission under narrow band RF frequencies.

9. SIGNIFICANCE OF ECG SIGNAL

ECG signal can be recorded using Electrocardiography. The main reason for performing Electrocardiography includes the patients [Cardionectics, 2016]

- With suspected heart attack, which occurs when blood flow stops to part of the heart causing damage to the heart muscle. The most common symptom is chest pain or discomfort which may travel into the shoulder, arm, back, neck, or jaw.
- With suspected pulmonary embolism which is caused due to the blockage of the lung's main artery or one of its branches by a substance that has traveled from elsewhere in the body through the bloodstream (embolism).
- With third heart attack which is a rare extra heart sound that occurs soon after the normal two lub-dub heart sounds
- With fourth heart sound is a rare extra heart sound that occurs immediately before the normal two lub-dub heart sound
- Heart murmurs are abnormal heart sounds produced when blood flows across one of the heart valves that is loud enough to be heard with a stethoscope.
- Cardiac arrhythmia, also known as cardiac dysrhythmia or irregular heartbeat, is a group of conditions in which the heartbeat is irregular, too fast, or too slow.

9.1 Different Types of Heart Rate

- Normal rate are the heart rate between 60 and 100 beats per minute
- Bradycardic are the heart rate slower than 60 beats/minute
- Tachycardic are the heart rate faster than 100 bearts/minute

9.2 Different Types of Rhymes

There are different types of rhymes occurs due the heart rate being too fast or too slow [Cardionectics, 2016]

- Rhythm which causes the heart rate to be slow and symptomatic is known as a heart block. Commonly occurring heart block is AV block
- Rhythm which causes the heart rate to be too fast and symptomatic is known as sinus tachycardia.
- When there is improper electrical activity of the heart, it leads to supraventricular tachycardia.
- When there is uncoordinated contraction of the cardiac muscle of the ventricles in the heart, it leads to Ventricular fibrillation (V-fib or VF) condition. It is found in cardiac arrest parients. In this, ventricles will not contract properly.
- When there is rapid heartbeat that arises from improper electrical activity of the heart which leads to rapid heart rhythm in ventricles are called Ventricular tachycardia (V-tach or VT). It causes low blood pressure and may lead to asytole and sudden death.

10. ECG WAVEFORM

Heart beat produces different deflection on the ECG. These deflections look like positive and negative waves. There are typically five visible waveforms (Kumar 2010)

- P wave is called the first deflection of the heartbeat. It is small upward wave which indicates artrial depolarisation. the first portion of P wave reflects right atrial depolarisation and terminal portion is the reflection of left atrial depolarisation.
- The initial downward deflection after the P wave is called Q wave. It represents septal depolarisation. For a heart attack person, the Q wave will be found to be wide and deep. It is due to the dead muscles which produces no current so ECG picks up the current which flows away from this muscle thereby causing a strong negative deflection
- The second t upward deflection after the P wave (even when Q waves are absent) are called R wave. It is very easy to identify the ECG and it usually represents early ventricular depolarisation.
- The first negative deflection after the R wave are called S wave. It denotes the late ventricular depolarisation where the rim of the ventricular muscle is the last to contract.
- The T wave represents repolarisation of the ventricles. It is normally upright, somewhat rounded, and slightly asymmetric. Figure 20 (Kumar 2010) shows the different waveforms in ECG and Table 2 depicts the duration of occurrence of different waves (Kumar 2010).

11. MEASUREMENT OF ECG

Ten electrodes are used for a 12-lead ECG (Kumar 2010). The electrodes usually consist of a conducting gel, embedded in the middle of a self-adhesive pad. The names and correct locations for each electrode are shown in Table 3 and placement of electrodes in patients are shown in Figure 21.

12. CONVENTIONAL BEDSIDE MONITORING OF ECG SIGNAL

For monitoring ECG, conventional clinical setting employs wired bed side ECG monitors which restrict the patient mobility as shown in Figure 22. In hospital ICUs where about 24 beds are installed, the sig-

Figure 20. Different waveform in ECG signal

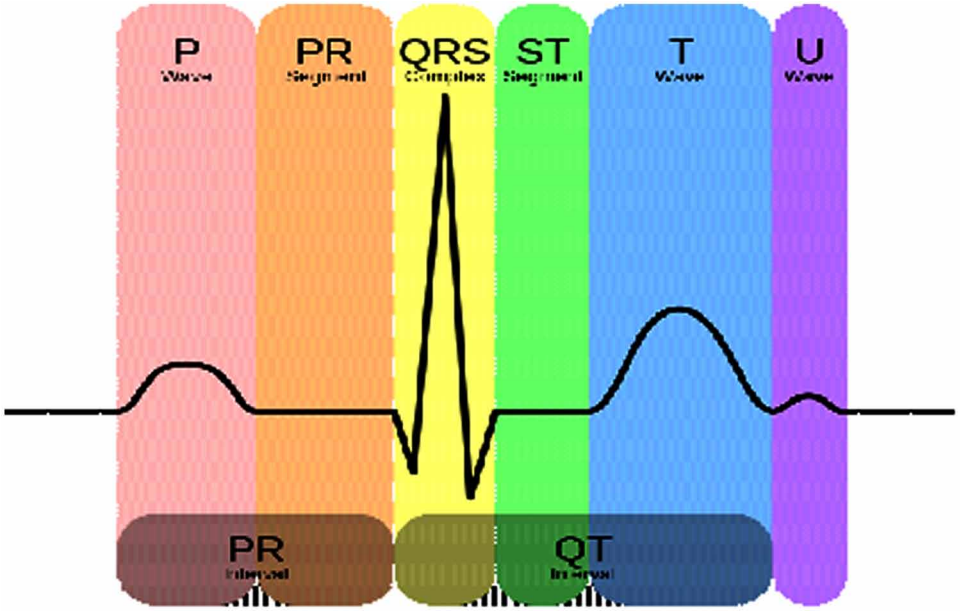


Table 2. Duration of each waveform with description

Feature	Description	Duration
P- wave	The p-wave represents depolarization of the atria. Atrial depolarization spreads from the SA node towards the AV node, and from the right atrium to the left atrium.	<80 ms
PR interval	The PR interval is measured from the beginning of the P wave to the beginning of the QRS complex. This interval reflects the time the electrical impulse takes to travel from the sinus node through the AV node.	120 to 200 ms
QRS wave	the QRS complex represents the rapid depolarization of the right and left ventricles. The ventricles have a large muscle mass compared to the atria, so the QRS complex usually has a much larger amplitude than the P-wave.	80 to 100 ms
ST segment	The ST segment connects the QRS complex and the T wave; it represents the period when the ventricles are depolarized.	
T wave	The T wave represents the repolarization of the ventricles. It is generally upright in all leads except a VR and lead V1.	160 ms
QT Interval	The T wave represents the repolarization of the ventricles. It is generally upright in all leads except aVR and lead V1.	<440 ms
u-wave	The U wave is hypothesized to be caused by the repolarization of the interventricular septum. It normally has a low amplitude, and even more often is completely absent.	

Table 3. Location for placement of electrodes

Electrode Name	Electrode Placement
RA	On the right arm, avoiding thick muscle
LA	In the same location where RA was placed, but on the left arm.
RL	On the right leg, lateral calf muscle.
LL	In the same location where RL was placed, but on the left leg.
V1	In the fourth intercostal space (between ribs 4 and 5) just to the right of the sternum (breastbone).
V2	In the fourth intercostal space (between ribs 4 and 5) just to the left of the sternum.
V3	Between leads V_2 and V_4.
V4	In the fifth intercostal space (between ribs 5 and 6) in the mid-clavicular line.
V5	Horizontally even with V_4, in the left anterior axillary line.
V6	Horizontally even with V_4 and V_5 in the midaxillary line

Figure 21. placement of different electrodes

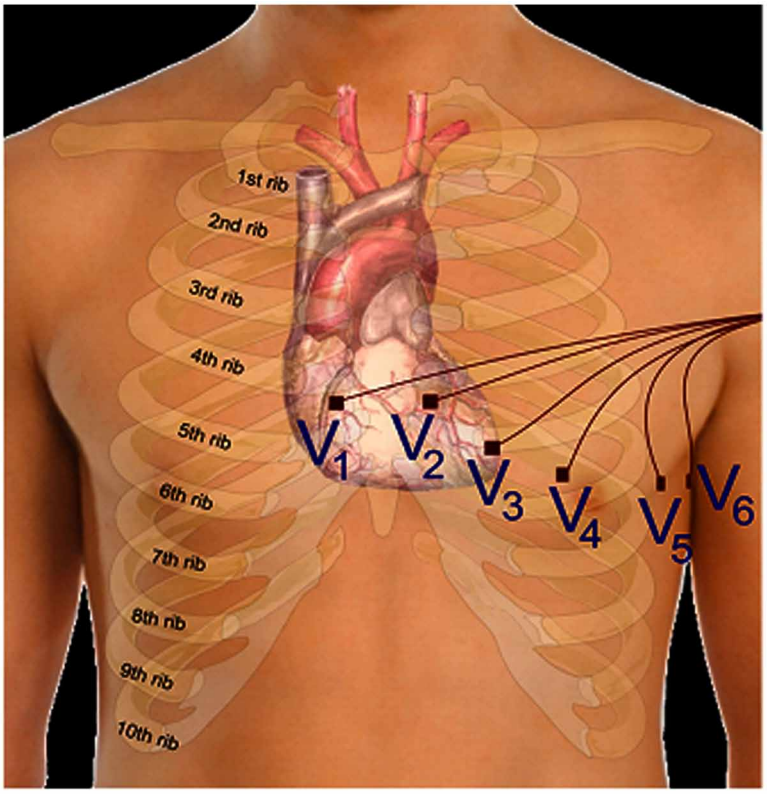
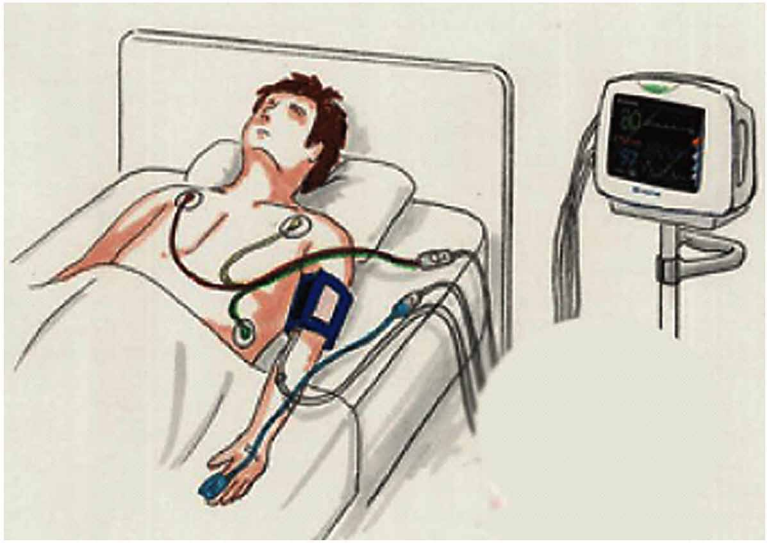


Figure 22. Conventional bedside ECG monitor



nal is monitored there itself. This causes all the patients to be panic when any of the system alerts, the situation become some more worse in case of alarms at late nights. Introduction of wireless monitoring addresses these two issues. It provides the freedom of mobility to the patients while being monitored. As the signal is monitored wirelessly it can be monitored in nearby room providing a better assistance to patients without alerting them about the situation.

13. MONITORING OF ECG OVER WIRELESS TRANSMISSION

The system shown in Figure 23 makes use of a standard ECG amplifier to acquire the ECG signal from patient. This acquired analog signal converted to digital and is transmitted wirelessly in licensed healthcare spectrum to the nearby fixed receiver. The receiver will reproduce the same analog waveform from the transmitter and is given to the ECG display. The wireless transceiver is enough powerful for transmitting the signal to nearby monitoring room and allows monitoring without disturbing the patient for RPM, at the receiver end, a PC based web server is installed which can publish the received signal on a webpage which allows the real-time monitoring of patient through Internet/Intranet. Thus RPM can be used to monitor a patient even outside the clinical settings. It allows the patients to be with their loved ones at their own homes while being monitored.

13.1 Feature of MSP430 Microcontroller

Figure 24 block diagram of MSP430 Microcontroller (Texas Instruments 2016). MSP430 microcontroller from Texas Instruments is a low power 16 bit device. It consists of 16 bit CPU Core and different peripheral are interface using JTAG (Joint Test Action Group).

Figure 23. Overall system architecture

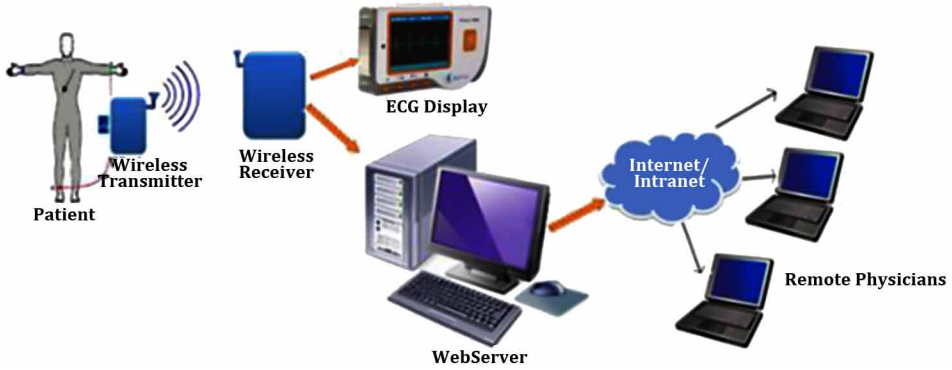
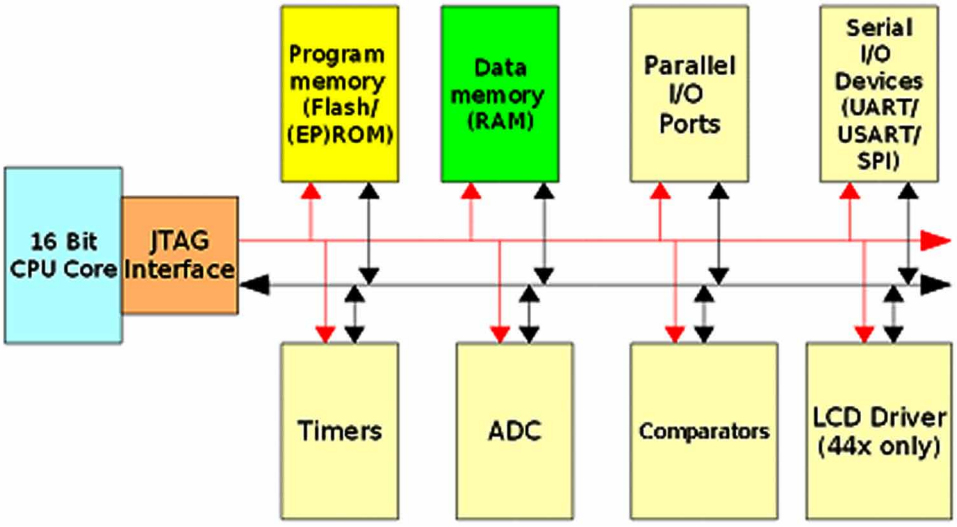


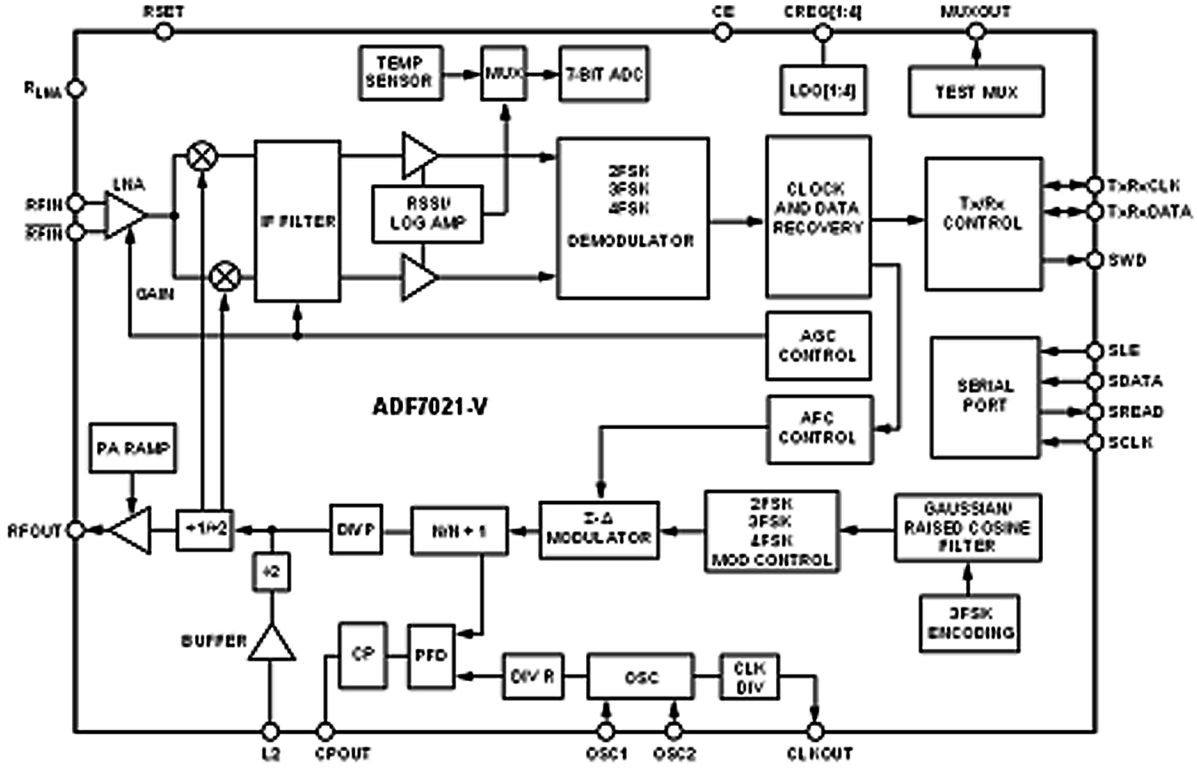
Figure 24. Block diagram of MSP430 microcontroller



The features are (Texas instruments 2015)

- Ultralow-power architecture extends battery life:
  - 0.1 µA RAM retention.
  - 0.8 µA real-time clock mode.
  - 250 µA/MIPS active.
- 16-bit RISC CPU enables new applications at a fraction of the code size:
  - Large register file eliminates working file bottleneck.
  - Compact core design reduces power consumption and cost.
  - Optimized for modern high-level programming.
  - Only 27 core instructions and seven addressing modes.
  - Extensive vectored-interrupt capability.
- In-system programmable Flash(16KB) permits flexible code changes, field upgrades and data logging.

Figure 25. Block diagram of ADF7021-V transceiver

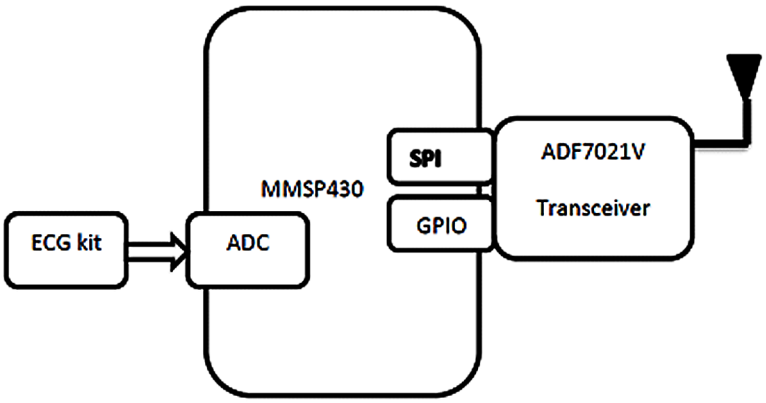


13.2 ADF7021-V Transceiver

Analog Devices 2016 shown in Figure 25 has the following features:

- It is high performance, low power narrow – band transceiver.
- Frequency bands using external VCO is 80 MHz to 960 MHz.
- Improved adjacent channel power and adjacent channel rejection.
- **Programmable IF Filter Bandwidth:** 9KHz, 13.5KHz and 18.5KHz.
- **Data Rates:** 0.05 Kbps to 24 Kbps.
- **Programmable Output Power:** -16 dBm to +13 dBm in 63 steps.
- **Power Supply:** 2.3 to3.6 V.
- Automatic power amplifier ramp control.
- **Receiver Sensitivity:** -125 dBm at 250 bps, 2FSK; -122 dBm at 1Kbps, 2FSK.
- On-chip 7 – bit ADC and temperature sensor.
- Fully automatic frequency control loop.
- Digital received signal strength indication.
- Integrated Tx/Rx switch.

Figure 26. Block diagram at the transmitter end



13.3 Transmitter End

A low power microcontroller MSP430 interfaced with low power narrow band transceiver ADF7021V is used for the transmission of signal. The ECG signal from patient is filtered and amplified with a standard ECG amplifier available. This signal is sampled acquired by the in-built Analog to Digital Convertor (ADC) of microcontroller with required sampling rate and resolution. This acquired signal is then buffered, packetized with required header and CRC and is transmitted through the RF(Radio Frequency) Interface as shown in Figure 26. The transceiver should be configured as transmitter with required baud rate, frequency, bandwidth and tx power. interfaced with ATMega16 to receive the signal. This signal is extracted from the data packet by removing the header and CRC. The checksum is calculated again to verify about errors in received packet and is fed to the display through an I2C based Digital to Analog Convertor (DAC).

13.4 Receiver End

In the receiver end, the RF receiver is configured to receive the transmitted signal and is given to microcontroller. Receive makes us of ADF7021-V interfaced with ATMega16 to receive the signal as shown in Figure 27. This signal is extracted from the data packet by removing the header and CRC. The checksum is calculated again to verify about errors in received packet and is fed to the display through an I2C based Digital to Analog Convertor (DAC).

14. HARDWARE DESCRIPTION

A battery powered standard low power wireless transmission device for medical applications has to be designed and developed. To suit wearable biomedical applications, Texas Instruments' MSP430G2553 is chosen as it has low power modes which can extend the life of battery operated portable devices and is used for interfacing ADF7021V (Analog Devices, 2016). A PCB is designed and fabricated to suit various biomedical applications. The device aims to transmit various biomedical signals like ECG, Accelerometer, Bio-Impedence, etc. Figure 28 shows the fabricated PCB developed for transmitter end.

Figure 27. Block diagram at the receiver end

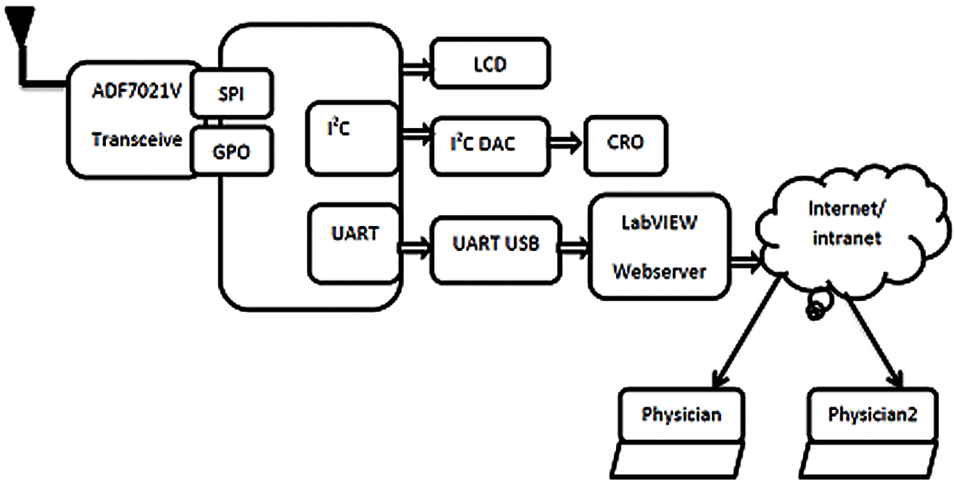
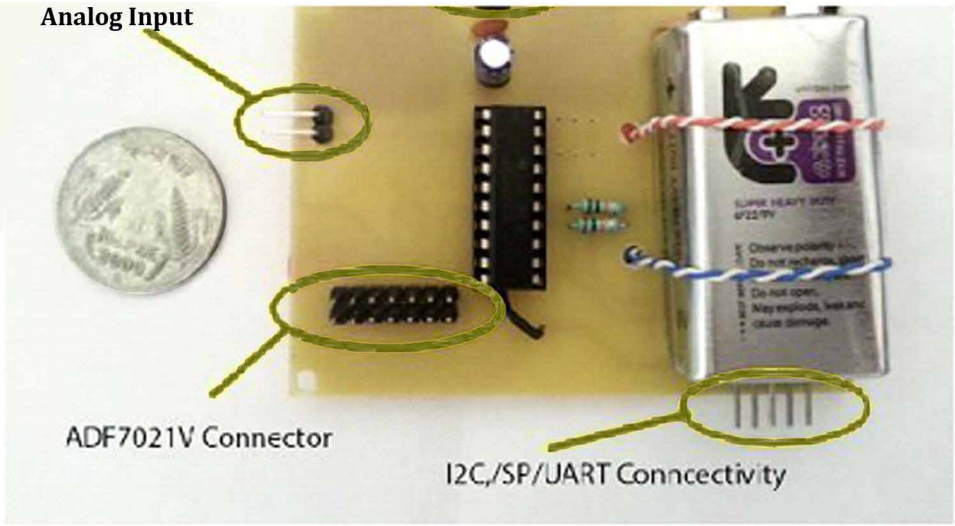
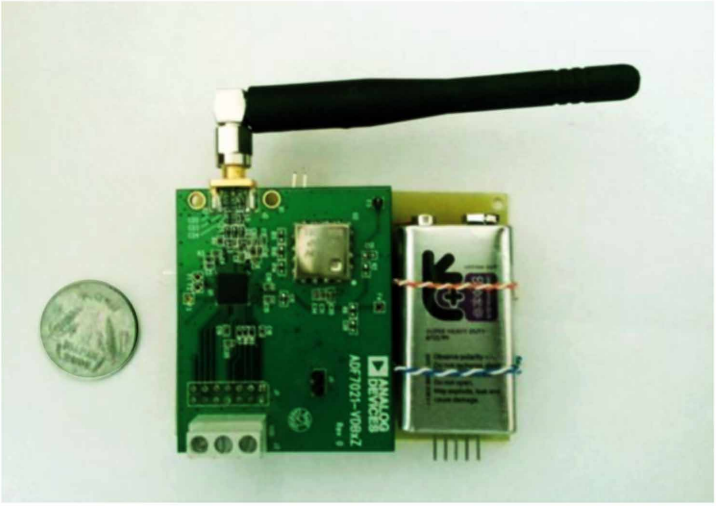


Figure 28. Fabricated transmitter PCB



ADF7021V (Analog Devices 2016) is a High performance, low power, narrow-band transceiver with external Voltage Controlled Oscillator(VCO) with improved adjacent channel power and adjacent channel rejection having programmable IF bandwidth. It follows the FCC and ETSI regulations for healthcare. ADF7021V requires two separate interfaces, one for data transfer (RF transmission) and other for configuring daughterboard. SPI Interface is chosen for data transfer as it allows different modulation schemes and data rates. 16 registers of ADF7021 [reg0 to reg15] have to be configured for efficient data transfer in both transmitter and receiver end. Configuring registers have to be done using 3 wire GPIO interface. As this is not following any standard protocol, bit banking method is used to configure these registers. Figure 29 shows the ADF7021 transceiver plugged along with transmitter end.

Figure 29. Transmitter with ADF7021V plugged in



The hardware mechanism in automatic Sync Word Detection (SWD) of ADF7021V allows the detection of sync-word in the incoming data stream and thereby to track the start of the data stream to be received. Since power consumption is not critical at fixed receiver end, ATMega16 is used to interface ADF7021V at receiver end. An isolated level convertor based on ADUM6402 and ADUM2250 is used to interface between 5V ATmega16 and 3.3V ADF7021V. The 40 pin ATMega16 is having various interfaces like SPI, UART, I2C and can work simultaneously. The ADF7021v provides the received data via SPI interface and the ECG waveform is displayed in ECG display using an I2C interfaced DAC. The same data is sent through UART and is interfaced with a PC based server using USB to UART convertor based on MCP2200. The PC makes use of LabVIEW software and plots the ECG waveform and is published in a webpage. This makes the waveform available throughout the Internet/Intranet and makes remote monitoring possible.

15. FUNCTIONAL DESCRIPTION

The amplified Real time ECG signal is sampled at 1500Hz with 8bit resolution. Double Buffering concept is used to avoid loss of data. The data is sampled and is stored in a 64 byte buffer. Once the buffer is filled by continuous 64 samples, the whole buffer will be transmitted. While one buffer is being filled, other buffer will be transmitted in parallel as shown in Figure 30. Transmission rate is configured at 14kbps in such a way that, transmission of one buffer will be complete before the next buffer got filled by new data.

15.1 Data Integrity

Data integrity is maintained by CRC check, once the buffer is filled in transmitter, a 16 bit CRC of the 64 byte buffer is calculated and is transmitted along with the data. At the receiver, the CRC of the received packet is again calculated and is compared with the received CRC. If any mismatch in CRC is found and a buzzer is activated. An LCD is interfaced to display the no of received packets and packets with CRC mismatch. The LCD display is shown in Figure 31.

Figure 30. Double buffering of data

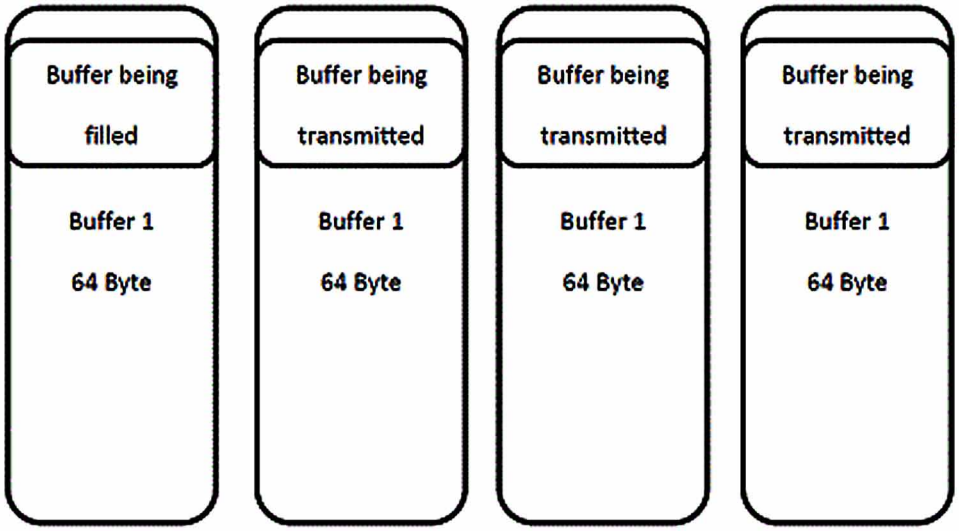
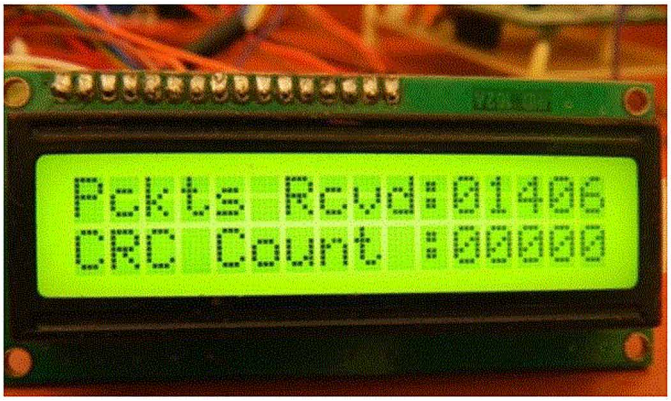


Figure 31. LCD display of packets received and CRC count



15.2 Data Packet Format

Data is packetized with minimum overhead. With a 5byte header and 2 byte CRC which improves the energy efficiency of system. 64 Byte data are framed with a 5 byte unique header and two byte CRC. 16 bit preamble of 010101…01 is required to synchronize the receiver to receive the data. The 24 bit sync word is a unique sync-word which is stored in the receiver given in Figure 32. The receiver hardware will scan the stored 24bit sync-word in the incoming bit stream and informs the processor if any match is found. This helps the receiver to track the start of data frame. Then the 64 byte data buffer followed by 16 bit CRC.

Figure 32. Data packet format

Preamble 2 Byte	Sync Word 3 Byte	Data 64 byte	CRC 2 byte

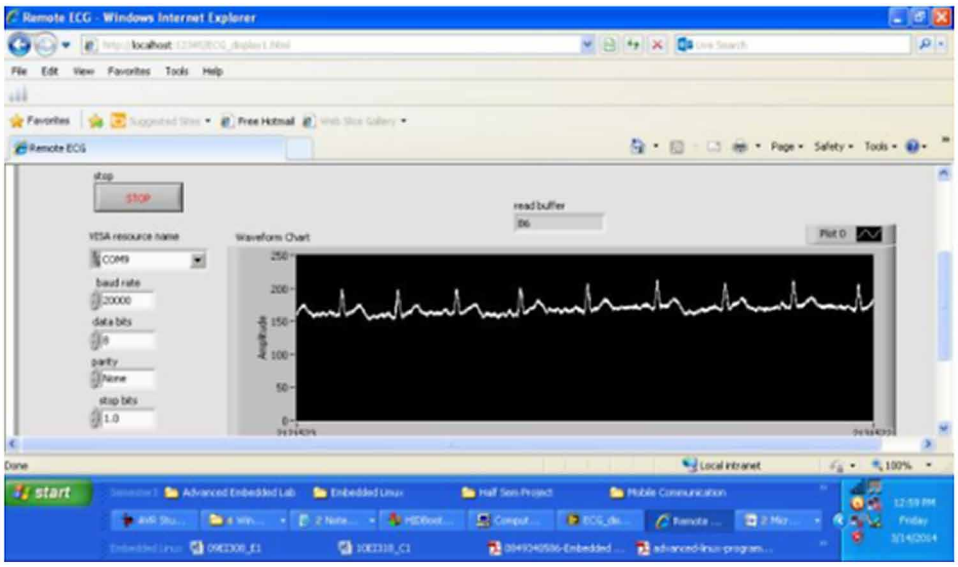
15.3 Data Reception

Once the sync word is detected, the next 64 bytes and CRC is received by the receiver. The CRC is verified at receiver by calculating the CRC of received packet and comparing with the received one. This data is displayed through the display with the help of an I2C based DAC. While reproducing the wave, to retain the shape of wave, the samples are sent at the same sampling rate of transmitter. Figure 33 shows the transmitted and received waveform displayed in CRO. The Yellow wave (Bottom wave) shows the transmitted wave and the Blue one (Top wave) shows the received wave. The same rate is maintained while transmitting data to LabVIEW server via UART-USB interface using MCP2200. Figure 34 shows the remotely monitored ECG waveform using Internet Explorer.

Figure 33. Transmitted and received data waveform displayed in CRO



Figure 34. remotely monitored ECG waveform using Internet Explorer



15.4 Performance Analysis

With the interfaced LCD to the receiver, a performance analysis of the system is done under various conditions given in Table 4. The interfaced LCD shows the total number of packets received and the no of packets with CRC mismatch. The displayed CRC mismatches are counted out of 1406 received packets.

This performance analysis shows that the system is suited best for the transmission of biomedical signals both in indoor and outdoor.

15.5 Power Consumption

The power consumption of the device is calculated with different microcontroller and power consumption is as shown in Table 5. As transceiver is 3.3V TTL logic, interfacing 5V microcontroller needs additional

Table 4. Performance analysis

S. No.	Distance (Feet)	Packets Received with CRC Error (Line of Sight – LOS)	Packets Received with CRC Error (LOS with Interference with People Moving About)	Packets Received with CRC Error (No LOS – with Walls in Between)
1	2	0	0	0
2	10	0	0	1
3	20	0	0	45
4	50	0	8	-
5	100	0	58	-
6	150	1	158	-

Table 5. Power consumption by different controllers

Device	Current Consumption (mA)	
	ATmega 16	MSP 430
Microcontroller	16	6
Level Converter	105	-
AD7021-V	47	47
Total	168	53
Power	840mW	175mW

level converting hardware. The system is found working at a lowest power consumption of 175mA with MSP430 and can work continuously for 21hours with a 3.7Wh Li-ion Samsung Battery. This allows the patient to be monitored continuously without disturbing him even for recharging the battery.

16. CONCLUSION

The wireless communication of PPG signal, in order to get database anywhere within the hospital was presented in this chapter. This is especially helpful in monitoring the postoperative patient, though a separate person to watch them is not necessary. The doctor can view the patient details anywhere within the hospital. Also it is a continuous monitoring of the PPG signal for a long time, which shows the results of Heart Rate and SpO2. Also a reliable low power wireless transmission mechanism of biomedical signals for RPM which works on licensed narrowband RF frequencies was also presented. This system provides the freedom of mobility to the patients instead of being strapped in hospital beds for the monitoring of vital signals. As the data is transmitted over licensed healthcare band, unauthorized data access is prevented.

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Section 4

Patient-Provider Interface

Chapter 20
Investigating Acceptance of Nursing Information Systems through UTAUT Lens

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ABSTRACT

It is widely known that nurses are pivotal in coordinating and communicating patient care information in the complex network of healthcare professionals and service delivery. Yet, despite their pivotal role, information communication technologies have historically rarely been designed around nurses' operational needs. This could explain the poor integration of technologies into nursing work processes and consequent rejection by nursing professionals. The complex nature of acute care delivery in hospitals and the frequently interrupted patterns of nursing work suggest that nurses require flexible intelligent systems that can support and adapt to their variable workflow patterns. This study is designed to explore nurses' initial reactions to a new integrated point of care solution for acute healthcare contexts. We report on the first stage of a longitudinal project to use an innovative approach involving nurses in the development and refinement of this solution. Unified Theory of Acceptance and Use of Technology was used to evaluate acceptability of the proposed system by nurses.

INTRODUCTION

It is widely known that nurses are the largest group of healthcare professionals in hospitals providing 24-hour care to patients. They are pivotal in coordinating and communicating patient care information in the complex network of healthcare professionals, services and other care processes. Yet, despite nurses'

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central role in health care delivery, information communication technologies (ICTs) have historically rarely been designed around nurses' operational needs. This could explain the poor integration of technologies into nursing work processes and consequent rejection by nursing professionals. The complex nature of acute care delivery in hospitals and the frequently interrupted patterns of nursing work suggest that nurses require flexible intelligent systems that can support and adapt to their variable workflow patterns. This study is designed to explore nurses' initial reactions to a new integrated point of care solution for acute healthcare contexts. The following reports on the first stage of a longitudinal project to use an innovative approach involving nurses in the development and refinement of this solution. In this project, UTAUT (unified theory of acceptance and use of technology) was used to evaluate acceptance (Venkatesh et al., 2003).

BACKGROUND

The complexities associated with the coordination, communication and delivery of health care at the point of care, presents particular challenges for the design of IT systems. In an Australia-wide qualitative study that examined nurses' experiences of already established Computerized Patient Information Systems (CPIS), Darbyshire, (2004) found that nurses often considered that these established systems made no "clinical sense" and were perceived to waste time. Overriding of the system, duplication of documentation, and a reversion to familiar systems such as paper recording have all been reported as work-around strategies used to continue delivery of safe and reliable clinical communication and care in the face of technological solutions that do not meet clinicians' needs (Alaszewski, 2005; Dowding et al., 2009; Lau et al., 2010; Viitanen et al., 2011).

Creating an ongoing-collaborative process in which both nursing and information technology industries actively contribute to the development and sequential implementation of an intelligent tool for nursing work within healthcare settings is proposed as a feasible, viable and crucial solution. An intelligent system specifically designed for the discipline of nursing that can adequately and appropriately meet the requirements of nursing in terms of design and flexibility, hence, is challenging. Further, user adoption is a central theme in much of the IS literature from the theoretical development (Venkatesh et al., 2003; Venkatesh et al., 2012; Rogers, 2003; Bandura, 1986) as well as user acceptance examination (Yu et al., 2009; Wills et al., 2008; Kaushal et al., 2009; Mills et al., 2013). This is primarily due to the fact that user adoption is a proxy for trying to determine a priori if the system will be successful or not. Given the amount of time and financial resources invested into so many IS/IT projects and then the expected benefits, not to mention, impact these systems have on critical business functions, it is understandable that user acceptance is an important consideration.

USER ACCEPTANCE OF TECHNOLOGY

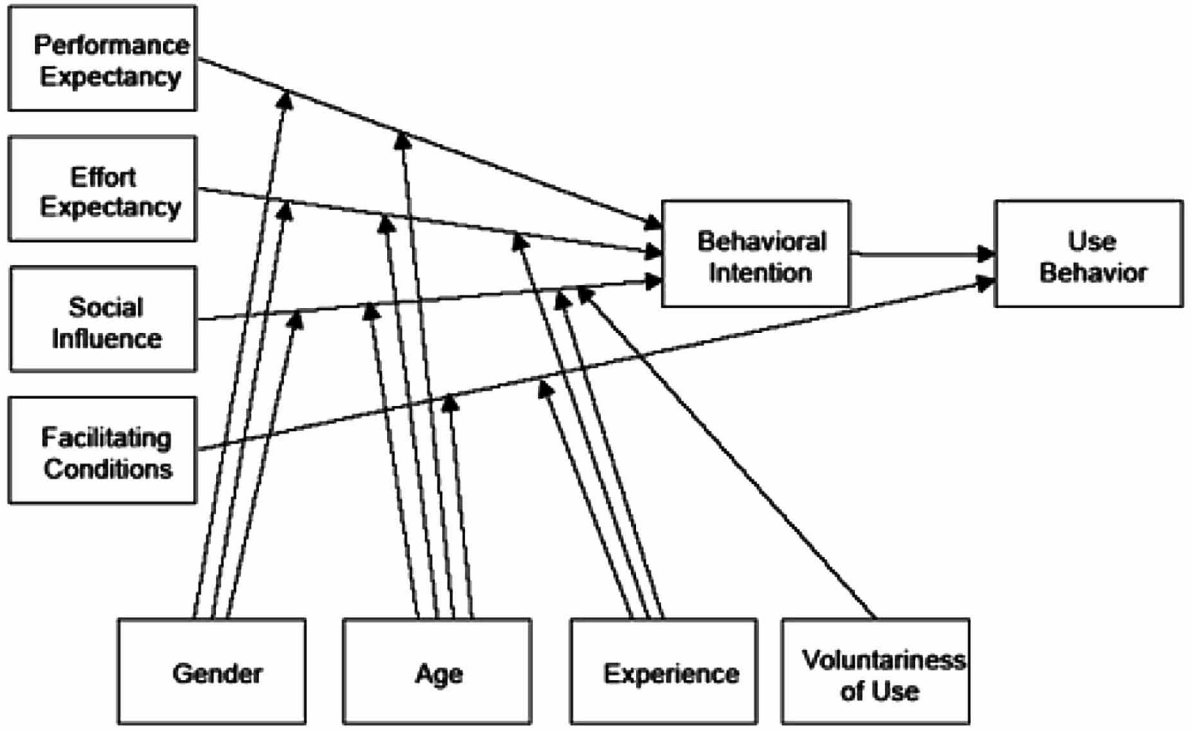
To date within the IS field several models have been developed to examine the critical issue of user acceptance, for example theory of reasoned action (TRA) (Ajzen & Fishbein, 1980), technology acceptance model (TAM/UTAUT) (Davis, 1989; Venkatesh et al., 2003; Venkatesh et al., 2012), theory of planed behaviour (TPB) (Ajzen, 1991), social cognitive theory (SCT) (Bandura, 1986) and innovation and diffusion theory (IDT) (Rogers, 2003). As noted by Venkatash et al., (2003, pp. 467) due to a need "… to

integrate the fragmented theory and research on individual acceptance of information technology that captures the essential elements of eight previously established models" and thus they developed UTAUT (unified theory of acceptance and use of technology), we use UTAUT for our research.

UTAUT proposes that four constructs including performance expectancy PE (i.e. by using the technology will this have a positive impact on performance/outcome), effort expectancy EE (i.e. will using this technology require much effort on the users part), social influence SI (i.e. is using this technology a socially acceptable activity) and facilitating conditions FC (i.e. individual perceived organizational / technical resources and support for use of the system) act as determinants of behavioural intentions and usage behaviours (Venkatesh et al., 2003). Behavioural intention refers to the degree to which an individual plan to use or not use the system under study. In addition, there are four key moderator variables including: gender, age, experience and perceived voluntariness of use. Figure 1 depicts the UTAUT model (Venkatesh and Davis, 2000; Venkatesh et al., 2003).

Given that we are interested in examining what drives nurses to adopt technology in acute care contexts, it is important to look closely at the role of nurses as it relates to technology adoption and the tasks they must perform. Consequently, we focused on the following research question: "Based on various UTAUT dimensions, what are initial reactions of nurses to the proposed solution?" We contend that by answering this question it is possible to then better understand nurses' requirements and improve their acceptance of new ICT solutions.

Figure 1. UTAUT
Venkatesh et al, 2003.



RESEARCH APPROACH

A survey was conducted as a component of a mixed method research design to address several research questions during a clinical trial of a proposed technology solution called SW. SW is a sophisticated, multi-functional information system designed to support nurses in documentation of the delivery of patient care by releasing time nurses' time spent on administrative tasks to allow direct patient care, create an electronic record of patient care delivery, reduce errors, and provide a positive enhancement to nurses' work experience.

Data Collection

The survey collected demographic data, responses to UTAUT items, and additional questions related to the training, support and implementation of the SW system. This paper reports findings related to nurses responses to 26 items addressing the five UTAUT constructs and four key moderator variables using a 7-point Likert scale (from 1 being Totally disagree to 7 being Totally Agree). The items included:

- Performance Expectancy (PE), n=8,
- Effort Expectancy (EE), n=4,
- Social Influence (SI), n=5,
- Facilitating Conditions (FC), n=4,
- Behavioral Intentions (BI), n=5. As the system was in a testing stage, only intention rather than actual use was included.

Overall contextual variables included demographic profiles of the participants and their perceived voluntariness of use:

- Age,
- Gender,
- Years of Experience as Nurse,
- Computer skills and frequency of computer use,
- VU voluntariness, n=3.

Out of 50 surveys sent out, 43 responses were received, i.e. response rate was 86%. After removing invalid responses, 38 responses were used in data analysis. Out of 38 valid responses, only 2 were male (5.3%) hence, gender was excluded from further analysis.

Data Analysis

Data were then cleaned and imported into SPSS v22 for statistical analysis and into Excel for result visualization. Descriptive analysis and hypothesis testing were conducted. The intention here was not to validate the UTAUT model nor predict the nurses' behavioural intention, but to describe and examine the constructs PE, EE, SI, FC and testing the correlations of these constructs on BI.

DATA ANALYSIS RESULTS

Demographic Profiles and Contextual Variables

Table 1 shows the demographic profiles of the nurses that responded to the questions about age and years of experience as nurse (YoEaN).

Age and YoEaN were recoded into groups. Most frequently aged groups include 23 to 32 years old (41.2%, N=14) and 42 to 53 years old (35.3%, N=12). Over half of the respondents has less than 5 years of experience as nurse (55.3%, N=21) (see Figure 2).

Figure 3 displays the distribution of computer skills (N=38) and frequency of computer use (N=38) in computer use as rated by the respondent nurses.

Voluntariness of use can be described through the degrees toward whether SW should certainly not be compulsory in my job, whether their boss should not require them to use it, and whether their

Table 1. Demographic profile of the respondent nurses

	N	Min-Max	Mean	Std. Deviation	Std. Error	95% Confidence Interval
Age	34	23 - 58	38.00	10.751	1.844	34.25 – 41.75
Years of Experience as Nurses (YoEaN)	38	0.04 - 40	12.35	11.65	2.061	7.365 – 15.495

Figure 2. Distribution of age groups and YoEaN groups (in percent)

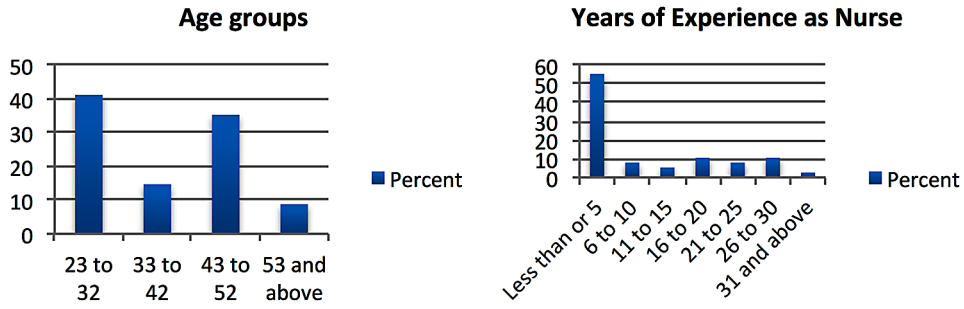


Figure 3. Distribution of computer skills and frequency of use (in percent)

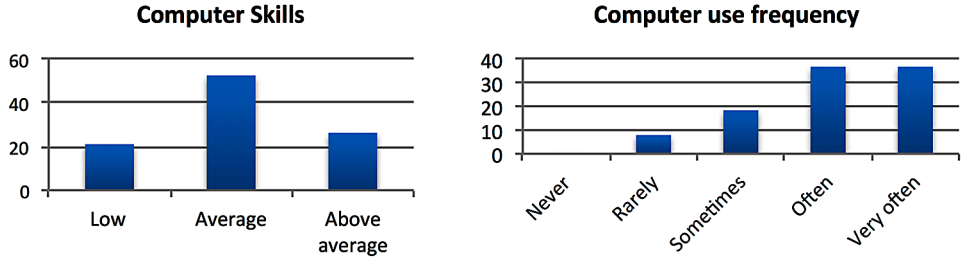
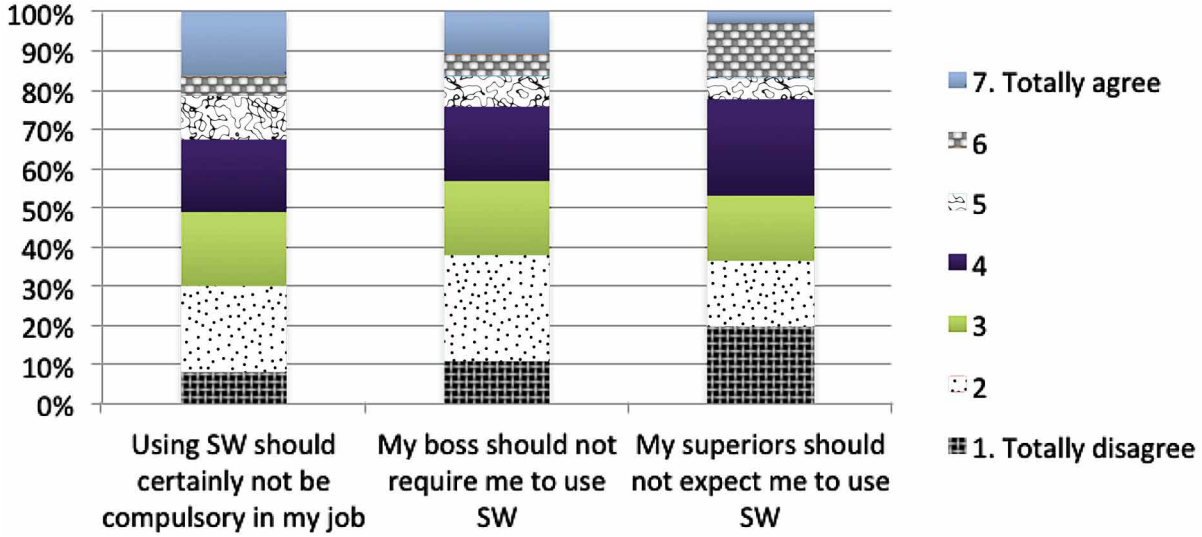


Figure 4. Perceived voluntariness of use



supervisors should not expect them to use it. Around half of the responding nurses were found to be to different levels negative toward a voluntary use of SW (see Figure 4).

Descriptive Statistics Analysis of the Determinants and Behavioral Intention

Figure 5 (a, b, c and d) shows the distributions of various items of the four determinants of the intention to use the SW under study as described in the UTAUT model.

Figure 6 shows the distribution of Behavioural Intention of the respondent nurses.

Correlations between the Determinants (PE, EE, SI, and FC) and Behavioral Intention BI

Reliability statistics test of the determinants was conducted. Table 2 presents the result.

All the Cronbach's Alpha results are strong. Composite scores of the all the determinants and BI were calculated. Table 3 presents descriptive statistics of the composite scores of these constructs.

The following hypotheses about the correlations between the determinants and BI were tested respectively:

$H1_0$: There is no significant correlation between PE and BI.
$H2_0$: There is no significant correlation between EE and BI.
$H3_0$: There is no significant correlation between SI and BI.
$H4_0$: There is no significant correlation between FC and BI.

Table 4 presents the results.

Figure 5a. Distribution of performance expectancy

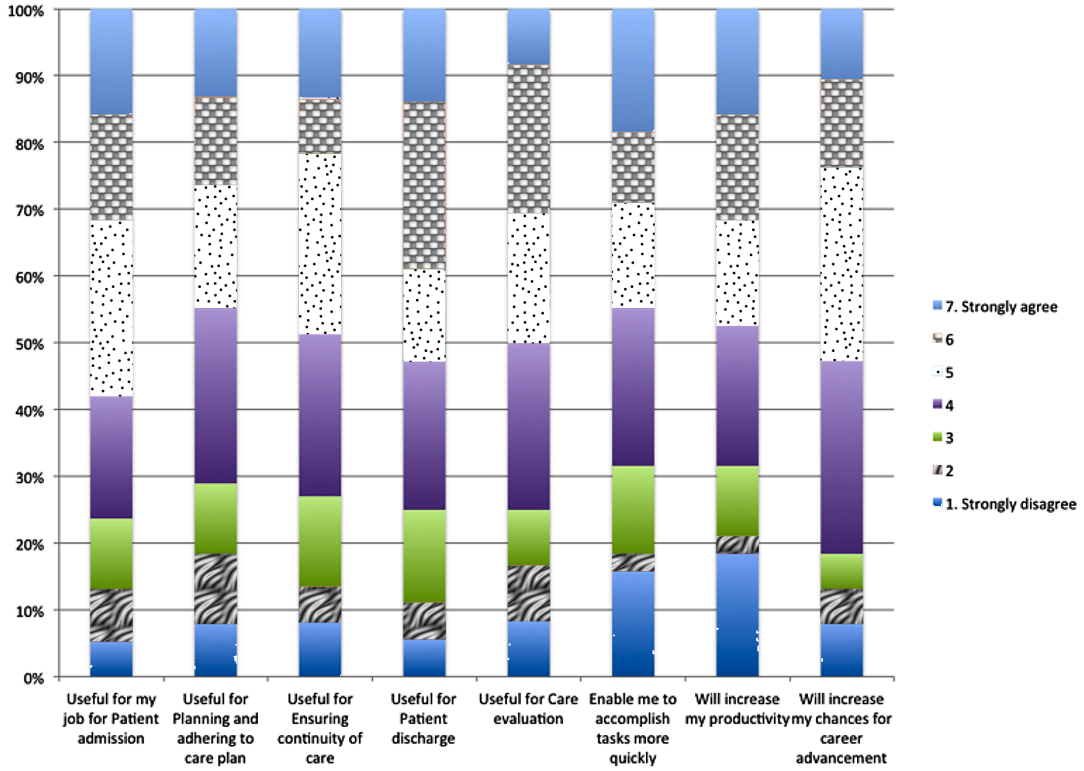


Figure 5b. Distribution of effort expectancy

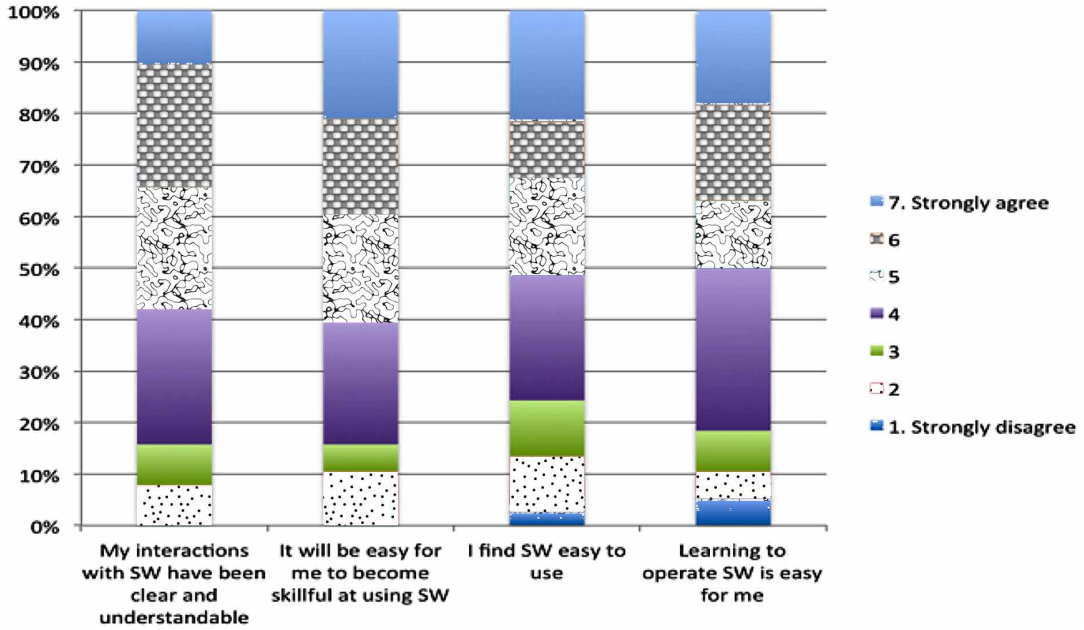


Figure 5c. Distribution of social influence

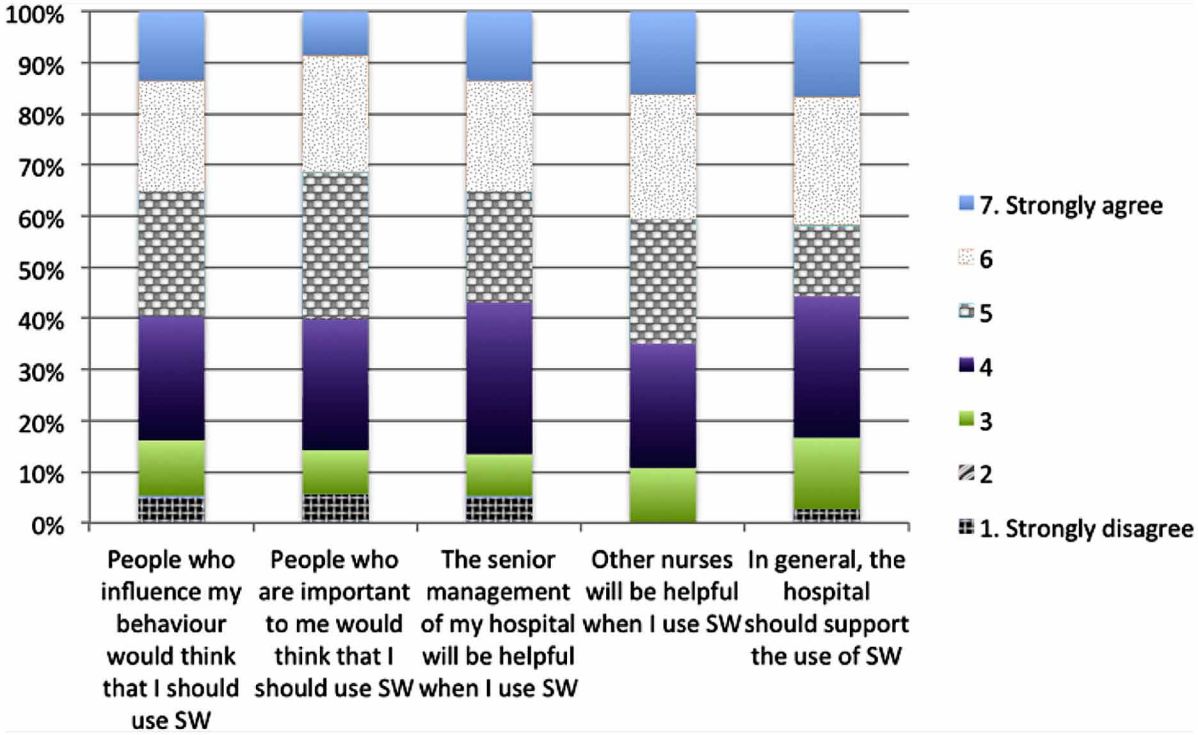


Figure 5d. Distribution of facilitating conditions

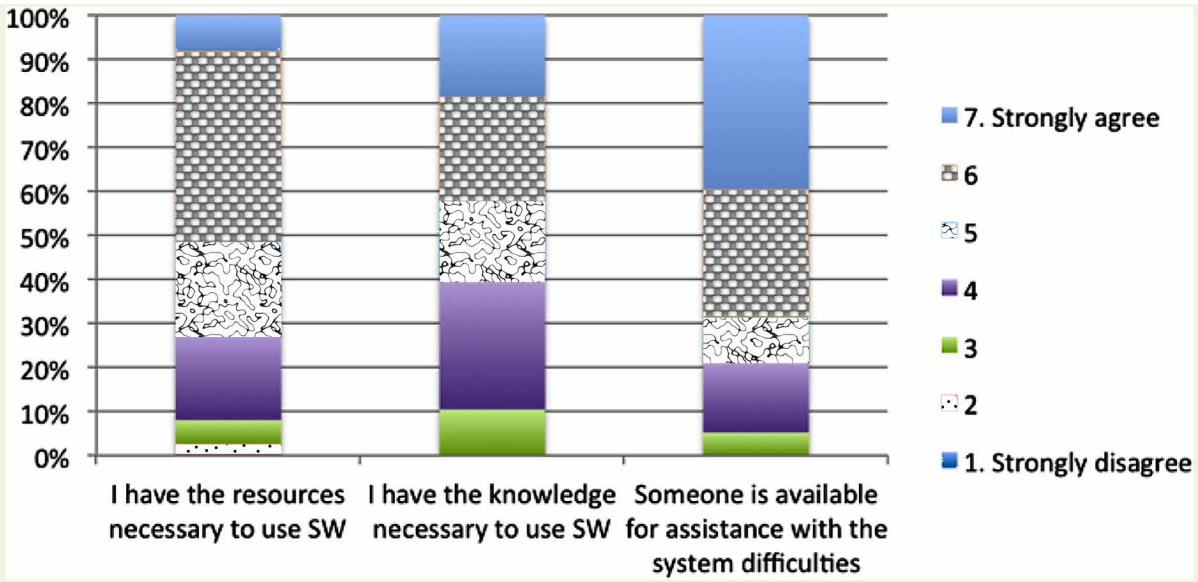


Figure 6. Distribution of behavioural intentions

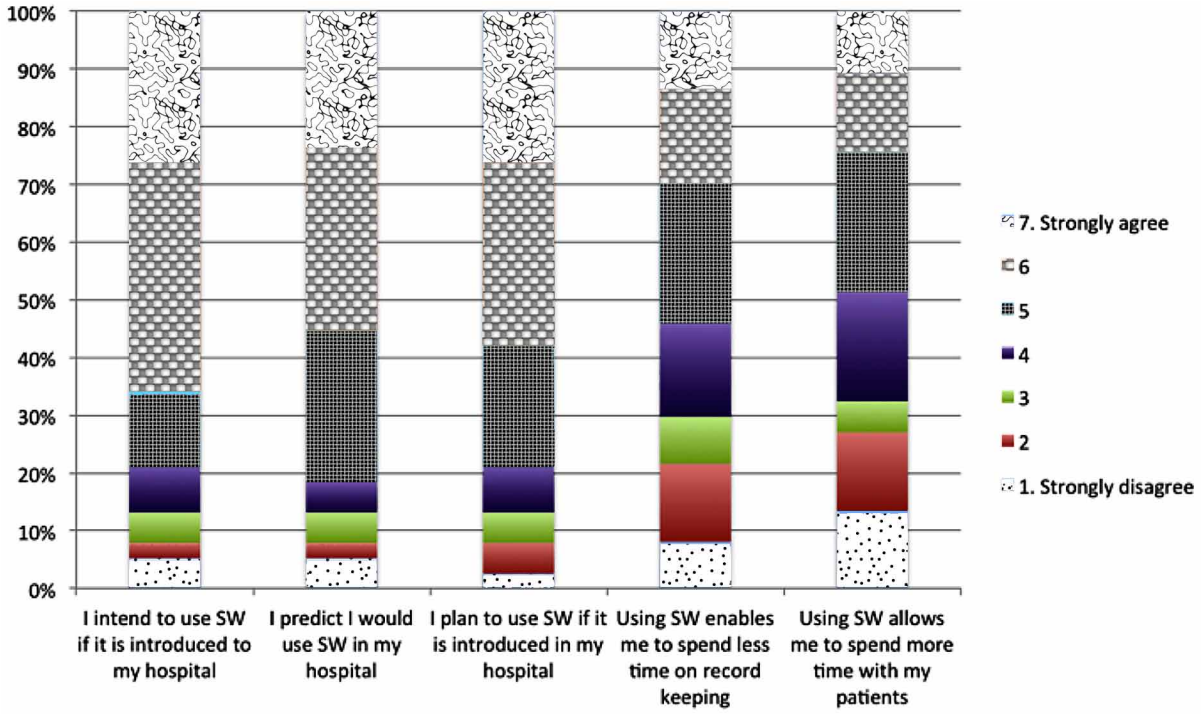


Table 2. Reliability statistics result

	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
PE	0.969	0.970	8
EE	0.972	0.974	4
SI	0.859	0.859	5
FC	0.813	0.816	3
BI	0.943	0.946	5

Table 3. Descriptive statistics of the composite scores

	N	Min-Max	Mean	Std. Deviation	Std. Error	95% Confidence Interval
PE	38	1.00–7.00	4.364	1.647	0.267	3.823–4.906
EE	38	1.75–7.00	4.779	1.535	0.249	4.274–5.283
SI	38	2.80–7.00	4.863	1.184	0.192	4.474–5.253
FC	38	2.67–7.00	5.386	1.067	0.173	5.035–5.737
BI	38	1.00–7.00	4.953	1.548	0.251	4.444–5.461

Table 4. Correlation matrix

		PE	EE	SI	FC
BI	Pearson Correlation	.772**	.751**	.613**	.600**
	Sig. (2-tailed)	.000	.000	.000	.000
	N	38	38	38	38

Correlation is significant at the 0.01 level (2-tailed).**
Bootstrap results are based on 1000 bootstrap samples.

Since all p-value <0.01, we can reject all the above null hypotheses (that there is no significant correlation between each of the constructs PE, EE, SI and FC and BI). Hence at the 0.01 significant level, there is statistical evidence for positive correlation between each of the constructs and BI.

Moderation Analysis Results

Moderation analysis was conducted using Process developed by Andrew Hayes (2013) to test the UTAUT moderations i.e. whether the correlation between each of the determinants PE, EE, SI and FC and dependent variable BI is moderated by age group, years as experience as nurse, computer skills, frequency of computer use, and VU (voluntariness of use). Three following interactions were found to be statistically significant.

The relationship between PE and BI is moderated by age group, b = 0.2149, 95% CI [0.0267, 0.4031], t = 2.3315, p = 0.0266 < 0.05, i.e. at 95% of confidence. The relationship between PE and BI is weaker in young nurses, b = 0.4437, 95% CI [0.1093, 0.7780], t = 2.7100, p = 0.0110 < 0.05 compared to the age group older than mean, b = 0.9020, 95% CI [0.5981, 1.2059], t = 6.0619, p < 0.01. The difference in slope is shown in Figure 7. The SPSS analysis details can be found in Appendix A.

The relationship between PE and BI is moderated by frequency of computer use b = 0.2629, 95% CI [0.0676, 0.4582], t = 2.7357, p < 0.01, i.e. at 99% of confidence. The relationship between PE and BI is weaker in low frequency of computer use, $b = 0.5114$, 95% CI [0.1707, 0.8520], $t = 3.0505$, $p < 0.01$ compared to high frequency of computer use, $b = 1.0077$, 95% CI [0.6314, 1.3841], $t = 5.4416$, $p < 0.01$. The difference in slope is shown in Figure 8. The SPSS analysis details can be found in Appendix B.

Figure 7. Difference in slope between low and high age groups

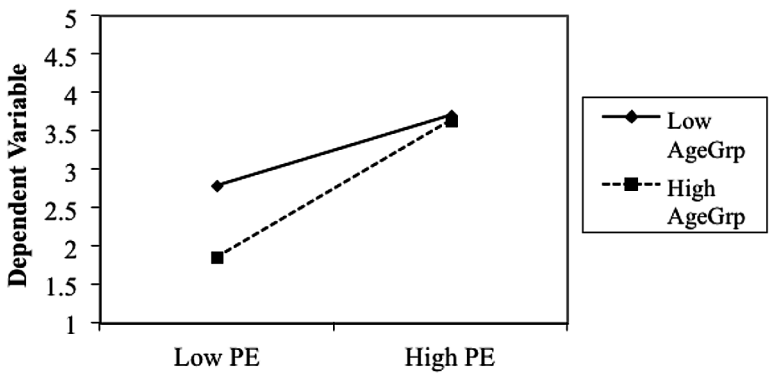
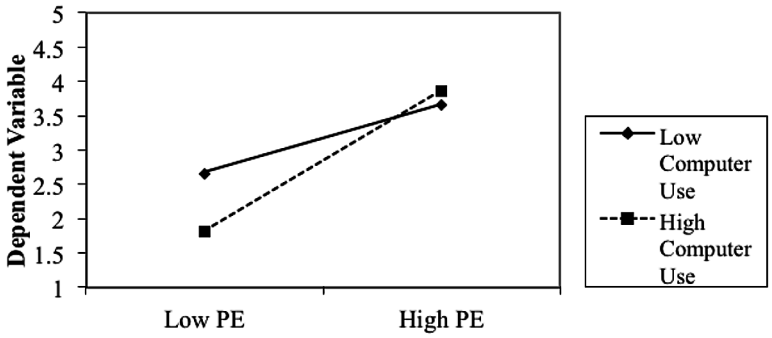


Figure 8. Difference in slope between low and high frequency of computer use



The relationship between PE and BI is moderated by level of perceived voluntariness of use, b = 0.1200, 95% CI [0.0343, 0.2057], t = 2.8500, p = 0.0266 < 0.01, i.e. at 99% of confidence. The relationship between PE and SI is weaker in low level of perceived voluntariness of use, b = 0.3294, 95% CI [0.0443, 0.6145], t = 2.3505, p < 0.01, compared to the high level of perceived voluntariness of use, b = 0.7518, 95% CI [0.4583, 1.0453], t = 5.2120, p < 0.01. The difference in slope is shown in Figure 9. The SPSS analysis details can be found in Appendix C.

Figure 10 depicts statistically significant correlations and moderations confirmed in this study.

DISCUSSION

Overall, the responding nurses were found to be slightly positive toward Performance Expectation and Effort Expectancy. Among different items within this construct, they were most positive about SW being useful for patient admission and for increasing their chance for career advancement. The highest frequency of negative responses (1 - Strong disagree as well as different levels of negative responses 1, 2 and 3 combined) was found in the items "SW would enable me to complete my tasks more quickly" and "SW would increase my productivity". The highest frequency of positive responses (5, 6 and 7 combined) was found in the item "it will be easy for me to become skillful at using SW". They were less so positive about the items "learning to operate SW is easy" and "I find SW easy to use". The frequency

Figure 9. Difference in slope between low and high VU

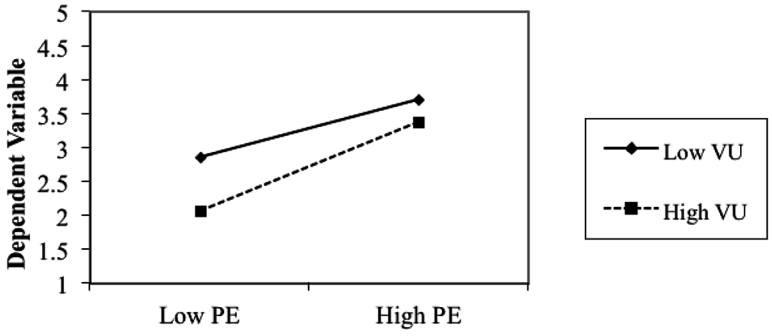
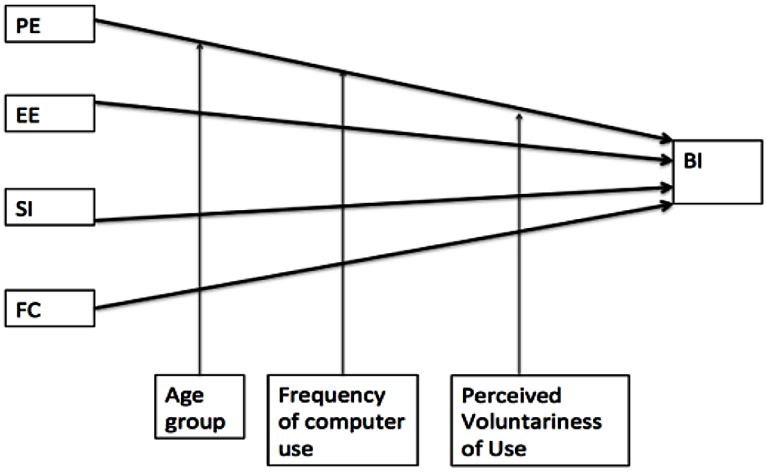


Figure 10. Confirmed direct correlations and moderated correlations



of negative responses to the SI items and FC was much lower compared to PE and EE. Variations in the distribution of the responses are similar to what has been found in Heselmans's et al. study (2012) in which family physicians perceived usefulness varies across different functions of a technology solution.

Nurses were especially positive about other nurses being helpful when they use SW and facilitation conditions to support their use of SW. In Heselmans's et al. study (2012), Social Influence was found to be much lower (the lowest construct) indicating that the physicians did not use the system because their colleagues did. In our study, FC was found to be moderately/strongly positive with mean 5.386 ± 1.067 (seven-point Likert scales). No 'Totally disagree' was found in any FC items. In Heselmans's et al. study (2012), FC was found to be less positive (with mean 3,47 ± 1,41).

Around 80% of the respondent nurses were positive to different extents about their intentions to use SW when it is introduced. They were less positive about benefits of SW that using it would enable them to spend less time on record keeping and more time with their patients.

Positive correlations between each of the determinants (PE, EE, SI and FC) and BI were confirmed. Nurses who were positive about each of the determinants (PE, EE, SI and FC) were also positive about their intention to use SW when it is introduced in their hospital. This is consistent with previous findings (Heselmans et al., 2012; Wills et al., 2008) examining technology acceptance of healthcare professionals through UTAUT lens.

Age groups, frequency of computer use, and level of perceived usefulness were found to moderate the relationship between PE and BI. However, they were not found to moderate the relationship between the other determinants (EE, SI and FC) and the dependent variable BI. Deviations from the UTAUT model were also reported in previous studies. For example, PE, EE, SI were not found to have significant influence on BI (Vanneste et al., 2013) and age was found to be the only significant moderator in a revised UTAUT model (Venkatesh et al., 2011). Other variables may be included for further analysis, for example role, attitude, anxiety, and self-efficacy as in previous studies (Kohnke et al., 2014).

CONCLUSION

Through the UTAUT lens, initial reactions of the participating nurses were examined. Our study appears to indicate that there is a general positive view to use technology in the nursing context. Differences between their responses to some specific items pose further questions, for example while nurses were moderately positive about their intention to use the system while holding a less positive view about its usefulness, usability and benefits in some areas. To address this issue we recommend follow up studies that include a mixed method approach and use qualitative techniques.

There are three limitations in this study. Firstly, this is not an empirical validation of UTAUT. Secondly, due to the complex nature of acute care wards and patient safety requirements, only a small number of nurses participated in the software trial. All these resulted in a small sample size of the acceptance survey (N=38). Still this sample size is similar to previous studies using UTAUT, N=39 in Heselmans's et al. study (2012) and N=52 in Wills' et al. study (2008). Thirdly, survey research by nature does not reveal a deep understanding of how and why behind the findings, i.e. changes or no changes in perceptions.

This paper contributes to theory in a very important way. The findings also suggest UTAUT can be used as a way to explore and planning user requirements and acceptance of innovative technology solutions and feedback to design. It also suggests that models such as UTAUT need further extension of IS theory to facilitate a fuller understanding of the complex and dynamic nature of healthcare and how and why this affects acceptance of specific solutions even though there appears to be a general acceptance that IS/IT is required. For practice the message is even stronger that user needs and requirements must be carefully considered when developing IS/IT solutions for healthcare contexts is a necessary but not sufficient consideration. More research into how to better meet the demands of a multiple heterogeneous user system such as the dynamic and complex healthcare environment is definitely needed.

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APPENDIX A

Moderation Analysis Results

```
Run MATRIX procedure:
*************** PROCESS Procedure for SPSS Release 2.13.1 **************
        Written by Andrew F. Hayes, Ph.D.       www.afhayes.com
    Documentation available in Hayes (2013). www.guilford.com/p/hayes3
**************************************************************************
Model = 1
    Y = BICompo
    X = PECompo
    M = AgeGrNew
Sample size
        34
**************************************************************************
Outcome: BICompo
Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .8344      .6962      .8769    18.2284     3.0000    30.0000      .0000
Model
              coeff         se          t          p       LLCI      ULCI
constant     5.1490      .1885    27.3126      .0000     4.7640    5.5340
AgeGrNew    -.2534      .1720    -1.4728      .1512     -.6047      .0980
PECompo       .6728      .1217      5.5288      .0000      .4243      .9214
int_1          .2149      .0922      2.3315      .0266      .0267      .4031
Interactions:
 int_1    PECompo     X     AgeGrNew
**************************************************************************
Conditional effect of X on Y at values of the moderator(s):
   AgeGrNew     Effect         se          t      p       LLCI       ULCI
    -1.0664      .4437      .1637     2.7100      .0110      .1093      .7780
     .0000      .6728      .1217     5.5288      .0000      .4243      .9214
    1.0664      .9020      .1488     6.0619      .0000      .5981     1.2059
Values for quantitative moderators are the mean and plus/minus one SD from mean.
Values for dichotomous moderators are the two values of the moderator.
**************************************************************************
Data for visualizing conditional effect of X on Y
Paste text below into a SPSS syntax window and execute to produce plot.
DATA LIST FREE/PECompo AgeGrNew BICompo.
BEGIN DATA.
   -1.6552    -1.0664     4.6849
     .0000    -1.0664     5.4192
```

```
    1.6552   -1.0664    6.1535
   -1.6552    .0000    4.0354
    .0000     .0000    5.1490
    1.6552    .0000    6.2627
   -1.6552    1.0664    3.3858
    .0000     1.0664    4.8788
    1.6552    1.0664    6.3718
END DATA.
GRAPH/SCATTERPLOT=PECompo WITH BICompo BY AgeGrNew.
****************** ANALYSIS NOTES AND WARNINGS ************************
Level of confidence for all confidence intervals in output:
   95.00
NOTE: The following variables were mean centered prior to analysis:
 PECompo  AgeGrNew
NOTE: Some cases were deleted due to missing data.  The number of such cases was:
 4
NOTE: All standard errors for continuous outcome models are based on the HC3 estimator
------ END MATRIX -----
```

APPENDIX B

Moderation Analysis Results

```
Run MATRIX procedure:
*************** PROCESS Procedure for SPSS Release 2.13.1 **************
        Written by Andrew F. Hayes, Ph.D.       www.afhayes.com
   Documentation available in Hayes (2013). www.guilford.com/p/hayes3
**************************************************************************
Model = 1
   Y = BICompo
   X = PECompo
   M = CompUseR
Sample size
        38
**************************************************************************
Outcome: BICompo
Model Summary
        R       R-sq        MSE          F        df1        df2          p
     .8087      .6539      .9026    12.2094     3.0000    34.0000      .0000
Model
             coeff         se          t          p       LLCI       ULCI
constant     4.7447      .1777    26.7075      .0000     4.3836     5.1057
CompUseR     -.1592      .1897     -.8394      .4071     -.5448      .2263
```

```
PECompo       .7595      .1515      5.0118      .0000      .4516      1.0675
int_1         .2629      .0961      2.7357      .0098      .0676       .4582
Interactions:
 int_1    PECompo     X     CompUseR
************************************************************************
Conditional effect of X on Y at values of the moderator(s):
   CompUseR     Effect         se          t          p       LLCI       ULCI
    -.9440      .5114      .1676     3.0505      .0044      .1707      .8520
     .0000      .7595      .1515     5.0118      .0000      .4516     1.0675
     .9440     1.0077      .1852     5.4416      .0000      .6314     1.3841
Values for quantitative moderators are the mean and plus/minus one SD from mean.
Values for dichotomous moderators are the two values of the moderator.
************************************************************************
Data for visualizing conditional effect of X on Y
Paste text below into a SPSS syntax window and execute to produce plot.
DATA LIST FREE/PECompo CompUseR BICompo.
BEGIN DATA.
   -1.6465    -.9440    4.0530
    .0000     -.9440    4.8950
    1.6465    -.9440    5.7369
   -1.6465     .0000    3.4941
    .0000      .0000    4.7447
    1.6465     .0000    5.9952
   -1.6465     .9440    2.9351
    .0000      .9440    4.5943
    1.6465     .9440    6.2536
END DATA.
GRAPH/SCATTERPLOT=PECompo WITH BICompo BY CompUseR.
****************** ANALYSIS NOTES AND WARNINGS ************************
Level of confidence for all confidence intervals in output:
   95.00
NOTE: The following variables were mean centered prior to analysis:
 PECompo  CompUseR
NOTE: All standard errors for continuous outcome models are based on the HC3 estimator
------ END MATRIX -----
```

APPENDIX C

Moderation Analysis Results

```
Run MATRIX procedure:
***************** PROCESS Procedure for SPSS Release 2.13.1 **************
        Written by Andrew F. Hayes, Ph.D.       www.afhayes.com
    Documentation available in Hayes (2013). www.guilford.com/p/hayes3
**************************************************************************
Model = 1
    Y = BICompo
    X = PECompo
    M = VUCompo
Sample size
        37
**************************************************************************
Outcome: BICompo
Model Summary
          R       R-sq        MSE          F       df1        df2          p
      .8755      .7665      .6273    46.5251     3.0000    33.0000      .0000
Model
             coeff         se          t          p       LLCI       ULCI
constant    5.1752       .1702    30.3998      .0000     4.8288     5.5216
VUCompo     -.2787       .1026    -2.7167      .0104     -.4874     -.0700
PECompo      .5406       .1214     4.4542      .0001      .2937      .7875
int_1        .1200       .0421     2.8500      .0075      .0343      .2057
Interactions:
 int_1    PECompo     X     VUCompo
**************************************************************************
Conditional effect of X on Y at values of the moderator(s):
   VUCompo     Effect         se          t          p       LLCI       ULCI
   -1.7594      .3294       .1401     2.3505      .0249      .0443      .6145
    .0000       .5406       .1214     4.4542      .0001      .2937      .7875
   1.7594       .7518       .1442     5.2120      .0000      .4583     1.0453
Values for quantitative moderators are the mean and plus/minus one SD from mean.
Values for dichotomous moderators are the two values of the moderator.
**************************************************************************
Data for visualizing conditional effect of X on Y
Paste text below into a SPSS syntax window and execute to produce plot.
DATA LIST FREE/PECompo VUCompo BICompo.
BEGIN DATA.
   -1.6207    -1.7594     5.1317
    .0000     -1.7594     5.6655
```

```
    1.6207   -1.7594    6.1994
   -1.6207    .0000    4.2990
    .0000     .0000    5.1752
    1.6207    .0000    6.0514
   -1.6207    1.7594   3.4664
    .0000     1.7594   4.6849
    1.6207    1.7594   5.9034
END DATA.
GRAPH/SCATTERPLOT=PECompo WITH BICompo BY VUCompo.
****************** ANALYSIS NOTES AND WARNINGS ************************
Level of confidence for all confidence intervals in output:
   95.00
NOTE: The following variables were mean centered prior to analysis:
 PECompo  VUCompo
NOTE: Some cases were deleted due to missing data.  The number of such cases was:
  1
NOTE: All standard errors for continuous outcome models are based on the HC3 estimator
------ END MATRIX -----
```

Chapter 21
Social Forces that Influence Health IT Use Behavior of the Elderly

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ABSTRACT

The social forces that influence patient portal use behavior among the elderly are not well understood. Using both institutional theory and the Unified Theory of Acceptance and Use of Technology, the proposed model examines three social environmental factors – normative, mimetic, and coercive forces – within a Health Information Technology (HIT) context. An empirical study involving 117 subjects in the United States was used to test the proposed model. Using the partial least squares method, mimetic and coercive pressures were found to significantly influence patient portal use behavior. These findings indicate that older people follow not only their providers' advice, but also follow the behavior of respected, higher-status peers from their network. Normative pressure was not found to be significant, implying that older people do not follow the bandwagon effect.

INTRODUCTION

The healthcare industry is paying greater attention to improving patient outcomes through better provider-patient communication (Tang et al., 2013; Chrischilles et al.,2014). One such tool that is seeing greater utilization by healthcare providers is the patient portal. Patient portals are secure online websites that allow patients to access their personal health information, such as communicate summaries of recent visits, medications, immunizations, allergies, and lab results, from any location with an Internet connec-

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tion (Krist et al., 2012; HealthIT.gov). More sophisticated patient portals are also capable of scheduling non-urgent appointments, downloading and submitting forms, processing prescription refills, accepting payments, and providing viewable educational material (Goldzweig et al., 2013). Patient portals have become a valuable tool for addressing the problem of rapidly aging populations in most countries (Bierman, 2012).

The use of electronic health records (EHR) is also on the rise. A 2014 study (Hsiao & Hing, 2014) shows that about 80% of office-based physicians in the US use EHRs, and a majority of them (69%) are committed to participate in the meaningful use incentive payment program available in the United States (Blumenthal & Tavenner, 2010). One of the Stage 2 Core Set objectives to achieve meaningful is "provide patients the ability to view online, download, and transmit their health information" (HealthIT.gov). This means that healthcare providers with EHR systems are mandated to provide patients with access to personal health information over the Internet using a secure online portal. Several other countries are introducing similar initiatives as they try to both improve health outcomes and strive for efficiencies in their health systems (Wickramasinghe, Davey, & Tatnall, 2013).

Numerous studies examine patient portal acceptance and use (Goldzweig et al., 2013; Ancker et al., 2011; Smith et al., 2015; Sarkar et al., 2011; Goel et al., 2011; Jung et al., 2011; Weppner et al., 2010). Patients with chronic conditions are more likely to accept and use patient portals (Goldzweig et al., 2013; Ancker et al., 2011; Millard & Fintak, 2002). Patient age is negatively correlated with portal adoption and use, especially among older patients (Goel et al., 2011; Jung, Padman, Shevchik, et al., 2011; Weppner et al., 2010). Roughly 20% of the US population will be over the age of 65 by 2030 in the next decade due to longer life spans and aging baby boomers (CDC, 2013), and it has been established that doctor visits and medical spending increase during the final years of life (Hogan, Lunney, Gabel, & Lynn, 2001). In fact, some studies indicate a quarter of an individual's medical spending occurs in their final year (Lubitz & Riley, 1993). Hence, one can conclude that while older patients could benefit most from patient portals, they are the least likely group to use them.

While there exists a number of empirical studies that examine various factors to better understand consumer health information technology (CHIT) acceptance and use, they rely primarily on technology acceptance theories (Klein, 2007). The variety of antecedents in the competing models show that older patients are less likely to accept CHIT by making use of online health information because of less comfort, efficacy, and control (Smith et al., 2015; Or & Karsh, 2009). However, one of these antecedents is social influence, also called subjective norm (Ajzen, 1991; Venkatesh & Davis, 2000; Moore & Benbasat, 1991), which remains unexplored in regards to older patients. According to Carley and Kaufer (1993), elderly patients are likely to conform to the attitudes, norms, and beliefs of those around them, meaning that social influence may be a motivator for the elderly to adopt and use patient portals. It is therefore prudent to examine social influence in more detail beyond the technology acceptance theories.

This empirical study argues that elderly patients' opinions about patient portal acceptance and use are influenced by those peers they respect. The conceptual model proposed herein is based on institutional theory's driving forces as a precursor of the driving forces of behavioral intention and use behavior within the Unified Theory of Acceptance and Use of Technology (UTAUT) Model. Data collected from the elderly in various social settings provides the basis of our empirical evidence that normative, coercive, and mimetic social forces significantly influence older patients' use behavior toward patient portals.

BACKGROUND

Two major determinants drive technology acceptance and use: individual beliefs and social factors. "Subjective norm" is the term commonly used to describe the social pressure to engage in an activity (Fishbein & Ajzen, 1975). An individual develops beliefs shaped by a motivation to comply with the perception of how influential peers or superiors think they should or should not perform (Fishbein, 1980). In the technology domain, influencers in the form of respected peers or superiors are found to be a strong determinant in shaping beliefs (Mathieson, 1991; Taylor & Todd, 1995). This study does not explore or hypothesize any relationship among the individual beliefs or social factors, but rather approaches the social factors from the basis of institutional theory.

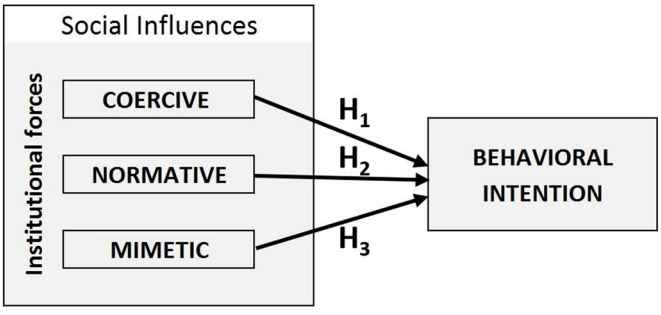
Technology use by individuals has been explored by examining the characteristics of both individuals and organizations. Institutional characteristics have been found to strongly influence technology use (Delone, 1988; Sanders & Courtney, 1985; Boynton, Zmud, & Jacobs, 1994). While institutional theory was developed and applied in an organizational context (Liang, Saraf, Hu, & Xue, 2007; Ang & Cummings, 1997; DiMaggio & Powell, 1983), organizations actually operate at the local, interpersonal relationships level through a network of individuals (Scott, 2001). Hence, this study will empirically investigate the effect of the social factors of institutional theory on patient portal use by the elderly, and will expand the theory's applicability through theoretical and managerial implications.

MAIN FOCUS OF THE ARTICLE

Social Forces as Precursor of Portal Use

In order to better account for the ways in which institutional forces influence patient portal use behavior by the elderly, this study presents the conceptual model shown in Figure 1, based on institutional theory (DiMaggio & Powell, 1983) and the UTAUT model (Venkatesh, Morris, Davis, & Davis, 2003). Although social forces are a major precursor in almost all major technology acceptance models, none of them have investigated social forces on a more granular level (Bozan, Davey, & Parker, 2015). Early studies of institutional theory identified three mechanisms, coercive pressure, normative pressure, and mimetic pressure, which promote structure and process similarities (DiMaggio & Powell, 1983; Scott, 2001). This study examines whether those three institutional forces significantly affect use behavior among older users.

Figure 1. Conceptual model



MODEL COMPONENTS

Use Behavior

For the purposes of this study, use behavior is defined as the degree to which a user regularly uses the system for the purposes it is designed. The most common dependent variables in technology acceptance literature are actual use, intention to use, and behavior. Behavior is defined as a specific or general action whose prediction is of interest in a particular model (Ajzen & Driver, 1991; Ajzen & Fishbein, 1980). In the "competing" technology acceptance models, the dependent variable is often preceded by the subjective norm, which is an individual's perception of influencers' approval or disapproval of the specific or general target behavior. The antecedents of use behavior are often linked to the subjective norm or social influence, hence our choice for the dependent variable of use behavior in our proposed conceptual model.

Coercive Pressure

Coercive pressure includes both the formal and informal pressures on an individual (social actor) by a more powerful individual (actor) to adopt the same practices, behaviors, or attitudes (DiMaggio & Powell, 1983). Formal or informal coercive pressure at the organizational level can be generated by a variety of sources, such as regulatory agencies, customers, suppliers, and other powerful actors (Teo, Wei, & Benbasat, 2003).

In the context of healthcare, regulatory pressure often impacts many facets of care at the individual level. Since this study is focusing on patient portal acceptance, the pressure that providers may put on patients to use patient portals is investigated. For example, physicians are powerful actors in the physician-patient relationship, and may informally pressure patients to access their portal for health-related communication in order to increase the effectiveness of care. Hence, it is hypothesized:

H1: Patients who perceive higher coercive pressure are more likely to use a patient portal.

Normative Pressure

Institutional theory posits that if an action, behavior, or belief is exhibited by an adequately large group of actors, a social actor is more likely to copy that action. Copying is not mandated and may not even be conscious, but rather becomes the norm, the "right" way (Harcourt, Lam, & Harcourt, 2005; Johnson, Dowd, & Ridgeway, 2006). When normative pressure acts as a social factor for adopting a behavior or belief, it can result in discord if peers whose opinions are valued are already using an innovation (DiMaggio & Powell, 1983; Van den Bulte & Lilien, 2001). Therefore, following the behavior, using the innovation, becomes an obvious and "right" choice for the social actor.

Older patients supported by a large network may often share details about their physical health with each other. During such discussions, if a respected peer mentions the use of patient portals, other individuals are more likely to consider trying one out. This effect has been described generally by Abrahamson (1991) as theories of fads. Hence, it is posited:

H2: Patients who perceive higher normative pressure are more likely to use a patient portal.

Mimetic Pressure

DiMaggio and Powell (1983) proposed mimetic pressure as the conscious and voluntary act of copying the behaviors of those with higher status and success. Such copying behavior is driven by the belief that the actions of more successful and respected actors result in positive outcomes. The assumption is that copying the behavior of respected members of a network is safer than experimenting new, "untested" behavior (Teo, Wei, & Benbasat, 2003). Seniors are often more aware of their health status because they more actively seek information about their health (Bennenbroek, Buunk, van der Zee, & Grol, 2002). If a trusted friend mentions their patient portal as being a reliable source of information, those who have not adopted a portal are more likely will try using it. Therefore, it is hypothesized:

H3: Patients who perceive higher mimetic pressure are more likely to use a patient portal.

RESEARCH METHODOLOGIES

Measurement

Questionnaire items were adopted from the literature for social forces (Liang et al., 2007; Teo, Wei, & Benbasat, 2003; Jan, Lu, & Chou, 2012) and use behavior (Venkatesh et al., 2003; Liu, Wu, & Sun, 2014). Social factors constructs were measured by six indicators, while the dependent variable was measured by three indicators. (Please see Appendix for the Questionnaire Items and indicators)

Data Collection

Convenience and snowball sampling was used for data collection. Several assisted living establishments were contacted and asked to promote our survey among their residents. The survey was also disseminated among a network of elderly individuals who were asked to share it with their contacts. 117 fully completed questionnaires were returned prior to data analysis.

Control Variables

Demographic variables, such as age and gender, have been found to have significant effect on social behavior studies (Mazman, 2011; Dabaj, 2009). Morris and Venkatesh (2000) found that older individuals are more susceptible to social influences, but a study by Botwinick (1973) indicates they are more cautious before they decide on an action. Women are found to be more perceptive regarding others' opinions than men (Venkatesh et al., 2003). Our study also controls for residence, since dwelling in an assisted living environment may have an effect on social factors as opposed to those who are somewhat more isolated in their residence (Cattan, White, Bond, & Learmouth, 2005; Nicholson, 2008). In addition, technical efficacy (Chaffin & Harlow, 2005; Purdie & Boulton-Lewis, 2003) and attitude toward self-health (Karwalajtys et al., 2005) were also examined for their effect on use behavior.

DATA ANLYSIS AND RESULTS

Instrument Validation

The Partial Least Squares (PLS) statistical method was used for scales validity assessment and hypotheses testing because it provides more flexibility with sample size and residual distribution (Anderson & Gerbing,1988; Chin, Marcolin, &Newsted, 2003; Chin, 1998). Using the most recent version of SmartPLS (version 3.2.1 for Windows 64 bit), the relationships between constructs (path coefficients) and the predictive power of the dependent variable – R-squared (Chin, 1998) is examined.

Table 1 presents the measurement model t-statistics and factor loadings. Factor loadings of less than 0.7 have been removed to strengthen the item reliability. Since reflective indicators are interchangeable (meaning they ask the same thing), some can be omitted and PLS is flexible and reliable even with a low number of factors per latent variables (Wold, 1985), therefore the factors loaded less than 0.7 can be safely removed. Construct reliability was tested by Cronbach's Alpha and the results were above the recommended 0.7 value (Nunnaly, 1978). Convergent validity values, in terms of average variance extracted (AVE), were above the recommended 0.5 value (Fornell & Larcker, 1981).

Hypotheses Testing

Our measurement model was tested against the hypotheses through path coefficients (relationship strength between IV and DV) and R-squared values to measure the predictive power of the model (Barclay, Higgins, & Thomson, 1995). T-statistics were calculated using the bootstrapping technique in SmartPLS.

The path coefficients from coercive pressure to use behavior ($b=0.24$, $p<0.05$) and from mimetic pressure to patient portal use behavior ($b = 0.351$, $p<0.001$) supported hypothesis 1 and 2 respectively, indicating that coercive and mimetic forces have a significant effect on the adoption and use of patient portals among the elderly. However, normative pressure showed no significant impact on patient portal use behavior ($b=0.11$, NS).

The research model explains 28% of the variance of social forces on patient portal use behavior as indicated by the r-squared value. This magnitude is somewhat expected as technology adoption and use behavior is a cumbersome subject with numerous antecedents. This study focuses on social factors and intentionally omitted other, well established constructs. Therefore, the predictive power of the model was expected to be on the lower side.

Control variables showed an insignificant effect on patient portal use behavior with path coefficients of $b= 0.04, -0.07, -0.05, 0.03$ respectively for attitude toward self-health, gender, resident type, and technical affinity respectively.

Table 1. Factor loadings, t-statistic and Cronbach's Alpha for the measurement model

Construct	Loading	t-Statistic	Cronbach's Alpha
Coercive	0.24**	2.93	0.71
Normative	0.11	1.31	0.78
Mimetic	0.35**	4.83	0.80

**t-Statistics are significant on the 0.01 level.

SOLUTIONS AND RECOMMENDATIONS

This study examined the effect of social factors on patient portal adoption and use behavior among the elderly. The conceptual model was constructed on institutional theory and UTAUT. With the adoption and use of patient portals by the elderly serving as the dependent variable, this study empirically tested the strength of the effects of three independent variables, namely coercive, normative, and mimetic pressures.

The study revealed theoretical and practical findings. First, both coercive and mimetic forces have a significant effect on the adoption and use of patient portals among the elderly. One of the main coercive forces on elderly patients is their providers; older patients follow the advice of their medical provider. With regard to mimetic forces, it became apparent that higher profile, respected peers influence the elderly with regard to patient portal adoption. Mimetic pressure has a stronger influence than normative pressure; satisfied portal users will have a stronger effect on other elderly patients to adopt and use patient portals. Normative pressure, however, has an insignificant effect on use behavior, which is a significant finding of this study. It indicates that elderly people do not follow the bandwagon effect. They have established practices, which may only change if a respected, higher status actor from their network suggests it.

The low effects of the control variables are also important findings as a more general approach is sufficient to reach the elderly to the same extent.

FUTURE RESEARCH DIRECTIONS

While this study makes a contribution to the relevant literature and provides valuable directions, it has limitations that may affect the generalizability of the findings. Data collection followed convenience and snowballing sampling. Geographical distribution was not tracked and the results may only represent that of a particular area. Also, the subjects were mostly contacted through email and social media and the survey was conducted online, in effect requiring that every respondent have a basic level of familiarity with the Internet and computers.

It is important to keep in mind that most of the variables (72%) in use behavior remain unexplained by the variance in the measurement model, which implies that there could be a number of other factors that may influence adoption and usage of patient portals by the elderly. This provides the opportunity for future research to enhance the model to examine other important social factors that may strengthen the predictive power of the model.

It might be informative to investigate a similar model with behavioral intention as the mediator between social factors and use behavior, similar to UTAUT. Since this study investigates social factors on a more granular level, one may wonder whether or not all three institutional forces are significant with the moderator or only with the dependent variable.

CONCLUSION

This study serves to extend the literature on patient portal use, as use behavior of the elderly has not been previously investigated with respect to social forces. The application of institutional theory as the pillar of our model, accompanied by significant findings, adds to the growing literature on the adoption and usage of information and communication technologies in healthcare by the elderly. Additional fac-

tors have been identified for health communication technology adoption by the elderly population, and promise to lead to future research that can reveal additional important social factors that may strengthen the predictive power of the model.

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KEY TERMS AND DEFINITIONS

Elderly Citizens: People over the age of 65 years.

Health IT Adoption: Healthcare information technology (Health IT) is the use of computer applications to record, store, protect, retrieve, and transfer clinical, administrative, and financial information electronically within and among various health care settings. (www.hrsa.org). Adoption of Health IT for the purposes of this research is defined as the process from being aware of the technology to the effective and efficient usage for the intended purpose.

Health IT Usage: Accessing personal health information by the intended recipient through electronic medium and application designed for informational or decision making reason purpose.

Institutional Theory: In this paper, Institutional Theory is defined as the guidelines for social behavior in the form of accepted structures, schemas, rules, norms, and routines influenced by other members of the collective network of actors.

Unified Theory of Acceptance and Use of Technology (UTAUT): The UTAUT model explains Technology use intention and behavior with numerous constructs including social influence.

APPENDIX

Questionnaire Items

(Strongly Disagree =1, Strongly Agree =7)

Coercive Pressure (Adopted from Teo, et al., 2003; Liang, et al., 2007; Jan, et al., 2012)

Q1: I trust the diagnosis and treatment my physician prescribes.
Q2: My physician strongly encourages me to use and understand information on an Online Personal Health Information website.
Q3: I understand that information related to my condition can be found on an Online Personal Health Information website.
Q4: Interaction with my physician requires me to access an Online Personal Health Information website.
Q5: Is your physician the only person who controls your treatment? If not who else do you go to for help and how much help do you get from them? (Do not use an actual name, rather please describe the person's role or your relation to this person)
Q6: Who is the most important person you go to for health advice outside your physician and why do you trust their advice? (Do not use an actual name, rather please describe the person's role or your relation to this person)

Normative Pressure (Adopted from Teo, et al., 2003; Liang, et al., 2007; Jan, et al., 2012)

Q1: I am aware that some of my close family or friends are regularly accessing their Online Personal Health Information website.
Q2: Those who use their Online Personal Health Information website would help me to access an Online Personal Health Information website if I asked for it.
Q3: People around me believe that it is beneficial to access their Online Personal Health Information website.
Q4: I feel that I would be better informed if I used an Online Personal Health Information website.
Q6: What new technology have you used in the last few years? E.g. do you use the internet, do you have a tablet or portable computer, do you use your mobile phone for more than phone calls?

Mimetic Pressure (Adopted from Teo, et al., 2003; Liang, et al., 2007; Jan, et al., 2012)

Q1: My close friends who regularly access their Online Personal Health Information website have benefited from it.
Q2: My close friends who regularly access their Online Personal Health Information website are more respected for taking charge of their health.
Q3: I feel that I would be favorably perceived if I used an Online Personal Health Information website.

Q4: I feel motivated to find more information about my condition.
Q5: If everyone near me were to use an Online Personal Health Information website, it would influence me to try it.

Use Behavior (Adopted from Venkatesh, et al., 2003, Liu, et al., 2010,)

Q1: I plan to access an Online Personal Health Information website in the next year for the first time.
Q2: I plan to access an Online Personal Health Information website regularly.
Q3: I plan to continue using an Online Personal Health Information website.

Controls

Q1: I live in:
- My own home
- A retirement village
- In a nursing home

Q2: I am very good with technology:
- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

Q3: My age is:
- Under 65
- Over 65

Q4: I am:
- Male
- Female

Q5: Having good information about the state of my health and any conditions is important to me.
- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

Q6: I have used the internet for health advice.
- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

Q7: I ask other people to find health advice on the internet.

- Strongly Disagree
- Disagree
- Neither Agree nor Disagree
- Agree
- Strongly Agree

Chapter 22
Active and Healthy Aging: Satisfaction with Health Services by Elderly Patients in Turkey

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ABSTRACT

This study aims to investigate the difficulties experienced by elderly persons in accessing healthcare services and their satisfaction with issues as regards the healthcare system. In this study, qualitative research was carried out to assess the difficulties regarding the healthcare delivery system and satisfaction with the healthcare services. This qualitative research was performed through in-depth interviews with 6 men and 4 women aged 65+ years, in Ankara, the capital city of Turkey. It was discovered that elderly persons required the support of others to access a doctor, a health institution or hospital and the care and support of others for the regular intake of their drugs with increasing age. They were satisfied with the current family physician program. The most significant challenges experienced by elderly persons regarding the healthcare delivery system included crowded hospitals, difficulty walking, the unavailability of wheel chairs, and inadequate assistance from support staff.

INTRODUCTION[1]

Since the very beginning, human beings have strived hard to find ways to live healthy and even eternally. Developments in the second half of the past century and the effects of advancements in the fields of health and technology onto the quality of life for human beings prove that humanity's goal of "longevity" has been achieved. In 30-35 years, one out of every four Turkish citizens will be older than 65 years (TurkStat, 2014). In developed countries, the current rate of people older than 65 is one out of seven, and the same group will comprise a quarter of the total population in only 15 years. This has spurred on the conversation surrounding the "aging" process for the elderly population. By 2050, the number of "older elderly persons" will be six times more than that of "young elderly persons" above the age of 65. It is anticipated that the oldest population of elderly persons (aged 80 years and above) will increase by 160% globally by 2040, more than all other populations of elderly persons. Today, the average age is

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above 40 years in certain European countries, Canada, and Japan. In Monaco, average age exceeds 50 years, the highest in the world. Today, the average age around the world is 29.4 years, and 30.7 years in Turkey (TurkStat, 2014; WHO, 2015).

In addition, life expectancy at birth is increasing by the day. This, in turn, contributes to the global growth rate of the elderly population. Life expectancy at birth for women is the longest in Japan. Average life expectancy at birth for Japanese women is 86 years. Life expectancy at birth in Turkey is an average of 78 years. This span is 75.3 years for men and 80.7 years for women (TurkStat, 2015). Rapid aging is associated with dramatic changes in family structure, employment patterns, and migration movements. On the other hand, increase in the elderly population is generally considered to be associated with an increase in healthcare expenditures as well. In 2050, healthcare expenditures as a share of GDP will be doubled due to the increase in the elderly population. Health expenditures in Turkey were 6.1% of GDP in the previous years (2008), yet this percentage increased to an annual rate of 7.1% between 2000 and 2010 (OECD, 2015).

Increase in life expectancy around the world and in Turkey has also increased the need for meeting the social, cultural and economic needs of the elderly population as well as the reorganization of health and care services. Active and healthy aging practices have been initiated at the sectorial level in many countries around world. Endeavors such as the reorganization and standardization of services, mutual workforce exchanges among countries, and benchmarking systems have been accelerated within the scope of this process, which consider long life to be a risk. In order for a given country to improve its fight against aging, it is imperative that the same country review the applications in other countries with experience and techniques in place and develop a model compatible with its own economic and social conditions. As of 2100, life expectancy at birth will be 100 years throughout the world. In addition to the growth of the elderly population, the empowerment of women, the fight against poverty and protecting the planet from factors such as global warming are also conversations that are coming to the fore. Both individuals and governments will have to deal with the reorganization of the healthcare delivery system and social security expenditures. Therefore, there will be a need for balance between the resources allocated by the public and private sectors. The gap between the actual life course and life expectancy will require developmental tasks to be redefined in social terms. As for healthcare, there is a growing need for increasing the number of healthy years in a lifespan and revising the organization healthcare services (Lis, Reichert, Cosack, Billings and Brown, 2008; WHO, 2015). Herein, we are faced with the concepts of healthy and active aging as part of a comprehensive universal approach. This study aims to draw attention to the importance of the concept of healthy aging as elderly populations are growing around the world and in Turkey and to explain the execution of health services geared toward the elderly, healthcare satisfaction and commonly faced problems.

BACKGROUND

There is a direct correlation between the development levels of countries and health. In developed countries, society's health status is considered to be a natural consequence of socio-economic development. Development in the field of health is the most significant indicator of investment in human capital. The 21 targets listed in the World Health Organization's declaration titled "Health for All by the year 2000" for a level of health that would permit all individuals in society to lead a socially and economically pro-

Box 1.

Target: Healthy Aging.
By the year 2020, people over 65 should be able to enjoy their full health potential and play an active social role.
• There should be an increase of at least 20% in life expectancy and in disability-free life expectancy at age 65 years.
• There should be an increase of at least 50% in the proportion of people 80 years of age who live in a home environment, are able to meet their own needs, and maintain self-esteem and a place in society.

ductive life have been important determiners for health policies in Europe since the 1980s. One of these targets was set to focus on healthy and active aging and is explained as such (WHO, 2011):

The aim of healthcare services is to keep individuals alive while maximizing their physical, mental, and psycho-social capacity, making them feel happier by protecting them against potential health problems, and thereby improving their life quality. Healthcare services rank as a high priority in the national social policies of many countries with an aim of emphasizing the importance of human health in order to raise healthy societies. For this purpose, improving health and life quality, and eliminating inequality in the healthcare system have been set as objectives. The objective of ensuring easy access to healthcare services and improving life quality, especially for elderly persons, in a multidimensional fashion has become a major topic of discussion (WHO, 1999).

Aging is not a new notion in the globalized world. However, each day this concept is further complicated by new problems, and there is a need for new service models. All countries have had to face the issue of growing economic and social demands that occur during the aging process. Due to the world's changing conditions, the developing healthcare system, and cultural and social changes, aging and related issues have come to dominate the agenda of services (European Union, 2014). On the other hand, in consequence of the development of technology and healthcare services, the average life expectancy has increased. Old age is often unmanageable for elderly persons due to the change in needs and consumption habits, difficulties in meeting economic and social needs, and the prevalence of medical conditions such as dementia and Alzheimer's disease (Kinsella and He, 2009).

Achieving the goal of health for all means "increasing the number of healthy individuals in society, an increase in healthy individuals' capacity to absorb information, and development in their cognitive and physical skills". Preparing for old age, effectively benefiting from healthcare services starting from infancy and continuing through every stage of life, and adopting a healthy lifestyle are the most important criteria for being a healthy elderly person. The increase in elderly populations and rapid demographic change both around the world and in Turkey is increasing the need for active and healthy aging with each new day (Lis, Reichert, Cosack, Billings and Brown, 2008).

As recommended by the World Health Organization based on the objectives listed above, the concept of "active aging" means "the process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age." "Health" is the key concept in this definition. Active aging allows people to realize "their potential for physical, social, and mental wellbeing throughout the life course" and ensures their participation in society in accordance with their needs, requests, and capacities/skills, "while providing them with adequate protection, security and care when they need." (Paul, Ribeiro and Teixeira, 2012). The World Report on Ageing and Health published in 2015 by the World Health Organization defines the concept of healthy aging as the process of maintaining and optimizing functional abilities (capacity) that ensure wellbeing in old age (WHO, 2015). Healthy aging is a matter that must be examined with a holistic approach based on lifespan and functional status.

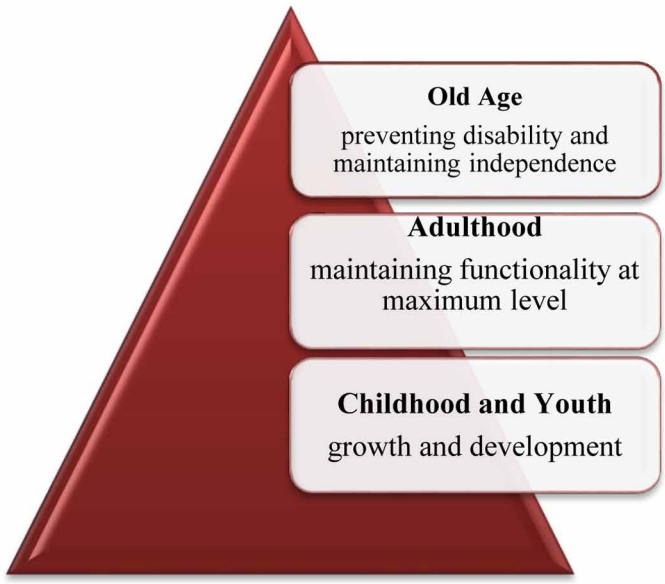
In addition, the key aspects of the active aging model, which includes healthy aging, can be listed as follows:

1. That the individual be in control of their daily life based on their own preferences and rules, that they be able to make their own decisions, and that they have the autonomy to be able to handle this process.
2. Independence is the capacity to be functional in daily life, and to live independently in society without requiring help from others or with a little help from others.
3. Quality of life is the status of life perceived by the individual in the place they live, in the value system, and in the cultural structure in connection to individual expectations, goals and standards. Quality of life, which is a comprehensive concept, includes aspects such as the individual's physical health, psychological state, level of independence, social relationships and beliefs.
4. Life expectancy is the years during which the individual can live in a healthy manner without disabilities or diseases (Paul, Ribeiro ve Teixeira, 2012; WHO 2015).

Thus, it is understood that active aging includes both objective and subjective conditions from the individual's life, does not simply focus on old age, and is described with various indicators based on different stages of life (Figure 1).

Active aging includes the concept of healthy aging and may also be commonly used to have a similar meaning to successful aging. Successful aging is a more comprehensive approach that includes the concepts of active aging and healthy aging. Successful aging implies a lack of disease, maintaining functional capacity and active participation in life. Individuals who show no loss or barely any loss of function compared to their own age group, and who don't lose their connection to life are defined as "successful" elderly individuals. Individual factors such as sports or exercising, adequate and balanced

Figure 1. Active aging and life cycle approach



nutrition, maintaining successful social relationships, traveling and active living are important in realizing successful aging. On the other hand, improving health services, quick and easy access to these services by the elderly, affirmative action toward older persons in providing health services, determining the problems faced in accessing health services and reorganization of the services comprise the environmental factors at the macro level for active and healthy aging. Successful aging has certain standards. These standards include:

1. Having no diseases and having no addictions associated with a disease.
2. Being able to use cognitive and physical functions.
3. Actively participating in life (Rowe and Kahn, 1998).

Elderly people have become and will continue to be the focus of health policies and social policies in every country due to the growing elderly population. An essential issue that concerns every individual in society is the opportunity to access reliable and quality health services. Today, countries that have adopted the social welfare approach are considered to be liable for provision of active, efficient, and adequate healthcare services as a basic human right to the entire society or for taking the necessary measures (National Institute on Aging, 2011). Services aiming to preserve and improve health, prevent pathogenesis, diagnose and treat patients as early as possible, prevent disabilities, provide disabled persons with medically and socially therapeutic services, and ensure people to live a quality, happy, and long life are collectively considered healthcare services. Healthcare services can also be defined as the total efforts of various types of healthcare professionals for the diagnosis and treatment of diseases and preserving people's current health status within a range of health institutions and organizations. The main goal of healthcare services is to provide society with said services at the required level of quality, timing, and lowest possible cost (UNFPA, 2012).

In many countries, the healthcare delivery model in practice today has not kept pace with the changing epidemiology and health needs of the population. The focus often remains on building new hospitals, buying expensive new equipment and upgrading acute service delivery structures. The management of care processes remains, to a large extent, focused around episodic care needs. However, population aging requires a different approach, involving a shift from acute, episodic and hospital centric care to the management of chronic conditions, building age-friendly hospitals, the delivery of continuity of care across different care settings and providers, and a strong role for primary care professionals such as general practitioners (Colombo, 2015).

In conjunction with the growing elderly population, the need for health and care services increases due to the high prevalence of diseases occurring during old age. Nevertheless, the scope of the services to be planned for old age should be revised in line with the characteristics of old age. Important steps that can be taken to achieve that end include providing the elderly, which as a group has been considered the most disadvantaged group in terms of health, with facilitated access to healthcare services and equal opportunities, generalizing practices focused around wellbeing, ensuring that hospitals maintain accessible physical conditions, accompanying elderly individuals inside the hospital, providing care after being discharged from the hospital, and planning home care.

The quality of healthcare services within the larger system, the problems experienced by the elderly in accessing the services, and their satisfaction with the services along with social, emotional, and environmental factors contribute to the level of life quality experienced during the aging period. In the healthcare delivery system, a main challenge will be the management of complex combinations of chronic

conditions. In many OECD countries, more than half of individuals aged over 65 years have more than one chronic condition, and many individuals aged 75 and older have three or more. Health and social care systems are still grappling with how to manage the diversity and uniqueness of this complex combination of diseases and care needs in an effective way, in relation to how to organize care teams, how to identify the right metrics for measurement, or how to equip health professionals with the skills they need to address changing population structures and epidemiological profiles (OECD, 2015; Colombo, 2015).

The anticipated requests posed by the elderly population regarding healthcare services will increase unless the prevalence of chronic diseases in elderly persons is decreased by strategies that promote and improve health. It is evident that the requirement for the workforce to provide the elderly with services will be on the rise as the healthcare demands of older people increase. Today, as with many other countries, there are only a limited number of healthcare professionals in Turkey with specialization to serve the elderly. It is important to employ healthcare professionals and support personnel with the knowledge and skills required to meet the demand for healthy aging. On the other hand, age-friendly hospital studies have just started. This study has been conducted to understand the implications of this situation for the elderly in the healthcare delivery system, to prove the difficulties experienced by elderly persons in accessing healthcare services and their satisfaction with issues as regards the healthcare delivery system.

MAIN FOCUS OF THE CHAPTER

The decline of health in old age is usually the result of chronic diseases. Most of these are diseases that are preventable or deferrable by adopting healthy habits. For this reason, physical activity and good nutrition become more important for health and wellness in later years. Other health problems can be effectively managed especially if diagnosed early. As individuals age, even if their capacity declines, with a supportive environment, they can go where they need to go when needed and do what they want to do. Countries have certain areas to work on to achieve active and healthy aging and improve health policies. The first of these is the increase in the elderly population and the diversity of health services required during old age by younger elderly persons and older elderly persons. For this reason, with the functional status of older individuals in mind, the areas that the policies should primarily be focusing on include elderly care, meeting the increasing demands regarding health services, the retirement system and social services (WHO, 2015).

Both the World Health Organization and the United Nations define the chronic diseases increasing in parallel with the aging of the world's population as the 21st century's most important health issue. 40% of the European population older than 15 years suffers from a chronic disease. This percentage increases with the age categories and Europeans who reach the age of retirement are at high risk for developing at least one chronic disease. According to the World Health Organization, one out of three Europeans who have reached the age of retirement suffers from at least two chronic diseases. The distribution of diseases has undergone changes due to the increasing level of development and expected lifespan in Turkey, in parallel with the world. When the distribution of death causes according to disease groups at the national level in Turkey are compared to those in developed and developing countries, it is observed that non-communicable chronic diseases comprise 78.7% of all deaths. This rate increases up to 86% in the European Union and developed countries. In Turkey, ischemic heart disease (21.7%) and cerebrovascular diseases (15.0%) are the leading diseases that lead to death (Healthy Aging and Chronic Disease Report, 2012).

According the active ageing index in practice in European Union countries, the average active ageing index score obtained from 28 European Union countries was 33.9. Among the European Union countries, the country with the highest active ageing index score was Sweden (44.9) followed by Denmark (40.3) and the Netherlands (40.0). The countries with the lowest active ageing index scores were Greece (27.6), Poland (28.1) and Hungary (28.3). While Denmark and Finland share the lead for independent living, one of the domains of the active ageing index, Sweden was the leader in the capacity for active ageing and employment domains, and Ireland was first in terms of participation in society. On the other hand, Slovenia, Poland, Latvia and Romania were last in terms of employment, participation in society, independent living and capacity for active ageing, respectively.

When the difference in men and women is European Union countries is considered in terms of the active ageing index, it is observed that while the active aging index score is higher in men in most countries, the active ageing index score in Finland, Estonia and Latvia is higher in women than in men. When the active ageing index data from 2010 and the data from 2014 were compared in terms of the domains of employment, participation in society, independent living and capacity for active ageing, it was determined that there was general improvement in active aging in European Union countries, and that the scores obtained in 2014 increased in all domains (EU, 2015).

According to the 2015 report of the global aging index, in which the general living conditions and levels of wellbeing are evaluated, Turkey placed 75th among 96 countries. Switzerland, Norway and Sweden were the top three countries. The USA placed 9th in the index in terms of the wellbeing of the elderly, while Afghanistan placed last. When the subcategories of elderly wellbeing are considered, Turkey ranked 35th in terms of matters related to income security such as retirement income and per capita income, 40th in terms of matters related to having an active environment such as social ties, physical safety and citizenship, and 52nd in terms of health status explained with variables such as life expectancy, health and psychological wellbeing at age 60. According to the global aging index, elderly persons in Turkey are most behind in the domain of capacity level, explained by employment status, having a profession and level of education. Turkey ranks 93rd in this category. This is why it is important to offer individuals the opportunities and technologies for lifelong learning and support individual productivity (Scobie et al., 2015).

The "Profile of Retired Persons in Turkey" (2012) conducted with 3400 retirees by the Turkish Association of Retired Persons investigated individuals' competence of independent living, physical and psychological health status, and whether or not they were benefiting from healthcare. The mean age of the participants was 60.8 years. In the study, while 59.2% of the retired individuals reported their physical activity as good or at a normal level for a retired person, close to a quarter (24.3%) of the retired individuals reported their physical activity as poor, and 7.4% reported their physical activity as very poor. Retired individuals reported that they do not struggle with hair care (77.5%), bathing (72.1%), and going to or getting out of bed (71.5%), but mostly struggle and receive help with climbing stairs (23.1%) and going to the doctor (15.4%). Retired individuals reported that they do not struggle with preparing meals (65.0%) or washing dishes (66.7%), but mostly receive help with home care and cleaning (10.2%) and small repairs around the house (10.8%). While nearly half of the retired individuals (48.6%) reported their physical health as good, 42.1% reported their physical health as poor. The most commonly occurring diseases included rheumatic diseases (56.8%), cardiovascular diseases (45.0%), visual disorders (35.5%), bone-related diseases (30.0%), nervous system disorders (23.4%) and digestive system diseases (21.8%). The majority of retired individuals included in the study (90.6%) were using walking aids. 87.4% were

using hearing aids. Considering the fact that participant mean age was 60.8 years, these rates could be regarded as negative in terms of healthy aging.

The Life Satisfaction Survey is conducted by the Turkish Statistical Institute (TurkStat) each year in every province of Turkey, and a significant part of this survey is the section covering satisfaction with the healthcare and social security services. For the purposes of the present study, the satisfaction with healthcare and social security services was assessed by the author as based on the data collected with the Life Satisfaction Surveys conducted in 2012, 2013, and 2014. The level of satisfaction felt by individuals 65 years of age and above regarding healthcare services has been explained within the context of a range of topics.

First, the general satisfaction with healthcare services has been explained according to the age groups, using the data collected in the years 2012, 2013, and 2014:

The percentage of individuals aged 65 years and older who were "very satisfied" and "satisfied" with healthcare services, was 86.76% for the year 2012. The percentage of those "not satisfied" and "not satisfied at all" was very low (4.48%). In 2013, the percentage of individuals aged 65 years and older who were "very satisfied" and "satisfied" with the healthcare services was 84.94% for the year 2013 and 84.72% for the year 2014.

Regarding the satisfaction with the physical examinations at healthcare institutions by the year; it was observed that 77.63% of individuals aged 65 years and older were satisfied with said service in 2012. The percentage increased to 78.39% in 2013 and decreased to 71.04% in 2014. The percentage of individuals aged 65 years and older who were not satisfied with the physical examinations at healthcare institutions was 20.06% in 2012, 20.08% in 2013, and 27.21% in 2014.

The satisfaction felt by aging individuals regarding the behavior of physicians toward patients was investigated based on the data collected with the Turkey Life Satisfaction Survey carried out by TurkStat. To determine the level of satisfaction, the answers given to the question "Is there a problem with the behavior of physicians toward patients?" were assessed. The percentage of individuals aged 65 years and older who stated that there was a problem with the behavior of physicians toward patients was 17.08% in 2012, 9.77% in 2013, and 10.61% in 2014. The percentage of individuals aged 65 years and older who stated that there was no problem with the behavior of physicians toward patients and that they were satisfied with the behavior of physicians was 80.71% in 2012 and increased to 88.69% in 2013 and 87.27% in 2014.

Satisfaction regarding the behavior of nurses/caregivers toward patients was assessed with the following question: "Is there a problem with the behavior of nurses/caregivers toward patients?" 14.42% of individuals aged 65 years and older said there was a problem with the behavior of nurses/caregivers toward patients in 2012. The percentage decreased to 7.96% in 2013 and increased to 10.82% in 2014. In other words, the satisfaction felt by individuals aged 65 years and older regarding the behavior of nurses/caregivers toward patients was 82.61% in 2012, 89.55% in 2013 and 86.76% in 2014. It was observed that satisfaction with the behavior of both the physicians and the nurses/caregivers slightly decreased in 2014.

Satisfaction regarding the number of physicians and healthcare professionals was assessed with the following question: "Do you think that the number of physicians and healthcare professionals is sufficient?" More than half (53.55%) of the individuals aged 65 years and older thought that the number of physicians and healthcare professionals was sufficient in 2012. This percentage decreased to 45.38% in 2013 and 42.1% in 2014.

In order to assess satisfaction regarding physical examination and analysis prices at healthcare institutions, the TurkStat Life Satisfaction Survey asked participants the following question: "Is there a problem with physical examination and analysis prices at healthcare institutions?" The ratio of individuals aged 65 years and older who suggested that there was a problem with physical examination and analysis prices at healthcare institutions was 31.0% in 2012. This percentage of dissatisfaction increased to 36.44% in 2013 and 37.3% in 2014. Thus, as with the other age groups, an annual decrease was observed in the level of satisfaction felt by those aged 65 years and older regarding physical examination and analysis prices at healthcare institutions (satisfaction rates: 54.88% in 2012, 44.85% in 2013, 45.66% in 2014).

The treatment and drug expenses of individuals aged 65 years and older have mostly been reimbursed by the Social Security Institution (84.77% in 2012, 81.82% in 2013 and 84.19% in 2014).

The TurkStat Life Satisfaction Survey assessed the level of satisfaction regarding the quality of healthcare services with the following question: "Is there a problem with the quality of healthcare services?" According to the 2012 data, 81.03% of individuals aged 65 years and older thought there was no problem with the quality of healthcare services.

Furthermore, it was observed that elderly individuals were satisfied with making appointments for physical examinations and analyses and did not think there were any problems regarding this matter. The percentage of those who were satisfied increased with each year, starting from 82.61% in 2012 to 84.59% in 2013 and 84.06% in 2014.

The ratio of elderly individuals who suggested that there was a problem with drug prices was 31.99% in 2012, 33.66% in 2013, and 40.85% in 2014.

The TurkStat Life Satisfaction Survey investigated the level of satisfaction with the cleanliness of healthcare institutions by asking, "Is there a problem with the cleanliness of the healthcare institutions?" It was observed that the opinions of individuals aged 65 years and older regarding the cleanliness of healthcare institutions gradually grew more positive. While 10.76% of the elderly individuals thought there was a problem with the cleanliness of healthcare institutions in 2012, the percentage decreased to 8.4% in 2013 and increased to 8.91% in 2014. In other words, while the percentage of those who did not think there was a problem with the cleanliness of healthcare institutions was 85.96% in 2012, 88.96% in 2013, and 88.21% in 2014.

According to the results of the TurkStat Life Satisfaction Survey in 2013, the percentage of satisfaction felt by all age groups regarding healthcare services in Turkey was 74.7%. The percentage of those who thought services were moderately satisfactory was 10.6%, and 14.7% were not satisfied with healthcare services (these results were calculated by the author using data from the TurkStat Life Satisfaction Survey, 2012; 2013; 2014).

Though studies that aim to determine the health conditions of the elderly in Turkey are common, there are very few studies aiming to determine the challenges faced by the elderly in accessing health services. The Life Satisfaction Survey, the results of which were mentioned above, aims to measure the general life satisfaction of all age groups. The survey also aims to present satisfaction or dissatisfaction with health services through the quantitative research method. These results and quantitative data do not fully explain the challenges experienced by elderly patients receiving healthcare. For this reason, this study aims to determine the challenges older persons face and the matters with which they are satisfied using the qualitative research method.

METHOD

The qualitative research method was employed for this study, which aims to investigate the difficulties experienced by elderly people in accessing healthcare services and their satisfaction with the healthcare delivery system.

Qualitative research separates social reality from physical reality. It has been suggested that physical reality is independent from personal interpretations, yet the social reality is formed by personal interpretations. Therefore, it is generally accepted that social reality is involved with both objectivity and subjectivity, that it differs depending on each individual's mode of perception, and that the data only becomes meaningful once interpreted. An observation/interview is required to investigate satisfaction as a reflection of the interaction between the individual and their environment or to investigate how problems occur, and said observation/interview can only be interpreted using the qualitative method (Balnaves and Caputi, 2001). This study has used the qualitative research method to determine the challenges the elderly face as a disadvantaged and vulnerable group in society and in accessing services and the matters with which they are satisfied. In this way, considering the challenge in determining topics specific to older persons and the scarcity of studies on satisfaction/dissatisfaction with health services which include all age groups, this study has attempted to determine challenges or matters of satisfaction specific to the elderly using the qualitative research method.

This study on healthy aging examines how elderly individuals view healthcare services. For this purpose, the study focuses on two basic questions:

1. Are elderly individuals satisfied with healthcare services? If so, what specifically are they satisfied with?
2. What difficulties do elderly individuals experience in accessing healthcare services?

In addition to these two basic questions, two other questions were included, one regarding individual health status and another regarding personal habits, in order to understand the process of healthy aging:

3. Do you have any chronic diseases that require you to take regular medication?
4. How do you spend the day? Do you play sports or exercise?

The interview technique was utilized in the qualitative research process. Interviewing is the most frequently used method in qualitative research and can be defined as a social interaction, which includes asking the participant previously prepared questions and systematically recording the answers. Semi-structured interview forms were used for this study. The semi-structured interview form was composed of open-ended questions and the questions were listed in accordance with the interview guide (Martin and Bridgmon, 2012).

The deep interview technique was used as the method of qualitative data collection. A total of 10 elderly individuals (6 men, 4 women) aged 65 years and older were interviewed in order to collect information. The interviews were realized in a time period of 40 to 50 minutes.

The interviews conducted with the semi-structured interview forms including the aforementioned open-ended questions aimed to collect information that could be used to interpret issues such as health problems, exercise and activity levels, thoughts on their lives and healthy aging, satisfaction/dissatisfaction with healthcare services, and difficulties in accessing healthcare services.

The intended population of the study was women and men aged 65 years and older residing in the city of Ankara (capital city of Turkey). Participants were recruited to the study on a volunteer basis. The elderly individuals were interviewed at the institutions where they were receiving healthcare services, or at their homes. In accordance with the purpose of the study, in order for objective assessments to be made regarding health services, the older persons who participated in the study were selected from a pool of elderly patients who routinely benefited from health services and who were periodically admitted to the hospital for check-ups. The elderly individuals were briefed on the research before the interview; their consents were obtained, and they were ensured that they would be able quit the interview anytime they wanted to and that the information they might provide during the interview would be used solely for research purposes based on principles of confidentiality. The information collected through the interviews has been disclosed in accordance with the purpose of the study.

Participants

Due to ethical considerations, code names were used instead of the true names of the participants. General information regarding the participants is provided in Table 1. In this study, 6 men and 4 women aged 65 years and older were interviewed. The participants were aged 66-84 years. While all the men were at least primary school graduates, 2 women were literate and 2 women were illiterate. The men were predominantly retired workers or civil servants. The women were housewives. Only one individual worked as a tradesman. All the participants had social security. The women were not employed, thus they benefited from their spouse's social security packages (Table 1).

It was observed that not having the opportunity to attend school, especially as a woman, leads to challenges in old age as with all stages of life:

I grew up in a village. I could not attend school because I had to work in the fields. That is how it was back then. I am not literate. I have difficulty going places. I even have a hard time signing my name. (Z.G., 80, female)

Table 1. General information regarding the participants

Participants	Gender	Age	Education	Occupation
M.M.	Men	75	Secondary school	Retired white collar
C.G.	Men	84	Primary school	Retired blue collar
M.A.	Men	75	Secondary school	Retired white collar
Ş.Ş.	Men	70	Secondary school	Retired white collar
M.A1.	Men	73	University	Retired teacher
C.Ş.	Men	70	Primary school	Tradesman
Z.G.	Women	80	Illiterate	Housewife
Y.H.	Women	70	Literate	Housewife
F.Ş.	Women	72	Illiterate	Housewife
N.G.	Women	66	Literate	Housewife

23.9% of the elderly population in Turkey (2013) is illiterate, while 41.2% are primary school graduates, and 4.7% are college or university graduates. The education status of the elderly population varies significantly by sex (TurkStat, 2014a). The education status of the elderly individuals interviewed within the scope of this study is similar to that of the elderly population in Turkey.

Healthy Aging: Satisfaction vs. Difficulties Regarding Access to Healthcare Services

This section covers whether or not the elderly individuals have chronic diseases that require taking regular medication, how healthy they feel, how they spend the day, whether or not they play sports or exercise, their satisfaction/dissatisfaction with healthcare services, and the difficulties they experience.

Chronic Diseases

Conditions such as cognitive impairment, immobility, instability, urinary/fecal incontinence, and insomnia as well as cardiovascular diseases, respiratory problems, pressure sores, genitourinary conditions, diabetes mellitus, thyroid, delirium, dizziness, and stroke, the diagnoses and treatments of which have gained importance, are prevalent in old age. Therefore, old age is a period marked with an increase in the prevalence of chronic diseases and dependence, that has particular healthcare requirements, that necessitates the planning of long-term post-treatment care. In old age, due to worsened health conditions, functional abilities are limited and dependence on others in engaging with daily life activities is increased. In this study, all the enrolled elderly individuals suffered from the aforementioned chronic diseases:

I was born in 1940. I suffer from cardiac insufficiency. I need to take frequent rests due to my condition. I need to take my medication regularly, and sometimes I forget to take them on time. (M.M., male)

I suffer from cardiac insufficiency. I can no longer go out by myself. I have trouble walking. I am unable keep up with medication or doctor-related errands. My children take care of them. They replace my medication when I run out. It is better if someone reminds me to take my medication or gives them to me. (C.G., 84, male)

I am 75 years old now. I have kidney failure. I have to go to the hospital frequently. (M.A., male)

I suffer from cardiac insufficiency. I feel I don't have enough strength to do anything. It is very hard to be old. (Ş.Ş., 70, male)

I have heart disease and diabetes. My son and daughter-in-law have taken care of me since my spouse's death. I actually have three kids. I regularly use insulin injections and cardiac drugs. I wish my wife was still alive. I forget about my diseases when I spend time with my grandchildren. It makes me happy. I feel healthy. (M.A1., 73, male).

I have a slipped disc and diabetes. I haven't been able to move much in the last week since my herniated disc worsened. I avoid going to the doctor alone. Because I have had difficulty walking, I go to the

hospital more often nowadays. I am looking for a hospital that can treat both my herniated disc and diabetes. I want to be better, and I try to take my drugs regularly. (N.G., 66, female)

I have hypertension. I have too much blood. My blood values are high. I also have a coagulation disorder and osteoporosis. I take care of things myself. I feel strong enough to. I am not dependent on others. I am going through a good time of life. I feel healthy for now. Even if I do not always do a good job, I always take care of things myself. (Z.G., 80, female)

I don't feel healthy at all. I have been smoking since I was a kid. I have many conditions induced by smoking. I need to see a doctor at least once a month. I experience shortness of breath. I have cardiovascular occlusion and diabetes. (C.Ş., 70, male)

I feel exhausted, and I cannot see. I can't say I'm that healthy. One of my eyes doesn't see, and I have hearing problems. I also have hypertension. I have to take my medication regularly. My children buy my drugs. I have five children. Every month I stay with a different child. I pay a monthly fee to whoever is hosting me that month. They provide for my hospital and drug expenses. They take me to the doctor. (F.Ş., 72, female)

I have osteoporosis. I suffer from gastrointestinal problems. I have no other diseases, no hypertension and no diabetes. I don't take my osteoporosis medication. I drink a lot of milk and eat a lot of yogurt. I don't go to the doctor for myself. I am taking care of my 85-year-old spouse. He has Alzheimer's and frequently falls. I give him his drugs regularly and on time. I give him fruits and vegetables. I get his drugs from the family doctor. I cannot leave him home alone. I cannot take him to the doctor alone. My children are far away. (Y.H., 70, female)

As is seen, the majority of the participants had cardiovascular diseases along with renal failure and gastrointestinal conditions. The individuals aged 66-84 years reported at least one health condition that required regular drug use. It is understood that they generally needed care and expected support from others for the regular intake of their drugs and going to a doctor. Especially as age increases, women and those who are older require more attention. Secondary aging effects such as smoking were also evident. It is striking that the 70-year-old woman participant took care of her 85-year-old spouse, without taking care of herself or going to the doctor

In the context of aging and gender, women assume approximately 70% of tasks related to caring for elderly individuals around the world. Among elderly couples, women usually take care of their spouses since women usually live longer and are younger than their spouses. Caring for the elderly is generally the responsibility of the elder daughter in the event that there is no spouse or if the man cannot take care of his spouse. It has been observed that in families that have both adult daughters and adult sons, the adult daughters assume two times the responsibility that the adult sons assume in caring for elderly parents (Özmete, 2015).

How They Spend the Day and Whether They Play Sports or Exercise

72-year-old F.Ş. reports that she raised 5 children, was a full-time mother, did not realize how fast the years passed went by because of how busy she was, felt alone after losing her spouse, but finds things to do by herself each day.

I wake up at 11 o'clock. I have my breakfast after I do my prayers. After spending some time for personal care and basic needs, I begin to knit decorative baby shoes (F.Ş. presented a gift of decorative baby shoes to the researcher during the interview as well). I talk with my daughter-in-law and grandchildren a lot. I sing ditties. I don't do sports and I am not accustomed to do so. Now I have diseases. I am at the end of my life. As I await death, I try to live my life to the fullest. I am always moving around in the house, and I would like people around me. I don't like to be alone. Sometimes I am terribly moved by the passing of my spouse. He comes to me in my dreams and tells me it's not time yet, and that I should wait a little longer.

An 80-year-old woman (Z.G.) said that she currently lives alone, but that if she needed care, she would like to live with her children and be cared for by them.

I live alone at home. I live by myself but I don't feel lonely. My children live near me, and I visit them whenever I want. I go out and walk around. I watch TV. I try to help my children with their errands and take care of my grandchildren. I cannot sit around and do nothing since I used to be very busy. I don't do sports, but I have daily occupations.

66-year-old female participant N.G. reported that she got along well with her children, that she had grandchildren who were employed or who were students, that she took care of them, and that she did her best to help them out. She explained how she spends the day as follows:

I wake up to do my prayers in the morning. I prepare breakfast. I have breakfast with my spouse. Then I don't understand how the time goes by. I start preparing lunch. Generally, my children visit since they live so close. Occasionally, I try to walk but I'm unable to do it regularly; old age, you know. I have always wanted to learn how to swim, and if I knew how to, I would swim more frequently. I also always wanted a house with a garden. I wish I had a garden to occupy myself with and get my hands dirty.

73-year-old male retired teacher M.A1, who stays with his son and daughter-in-law, reported that he would be very happy if his wife was still alive, yet he is happy to live with his son and daughter-in-law. He wants them to always be the ones who take care of him. He asks for help first from his son, and sometimes from his daughter-in-law and grandchild. M.A1. summarized a normal day as follows:

I don't regularly play sports or exercise. When I wake up in the morning, I read the newspaper until my daughter-in-law has prepared breakfast. Then I have breakfast with my daughter-in-law and grandchildren. After breakfast, I take the grandchildren to school. After that I go to the park, where my friends are. We chat together. At noon, when the call to prayer goes off, we go to the mosque all together. After that I go back home. I watch TV with my daughter-in-law. In the evening, I go to the school to pick up

my grandchildren. By the time we get back home, my son is usually already back. We have dinner. After watching TV and chatting with my son a little, I go to sleep.

Reporting that in the last three years since he lost his spouse, he has felt like he doesn't belong to this world, that he doesn't quite enjoy anything, and that he has had many diseases due to smoking, 70-year-old male participant C.Ş. summarized his routine day as follows:

I wake up early in the morning; I don't sleep after the morning prayers. I read the Quran. After breakfast, I go to my market. I own a small market. I spend most of my day at the mosque and the market. Occasionally I go out for visits. Sometimes I meet up my friends. I like to spend time with my grandchildren and children.

70-year-old Y.H., who takes care of her 85-year-old spouse with Alzheimer's reported that she was responsible for all the work at home, that she could not hire a caregiver, and that it is hard to find a reliable person and caregivers are economically costly.

I spend the entire day caring for my spouse. I wake up early in the morning. We have breakfast at the same time every day. I give him his medication, clean the house, cook, and wash the clothes and dishes. My neighbors visit me. I chat with them. I go out to buy bread and do some shopping, and quickly return back. The day is over before I know it, and I usually feel tired.

It was observed that the individuals in this study with reported medical conditions such as cardiac insufficiency and renal failure did not play sports or exercise due to their health problems, and they did not have such habits in the past either.

The interviewed individuals did not have habits of regularly playing sports or exercising. It is understood that they did not have such habits in the past either. The statements of the participants once again underscore the importance of adopting sports and exercise habits and raising awareness regarding the importance of adopting these habits at an early age. It is understood that doing one's prayers is a part of daily life for elderly individuals. Especially for the men, going to the mosque is a common practice for mobility, seeing friends, and praying. Furthermore, the men get out more frequently for the purposes of seeing friends, going to the mosque, going to the park, or walking the grandchildren to school. The women spend more time at home. In fact, women spend most of their time at home or in the neighborhood their entire lives, and this is not associated with aging. Therefore, it is understood that women are more akin to accept and adapt to an inactive life. For men, the loss of the role as a worker accelerates the acceptance of the phrase "I am old now!"

Satisfaction with Healthcare Services and Difficulties Experienced

In this part of the study the participants were asked about their satisfaction with healthcare services and the difficulties they experienced, separately. However, their replies included both the satisfactory components and the difficulties they faced. Therefore, the views that include both aspects are provided below.

70-year-old Y.H., who had osteoporosis and gastrointestinal conditions, and took care of her 85-year-old spouse with Alzheimer's disease, reported her views regarding the healthcare system as follows:

My spouse is a retired worker. We used to only be able to go to the Social Security Institution (SSI) hospitals. If we wanted to go to a state hospital, we had to be referred from a SSI hospital. Now we are able to go to any hospital in any city just by showing our identity cards. We can choose our hospital and doctor. Furthermore, the elderly does not have to wait in lines anymore. We can go directly to see a doctor for physical examination. It is hard to find a specialist doctor with experience in every hospital. You need to see different doctors just to be diagnosed with a single disease. I don't have the strength to do that on my own. I don't know where to go or how to make an appointment. It is very hard to bring my spouse to see a doctor. His movements are slow, he falls down, and I'm unable to walk him around inside the hospital. I need help from others. When he needs to be hospitalized, it is hard to find him a bed. Even if there is a bed, you need to be in communication with the doctors. These are our challenges. I am very happy with our family doctor. I can get our medication quickly, and the pharmacist is also helpful. They guide us in how to treat our diseases.

A 75-year-old retired male civil servant (M.M.) with cardiovascular disease explained:

Doctors are considerate when they have time. They are polite. Sometimes there are many patients. I cannot find a seat when I go to the hospital. I am old. I cannot stand up. I cannot find a wheelchair when I need to go somewhere else in the hospital for an analysis. There is nowhere to hold onto. Fortunately, I have relatives, but who would help me out if I didn't? I ask those working at the hospital. They say they will help but I only end up waiting. They say another patient took the wheelchair, and I will have to wait. Everything ends up taking longer than it should.

84-year-old C.G., who has cardiovascular disease, explained his views regarding the services provided at the healthcare institutions as follows:

My daughter deals with the process of getting me admitted to the hospital. Anyways, I'm unable to come by myself. I have difficulty walking. I cannot stabilize my balance. I use a wheelchair to get everywhere. The stretchers here are so high that I have difficulty climbing onto them. My daughter is unable to help on her own. The personnel are busy. My hands are weak, so I'm unable to much wait on them. I always need someone to accompany me during analyses. Otherwise everything takes longer. I cannot do anything without the help of my daughter.

Required to go to the hospital frequently due to renal failure, 75-year-old M.A. reported his satisfaction with healthcare services and the problems he faces as follows:

I have no complaints about this hospital. The doctors and nurses do their best and show concern. The staff is good. But I went to the polyclinic of another hospital. I could not get a physical examination because I didn't schedule an appointment with the hospital. I am an old person; I don't know where to call. My eyes cannot see the numbers or buttons on a phone. I cannot do it by myself. Sometimes I wait at the polyclinic for hours. It would be helpful to have the assistance of someone accompanying me who could help me with my procedures, tell me what is required. That would help older people like me. I come here alone. Sometimes I confuse the polyclinics. I do not know where to go. I try to find places by asking people as I go.

A 70-year-old retired male civil servant (Ş.Ş.) with cardiovascular disease reported his satisfaction with the healthcare services as follows:

Polyclinics are very crowded. The doctors try to show interest and respect. But they get tired too. Sometimes personnel speak harshly. We are old people. We are their elders. We wouldn't be here if we didn't have a problem. I want them to show respect and understanding. My ears don't hear. Sometimes they provide information regarding my disease, but they talk too fast and I cannot understand them. Sometimes they hardly say anything. They just hand me some papers and give me minimal information. Most personnel are not helpful. They say something like "I don't work in this department," and they go away. Also the toilets are very low here; there is nothing to hold onto. My knees are in pain. I have trouble bending over.

Thanks to the improvements in the healthcare services, individuals are able to go to any hospital in any city, and individuals aged 65 years and older are allowed to receive physical examinations without waiting in lines within the scope of affirmative action. The fact that elderly individuals have limited mobility in hospitals, difficulties regarding physical accessibility, and the need elderly individuals have for a patient consultant or an accompanying person requires the reorganization of healthcare services for elderly persons. As can be understood from the reports provided by the participants, elderly individuals experience problems related to making doctor's appointments, lack of information/inability to find where to go in the hospital, lack of physical strength to go to the relevant units, problems associated with physical accessibility including with toilets, and lack of attention by the support personnel due to patient crowd/intensity.

FUTURE RESEARCH DIRECTIONS

With the increase in the elderly population around the world and in Turkey, determining the social, cultural, economic and healthcare related needs of the elderly population has become important. In addition, easy access to protective and preventive therapeutic health services is important in terms of active and healthy aging. In the studies conducted to this day, generally quantitative research has been performed regarding the satisfaction of all age groups with health services. Whereas, the challenges elderly population faces in accessing health services and the matters with which they are satisfied should be evaluated with the characteristics of this group in mind. This study has used the qualitative research method to determine the challenges the elderly face in accessing health services and the matters with which they are satisfied. Qualitative research is an effective method in presenting social realities specific to this group that cannot be presented with quantitative data. On the other hand, qualitative research reveals data supporting the formation of question structures for future quantitative research plans. In order to determine the challenges older persons face in terms of health services and the matters with which they are satisfied, quantitative research must be conducted on a larger scale, and the subject must be presented with quantitative evidence.

CONCLUSION

The aim of healthcare services is to keep the individual alive while maximizing their physical, mental, and psycho-social capacity, making them feel happier by protecting them against potential health problems, and thereby improving their quality of life. Healthcare services rank as a high priority in the national social policies of many countries with an aim of emphasizing the importance of human health in order to raise healthy societies. For this purpose, improving health and life quality, and eliminating inequality in the healthcare system have been set as objectives. The objective of ensuring easy access to healthcare services and improving life quality, especially for elderly persons, in a multidimensional fashion has become a major topic of discussion.

As recommended by the World Health Organization based on the objectives listed above, the concept of "active aging" means "the process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age." Active aging allows people to realize their potential for physical, social, and mental wellbeing throughout the life course and ensures their participation in society in accordance with their needs, requests, and capacities/skills, while providing them with adequate protection, security and care when they need.

The factors that affect healthy aging include individual determinants such as the individual's educational status, employment status, economic status, genetic factors, attitudes and behaviors regarding healthy aging, and where they live as well as the social environment in which they live, interpersonal relationships, social structure, and the provision of healthcare services.

Today (2014), the percentage of individuals aged 65 years and older in the general population has increased to 8%. There are 9,063,677 citizens aged 60 years and older and 6,192,962 citizens aged 65 years and older. There are 1,315,845 citizens aged 80 years and older, who we call "the older elders." The average life expectancy at birth increased from 66 years in the year 2000 to 75 years in 2014. Pursuant to a study conducted by the World Health Organization as regards the basic health indicators in the European Region, it was predicted that average life expectancy at birth would increase to 77.2 in 2020, with 74.5 years for men and 80.0 for women (WHO, 2014). As can be understood from the above data, Turkey has rapidly entered into a process of becoming an aging society. This underscores the importance of arrangements and interventions with an aim to increase the number of healthy years in a lifespan.

Healthy and active aging is an approach that should be given attention throughout one's life as a whole and at every stage of life. It is harder to become a healthy and active elderly individual and develop individual attitudes and behaviors towards that end once the individual has gotten old. Therefore, from a perspective of lifelong learning, individuals should be encouraged to gain the habit of participating in sports activities and exercising beginning in the childhood period, making it a part of their life, and adopting it as a life style. Societies aim to have a healthy generation that is active and productive, distanced from smoking and other substances, gets adequate and balanced nutrition, participates in society and gets involved in volunteer work with an attitude of social sensitivity and social responsibility.

The needs of the elderly take on increased importance due to the increase in the average life expectancy at birth. Readiness for assuming a productive and valuable role at an advanced age is a phenomenon that should be explained on both the individual and societal levels. The youth should be supported in their preparations for their old age period. Preparation for a socially productive and healthy old age requires taking steps lifelong learning and providing equal opportunities for the elderly to participate in social and economic activities.

One of the most basic factors to attain healthy and active aging is to raise the level of health literacy in Turkey based on an awareness of healthy and active aging. Health literacy is an individual's capacity to obtain, interpret, and understand basic health information and services so as to protect and improve one's health and find cures for impaired health. 4,924 individuals from 12 regions participated in the Turkish Health Literacy Survey (2014) and it was discovered that 64.6% of the participants had inadequate or problematic health literacy. The general health literacy index of Turkey was determined to be 30.4 (Durusu-Tanriover et al., 2014). Considering that the mean age of the participants of the survey was 41.4 years, it is evident that in 20 years there will be an elderly population with inadequate capacity to obtain, interpret, and understand basic health information and services so as to protect and improve their health, and find cures for their impaired health. Therefore, education and awareness activities should be urgently initiated in order to raise society's awareness of healthy and active aging. Data and evidence regarding healthy and active aging should be produced in Turkey similar to the active aging surveys conducted in European countries which reveal changes over the years. Both in order to implement the Turkish Healthy Aging Action Plan and Implementation Program and also in accordance with the present study, it is understood that there is a need to determine the active and healthy aging index in Turkey. The evidence that will be obtained in this way is also important for the revision of the healthcare services to be provided to the elderly.

Along with the individual factors, structural factors such as the service plan and composition of the services are also determinative for healthy and active aging. 6 men and 4 women aging 65 years and above were interviewed within the scope of the present study on healthy aging and the experienced problems. Accordingly:

- The educational levels of the female participants were lower than those of the male participants. The male participants were at least primary school graduates and have been employed. Only two female participants were literate, while two women were illiterate. The female participants were never employed and were included in the social security system via their spouses.
- The elderly individuals had chronic diseases such as cardiovascular diseases, cardiac insufficiency, diabetes, renal failure, respiratory tract diseases, and vision and hearing problems that were prevalent in old age. They needed to see a doctor or be admitted to a health institution frequently (at least once a month).
- They needed someone's assistance in order to get to a doctor or a health institution.
- As age advances, they needed someone's attention and support to be able to take their medication regularly. Delays in replacing the finished drugs and forgetting the time of drug intake prevents regular intake.
- Matters regarding healthcare services considered to be satisfactory:
    - They thought that doctors were attentive and respectful.
    - They thought that access to physical examinations in any city and in any hospital was a significant improvement.
    - They were pleased that those aged 65 years and older had the opportunity to have physical examinations without having to wait in line.
    - They were happy with the family physician program.

- Difficulties experienced regarding healthcare services:
    - The hospitals were crowded, they couldn't find a seat, they couldn't walk, they couldn't find wheelchairs, and support personnel did not provide sufficient assistance.
    - They needed someone to accompany them during analyses and to access the units of the hospital. They were not able to resolve the procedures by themselves.
    - They had difficulty finding specialist doctors with experience, making different appointments with different doctors, and showing up for analyses and appointments with different doctors on different days.
    - They experienced difficulty finding a spare bed in the inpatient units when necessary. They needed to talk to the department heads or clinical chiefs to resolve this, but it was difficult for them.
    - The toilets were not suitable for elderly individuals and the stretchers were too high.
    - Especially the elderly individuals with vision and hearing disabilities complained that the personnel did not act in an understanding manner.

As is seen, the expectations of elderly individuals with regard to the healthcare services underscore the need for units that would take care of elderly individuals using a holistic approach with attention, support, respect, and understanding. Therefore, polyclinics that specialize in the medical branch known as Geriatrics to evaluate the elderly using a holistic approach must be popularized in hospitals. In addition to geriatric specialists, these polyclinics should employ a team of specialists from other branches of medicine, including Ophthalmology, Otorhinolaryngology, Neurology, Psychiatry, Cardiovascular Diseases, Physical Medicine and Rehabilitation, and Infectious Diseases etc. Upon geriatric assessment by the geriatric specialists, the elderly individual should be referred to another specialist, as necessary, in the same polyclinic without the need for being referred to other units. Furthermore, there is a significant need for someone to accompany elderly individuals in the hospital. It is evident that elderly individuals experience difficulty completing admission, appointment, analysis, and physical examination processes. Therefore, hospital attendants should be employed. The challenges faced by elderly individuals most frequently were the insufficient number of healthcare professionals and the prices of drugs etc. due to increased healthcare expenditures during a time of economic loss. The burden of chronic diseases on total healthcare expenditures is gradually increasing as the elderly population grows. Therefore, implementing the "Care Assurance/Insurance System" as used in developed countries, which have already faced the needs of elderly populations, in order to readily finance the healthcare expenditures of elderly individuals, will decrease the burden of future healthcare expenditures for both the individual the state. For example, the compulsory care insurance system (the Social Long-term Care Insurance [LTCI]) was implemented in Germany in 1995 based on the infrastructure prepared by the intergenerational agreement in 1956.

Unless the chronic diseases of the elderly are not mitigated by strategies aimed at improving and developing health, elderly individuals' demands of the healthcare systems will only increase. It is obvious that the need for labor force to serve elderly individuals will increase with the increased demand for medical care by elderly individuals. Today the number of healthcare professionals specialized in old age is limited as with many other countries. It is important to employ healthcare professionals and support personnel equipped with the knowledge and skills necessary to meet elderly individuals' needs for healthy aging. Together with the growing the elderly population, health policies and social policies will focus on elderly individuals in all countries today and in the future.

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KEY TERMS AND DEFINITIONS

Active Aging: The process of maximizing conditions such as participation in society, social integration, safe life environment, and being healthy for individuals starting at an early age.

Aging: Aging occurs as the result of accumulating disorders in the body's structure and functions. Aging is an unpreventable chronological, social and biological process.

Health Literacy: The level of capacity required to understand, obtain and process health information and services in order for individuals to make effective and appropriate decisions regarding health.

Health Policies: Policies that will primarily focus on providing solutions for the changing health problems and needs of vulnerable groups and that will ensure the reorganization of health services accordingly.

Health Services for the Elderly: A type of health service that is considerate of the healthcare needs of the elderly, takes affirmative action, and includes age-friendly hospital practices with the increasing elderly population in mind.

Healthy Aging: Ensuring equal opportunity in access to protective-preventive and therapeutic health services during all life stages so that individuals adopt an active lifestyle and age in a healthy manner.

Societal Aging: An increasing rate of elderly population aged 65 and older in a society.

ENDNOTE

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Chapter 23
Effecting Superior Pain Management Strategies by Combining Technology with Tradition

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ABSTRACT

Today we are witnessing a significant rise in chronic diseases and chronic pain. Modern medicine appears not to be sufficient to relieve symptoms and reduce or eliminate discomfort. The following proffers the need to look at alternate strategies. In particular, it suggests that a solution might lie if we combine modern technology with ancient wisdom and traditional approaches. This chapter serves to highlight strategies for prudent pain management. "Pain is not just from physical disorders but also from combinations of physiological, pathological, emotional, psychological, cognitive, environmental, and social factors. The keys to successful pain control are the mechanisms that initiate and maintain pain." "Now, the public and health professionals expect to control pain by using preventive and active strategies, including drugs and physical and psychosocial interventions." (Holdcroft & Power, 2003).

INTRODUCTION

Pain is a very good servant but a bad master. – Author unknown

Everybody knows what pain is but no one really knows how to switch it off especially when it becomes persistent and annoying.

Pain is not just from physical disorders but also from combinations of physiological, pathological, emotional, psychological, cognitive, environmental, and social factors. The keys to successful pain control are the mechanisms that initiate and maintain pain. Now, the public and health professionals expect to control pain by using preventive and active strategies, including drugs and physical and psychosocial interventions. (Holdcroft & Power, 2003).

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Have we lost sight of the real pathophysiology that underlies the phenomenon of pain? Are we concentrating on the end point rather than the cause of the malady? Drugs and physical therapies don't have all the answers to pain management. Is there another way? Maybe we should take a broader look at why the pain started in the first place and then we can work out the solution to the health challenge!

BACKGROUND

Pain arises when a living tissue is injured and the tissue responds with "inflammation". Inflammation involves a cascade of events involving cells, enzymes, cytokines and chemokines and other substances, which will initiate other secondary responses by other cells and blood vessels. Inflammation is the beginning of the process of repair and healing. Ancient civilisations used different modalities to manage pain. They used physical therapies, medicinal foods and herbs where appropriate.

Over the past century the pain and its management have changed dramatically. In this article I propose to discuss the reasons for the change in pain experience and will explore the practical aspects of pain management using the best from the "East & West". While the scientists are dwelling deeply into the complex issues of pain and inflammation, patients in pain need help and advice now. Drugs alone cannot relieve all the pains and sufferings, surgical and psychological treatment may help some but for most, a holistic approach may help to reduce or relieve the pain and suffering.

The Role of Food for Health and Wellbeing

We Are What We Eat

If we supply our body with inappropriate or inferior quality materials, the tissues and structures so made will be of inferior quality. Deficiency diseases like scurvy and rickets have been known to cause deformed tissues and cause pain with different characters. By correcting the deficiencies these maladies can be cured. In our modern society it seems like more people are experiencing and suffering in pain. Is it because the newer generations are made of 'weaker' materials or is it that the pain threshold is reduced or the background inflammation in the body system has heightened? The fact that we have not been able to quantify and identify the missing ingredients in chronic pain, it should not deter us from searching for an answer by going "back to basics". Our body is created to function efficiently and effectively when it is provided with all the nutrients it needs.

Modern Medical Model of Pain Management

In modern medicine pain is treated with analgesics and non-steroidal anti- inflammatory drugs. If the pain persists, then stronger narcotics and anti-inflammatory corticosteroids are used. Other drugs like anti-depression and anti-epilepsy drugs are often used in pain clinics to help modulate the pain experience. Unfortunately, all these medications have unwanted side effects. There is a growing awareness in the community that drug therapy is not the only way. People are looking for more natural alternatives, less harmful treatment modalities with more self-help involvement. They want to participate actively in the healing process. People are turning more and more to Alternative and Natural Therapies like physical therapies, (which include Physiotherapy, Osteopathy, Chiropractic) with stretching, mobilisation,

manipulations, heat/cold packs and acupuncture/acupuncture related techniques, along with diet and nutritional supplements, to help manage their painful conditions.

Traditional Medical Model of Pain Management

In Traditional Chinese Medicine (TCM), diseases develop when the flow of Qi (Energy, Prana, Life Force) is blocked or interrupted. The basis of TCM treatment is to re-establish the flow of Qi. The TCM Practitioners use needle acupuncture and or herbal remedies to alter or re-establish the flow of Qi to reestablish homeoestasis in the body (Chen, 1981; X. Cheng, 1987).

The Qi or Life Force is also derived from the air we breathe, the water and food we drink and eat. Proper breathing and nutrition form part of the total management in TCM to help bring the body back into balance. It is well known that the food we eat determines how we feel. There are certain foods that will initiate or aggravate the painful situation. Food sensitivities and intolerance can trigger inflammatory response and cause pain (*Author's Clinical Observation & Treatment Protocol (unpublished)*, 2000).

Alternative Therapies

Given the often poor results from modern medicine alone, many patients and their practitioners are now exploring how to combine modern medical approaches, strategies afforded to us today by technology with alternate strategies.

Acupuncture, LLLT, and TENS

Since 1974, acupuncture is an accepted treatment method in pain clinics around the world. There is only one slight draw back with acupuncture. Not many people, given a choice would like to have needles stuck into them. So scientists went into intensive research for a non-invasive acupuncture-point stimulation methods. In the east, traditional health practitioners used manual massage, Shiatsu, AnMo and Tui Na to stimulate the tissues and acupoints. Scientists discovered two modalities that can stimulate acupoints through the skin without inflicting pain by using Low Level LASER Therapy (LLLT) (Baxter & Waylonis, 1995; Noe, 1990; Wong & Fung, 1991) and Transcutaneous Electrical Nerve Stimulation (TENS). Both these techniques are well accepted by the patients, as needles are not used. There is evidence that these methods of acupoint stimulation may give some of the benefits of needle acupuncture treatment. Though TENS was introduced more than 30 years ago as an alternative therapy to pharmacological treatments for chronic pain and in spite of its widespread use, the effectiveness of TENS is still rather controversial. A meta-analysis was carried out by the scientists in 2001 and the results were published in the Cochrane Database Systemic Reviews which showed that there was no evidence to support the use of TENS in the treatment of *chronic low back pain* while the results for *chronic pain* was inconclusive.

Convention TENS stimulation has its limitation because of habituation from repetitive monotonous stimulation over the same points (Godfrey, 1988). However, the Canadian research scientists were able to overcome this habituation by using a novel machine called Codetron ® which uses 6 negative electrodes and one positive electrode. At any one time a pair of electrodes is stimulated. The sequence of stimulation is randomised so that the brain will not filter out the stimulation and will accept each individual stimulation as a novel one. Controlled studies were done comparing Codetron with Sham Codetron

therapy (Fargas-Babjak, Rooney, & Gerecz, 1989) and Codetron with Electroacupuncture (R. Cheng & Pomeranz, 1986). The findings were very favourable towards Codetron Therapy.

Diet, Nutrition, and Pain Management

Over the recent years many reports were published stating that certain types of food would cause or aggravate arthritic or rheumatic pain. Childers et al in their article "An Apparent Relation of Nightshades (Solanaceae) to Arthritis" (Childers & Margoles, 1993) suggested that Solanaceae can cause pain in at least two known ways. Firstly, the alkaloids in these food can act alone or with other *cholinesterase inhibitors* (caffeine or food impurities containing systemic cholinesterase inhibiting pesticides), can cause muscle spasm, aches and pain, tenderness, inflammation and stiffness of body movements. Secondly because Solanaceae can develop the very active metabolite of vitamin D3 (1a25 dihydroxycholecalciferol) which can cause calcinosis of soft tissues, ligaments, and tendons, mineralization in walls of major arteries and veins, and osteopetrosis and related pathology in livestock. Over a period of time these cause progressions to lameness and extended uselessness, with eventual death of livestock (Childers & Margoles, 1993).

It was reported that 28% of arthritis sufferers had a "marked positive response" and another 44% had a "positive response' when they eliminated nightshades from their diet over a period of a few months (Childers & Margoles, 1993). In my clinical practice, a high percentage of rheumatic and arthritic patients improved just by avoiding the nightshade plants in their diet. The response can be as quick as a few weeks (*Author's Clinical Observation & Treatment Protocol (unpublished)*, 2000).

Though rheumatoid arthritis (RA) is listed as an 'auto-immune disease', it may be linked to food allergies and sensitivities (Zeller, 1949). In some RA patients the pain is made worse when they eat foods to which they are allergic or sensitive to, and vice versa when these foods are avoided the patients feel better (Author's Clinical Observation & Treatment Protocol, 2000; Beri, Malaviya, Shandilya, & Singh, 1988; Darlington et al., 1991; Panush, 1988; Taylor, 1983). It is estimated that one-third of people with RA patients can control the disease completely through allergy elimination (Darlington et al., 1991).

Inflammation and Foods

Inflammation, with the accompanying features of redness, swelling, warmth and pain, is the basic way living tissues react to injury, irritation or infection. This is a form of nonspecific immune response.

The foods we eat have a powerful bearing on our health and specifically, inflammation. Some foods we eat are pro-inflammatory while others are anti- inflammatory. With the advent of fast food industries our normal balanced inflammatory index diet has shifted towards 30 times more pro-inflammatory when compared with our forefathers' diet. As a consequence, nowadays it is not surprising to note more people are suffering from different rheumatic type pain. One of the contributing factors could be the type of foods we eat and how we prepare out foods. To win the war against inflammation we have to turn the tide and go back to eating what Mother Nature wants us to eat – Fresh Living Natural Foods!

Fats, Oils, and Anti-Inflammatory Foods

Extremely low-fat diets have been reported to help people with RA (Lucas & Power, 1981) and very low fat, pure vegetarian diets have also proved helpful (Nenonen, Helve, & Hanninen, 1992; Skoldstam, 1986). While polyunsaturated fats like n-3 fatty acids and n-6 fatty acids of Evening Primrose oil are

helpful, oily fatty greasy fried foods are known to be pro-inflammatory and can aggravate inflammation and intensify pain. Vegetable oils heated to high temperature can turn into pro-inflammatory oil. There are many foods that are known to be pro-inflammatory in nature and wherever possible they should be avoided by people who suffer from aches and pains. Some of the common foods are milk products, wheat and wheat products, red meat, eggs, preservatives, additives and colorings, sugars and caffeine drinks (Author's Clinical Observation & Treatment Protocol, 2000; Kjeldsen-Kragh et al., 1991; Warmbrand, 1971).

In a laboratory experiment, Tall & Raja demonstrated that rats fed with soy protein diet had significantly less inflammation in their paws following an injection of Freud's adjuvant as well as having a higher tolerance to heat compare with those rats fed with casein-fed animals (Tall & Raja, 2002).

These results are consistent with previous research showing consumption of a soy-containing diet suppressed the development of pain following nerve injury (Shir, Raja, Weissman, Campbell, & Seltzer, 2001).

Preliminary evidence suggests that consumption of olive oil, rich in oleic acid, may decrease the risk of developing RA (Linos et al., 1999). One trial in which people with RA received either fish oil or olive oil, found those olive oil capsules providing 6.8 g of oleic acid per day for 24 weeks produced modest clinical improvement and beneficial changes in immune function. However, as there was no placebo group in that trial, the possibility of a placebo effect cannot be ruled out (Kremer et al., 1990).

Our forefathers used to eat food containing higher proportion of n-3 fatty acids. It was suggested that the ratio of n-3 fatty acids: n-6 fatty acids, was in the region of 1:1. Nowadays with intensive farming and chemical fertilisation the ratio of n-3 fatty acids: n-6 fatty acids is closer to 1:30. Possibly because of the skewed ratio more people are suffering more aches and pains in our society. To help correct this imbalance, it will be prudent for us to eat more n-3 fatty acids, which are found in deep-sea fish and flaxseed oil.

Omega 3 fatty acid is used by the cells to keep cellular and nuclear membranes soft and pliable for the cells to function properly. Omega 3 fatty acid is also converted into Prostaglandin E(3) (PGE 3) which is a potent anti-inflammatory eicosanoids. Omega-6 fatty acid, which is found in vegetable oil, is converted to either Prostaglandin E (1) (PGE1) or Prostaglandin E (2) (PGE2). PGE1 is a strong anti-inflammatory eicosanoid while PGE (2) is pro-inflammatory eicosanoids. Through proper diet and supplement with flaxseed oil, and fish oil it is possible to improve the n-3:n-6 fatty acids ratio and increase anti-inflammatory eicosanoids in the body (*Author's Clinical Observation & Treatment Protocol (unpublished)*, 2000; James, Gibson, & Cleland, 2000).

When we eat fatty red meat, egg yolks and organ meat we are consuming Arachidonic acids. This particular polyunsaturaed fat may be the most dangerous fat known when consumed in excess and is known as an Omega 6 fat. Arachidonic acid is converted to Prostoglandin E2 by an enzyme Cycloxygenase-2 (COX-2). A safe way to reduce production of Prostoglandin E2 is to follow a low Arachidonic acid diet and to take nutrient supplements like resveratrol, green tea extract, silymarin and quercetin.

Arthritis pain is cause by destruction of the joint cartilage. Leukotriene B4 destroys joint cartilage. The enzyme that converts arachidonic acid to leukotriene B4 in the body is called 5-LOX (5-lipoxygenase) (Martel-Pelletier et al., 2004; Sampson, 2009). Again to inhibit 5-LOX and the production of leukotriene B4 is to follow a low-arachidonic-acid diet and to take supplement with like curcumin, boswellia, fish oil and krill oil (Chambers, 2011).

Krill oil helps to reduce infiltration of inflammatory cells into the joint and joint-lining tissues, which reduces the pain, swelling, and loss of function in arthritis.

Ageing often results in accelerated loss of protective joint cartilage. Nutrients that help rebuild cartilage include glucosamine, chondroitin, and MSM (methylsulfonylmethane). These nutrients are unlikely to achieve complete results if chronic inflammatory factors continue attacking joint cartilage.

Free Radicals and Antioxidants

Many painful conditions like arthritis, fibrositis and fibromyalgia are due oxidative disorder due to free radical attacks. Increased free radical levels may be responsible for the development of many painful inflammatory conditions such as Rheumatoid Arthritis, Fibromyalgia, Osteoarthritis and different rheumatic painful conditions (Bagis et al., 2005; Packer, Hiramatsu, & Yoshikawa, 1999).

There is a wide range of Antioxidants found naturally in the foods we eat and the herbs and spices we use for cooking. The most well-known ones are Vitamin C and Vitamin E Complex. They play a major role in supporting the other antioxidants activity in the body. Free radical attack causes damage to the cell structure through disrupting the stable cellular membranes. Inherently a free radical is an unstable molecule with one or two missing electrons. Free radical will try and snatch an electron from another stable molecule and by so doing it will cause a chain reaction of free radical attacks on the tissues, leading to damage to the tissue structure. The body tissues have an endogenous antioxidant system and will try and repair the free radical tissue damage. When DNA is damaged by the free radicals and it cannot be repaired, the disrupted genetic coding will duplicate without any central control. This is how cancer cells develop and multiple.

Supplements with vitamins, minerals, phytonutrients such as carotenoids, flavonoids and cruciferous which contain potent anti-oxidants have proven to be very effective in quenching the free radical attacks. When we eat a wide variety of fresh colourful fruits and vegetables we are providing our body with a basket of antioxidant that will help neutralise the free radical activities and protect the cells from further damage (Packer et al., 1999).

Over the recent years, scientists have been looking at different phytonutrients in foods and plants that we consume in our diet. One such product is Pygnogenol (Procyanidins and Catechin) extracted from the French Maritime Pine Bark. It is a very potent antioxidant and is also a strong anti-inflammatory agent, which will helps relieve many painful conditions. Anthocyanins, procyanidins and quercetins are also found in the grape skins and grape seeds. Another antioxidant that has proven to have both antioxidant and anti-inflammatory properties has given great relief to people with different pain conditions is Xanthones. Xanthones are flavonoids and are found in some fruits and bark of trees but the highest concentration is found in the pericarb of the Mangosteen fruit. There are 200 known Xanthones and 44 of them are found in the pericarb of the mangosteen fruit.

Through personal communication by Dr. Vaughn T Johnson, DO who told me of his open study on patients who had elevated C-Reactive Protein CRP), an inflammatory marker. After putting them on the whole Mangosteen fruit puree for one month, 29 out of 30 of the patients' CRPs returned to normal. This suggests that the phytonutrients in the Mangosteen fruit puree containing Xanthones have a potent anti-inflammatory property. Many diseases are caused by inflammation and if there are substances in nature that will help reduce inflammation, people should consider taking these food-source phytonutrients to help reduce inflammation in order to prevent the development of medical diseases (Bagis et al., 2005).

Traditional health practitioners also use herbs and spices to treat painful conditions to reduce inflammation. Herbs like bupleurum, ginseng, licorice, ginger, cat's claw, guggul, curcumin, bromelain have potent anti-inflammatory action and hence have helped patients with painful conditions (Benito et al., 1998).

FUTURE RESEARCH DIRECTIONS

It is heartening to note that the patients and health practitioners are looking at alternative ways to help to manage their illnesses including pain. Combining technology and tradition for pain management is moving in the right direction. Present modern treatment methods have leveled off. Using stronger drugs to control pain is not the way to go. Taking a closer look at what is causing the seemingly increased number of people suffering from 'aches and pains' may help us to find a less invasive and maybe more effective solution to the painful problem.

Inflammation holds the key to the painful problem. If we can reduce the background inflammation by changing our lifestyle, our diet and nutrition to a more inflammatory neutral living, pain will be similarly reduced to a soft background tingle! More and more people and growing number of health practitioners are looking at alternative ways to help relieve pain. Using the scientific knowledge and the modern technology and integrate with some 'old fashion' remedies from Mother Nature, will see us winning the war against pain.

It would be most beneficial for future research to focus on how to develop an evidence base of how effective it is in pain management to combine traditional approaches with modern technology.

CONCLUSION

We live in an exciting but challenging time. The evolution of technology is outstripping the slow Darwinian's process of evolution. Things are moving too fast, the background noise is too loud, the light and the colour are too dazzlingly bright. The poor body is trying to cope with the massive changes. The body, so to speak, is not ready for the 21st century!

As a consequence of these massive changes, a new group of medical diseases have evolved. Pain, an unpleasant sensation, has grown 'louder and stronger' in the modern society. People are relying on stronger drugs, more intensive physical therapy and latest technology to combat pain. Technology driven solutions alone are not necessarily the optimal answer but a combination of both old and new from the 'East and West' may affect superior pain management strategies.

Holistic medicine is the wave of the present and the future. It is good medicine to "first do no harm" and to encourages the patients to be actively involved in the healing process using healing foods and herbs provided by the benevolent hands of Mother Nature. This integrative approach will ultimately lead to better practice of medicine and a superior quality of outcome.

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KEY TERMS AND DEFINITIONS

Anti-Oxidants: Chemical substances that donate an electron to the free radical and convert it to a harmless molecule.

Auto-Immune Disease: Normally the immune system protects us from disease and infection but if our immune system turns around and mistakenly attacks 'ourselves' an autoimmune disease ensues. Autoimmune diseases can affect many parts of the body like the connective tissues, nerves, muscles, endocrine system and digestive system.

Codetron: Has been classified as Acupuncture-Like TENS. The effect of this machine is equal to or better than electroacupuncture therapy.

Eicosanoid: Lipid mediator of inflammation derived from the 20-carbon atom Arachidonic Acid (20 in Greek is "eicosa") or a similar fatty acid. The eicosanoids include the prostaglandins, prostacyclin, thromboxane, and leukotrienes.

Free Radical: An atom or molecule, which has an "unpaired electron" in the outer ring. An "unpaired electron" will also always mean that there is an odd number since "pairing" of electrons goes by 2s. Free radicals are highly reactive molecules and cause damage to nearby cells causing a cascade of chain reaction of free radical damage to other cells and tissues.

Inflammation: A basic way in which the body reacts to infection, irritation or other injury, the key feature being redness, warmth, swelling and pain.

LLLT: Or Low Level Laser Therapy (also known as Low Power Laser Therapy) is the application of red and near infra-red light over injuries or lesions to improve wound / soft tissue healing and give relief for both acute and chronic pain non healing wounds, post-op pain and acupoint stimulation. First developed in 1967, it is now commonly referred to as LLLT. The red and near infrared light (600nm-1000nm) commonly used in LLLT can be produced by laser or high intensity LED. The intensity of LLLT lasers and LED's is not high like a surgical laser. There is no heating effect.

Nightshade Plants: Solanaceae (Nightshade Family) has been highly cultivated over the years - it includes potatoes, tomatoes, eggplant, sweet peppers, chili peppers (but not black pepper), tobacco and petunias. Some plants have great medicinal value, some are quite poisonous. The calyx and corolla are 5-lobed, and usually there are 5 stamens. The fruit is partitioned into 2 or 4 seed-producing divisions, and may be dry or a fleshy berry.

Pygnogenol: The patented trade name for a water extract of the bark of the French maritime pine (Pinus pinaster ssp. atlantica). Pygnogenol contains *oligomeric proanthocyanidins* (OPCs) as well as several other Bioflavanoids: *catechin, epicatechin, Phenolic fruit acids* and *taxifolin*. Procyanidins are oligomeric catechins are also found in red wine, grapes, cocoa, cranberries, and apples. Pygnogenol helps the integrity of the blood vessels, skin, mental function as well as being a potent antioxidant.

Qi: (Pronounced as 'chee'). Qi is proposed to regulate a person's spiritual, emotional, mental, and physical balance and to be influenced by the opposing forces of Yin (negative energy) and Yang (positive energy). Disease is proposed to result from the flow of Qi being disrupted and Yin and Yang becoming imbalance.

TENS: Transcutaneous Electrical Nerve Stimulation. produces neuro-modulation through the following pathways: (1) Presynaptic inhibition in the dorsal horn of the spinal cord (2) Endogenous pain control (via endorphins, Enkaphalins, and Dynorphins) (3) Direct inhibition of an abnormally excited nerve. (4) Restoration of afferent input The results of laboratory studies suggest that electrical stimulation delivered by a TENS unit reduces pain through nociceptive inhibition at the Presynaptic level in

the dorsal horn, thus limiting its central transmission. The electrical stimuli on the skin preferentially activate low- threshold myelinated nerve fibers. The afferent input from these fibers inhibits propagation of nociception carried in the small unmyelinated C fibers by blocking transmission along these fibers to the target or T cells located in the Substantia Gelatinosa (laminae 2 and 3) of the dorsal horn.

Xanthones: Close cousins to the polyphenols family and have strong antioxidant effects on the nervous system. They are found in several botanical tonics including St. John's wort, gentian root nectar and mangosteen. Current research on Xanthones suggests they are beneficial in helping with many conditions including allergies, infections (microbial, fungus, viral), cholesterol levels, inflammation, skin disorders, gastro-intestinal disorders, and fatigue. Xanthones have also been found to support and enhance the body's immune system and exhibit strong antioxidant activity, which is beneficial for neutralizing free radicals in the body.

Chapter 24
The Potential of Crowdsourcing in the Health Care Industry

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ABSTRACT

Crowdsourcing has immense potential in the health care industry as it can tap into a vast global pool of knowledge to solve a wide variety of health care problems. This chapter first categorizes the different problems in the health care industry. It then describes some existing health care services and also discusses the future challenges that a typical crowdsourcing service could face. The chapter emphasizes the potential of crowdsourcing to disrupt old ideas and introduce new ones as well as a make a significant improvement in the social quality for different population groups.

INTRODUCTION

The twenty first century has seen the advent of technical advances in storage, transmission and analysis of information. This has had a profound impact on the field of medicine. However, notwithstanding these advances, various obstacles remain in the world regarding the improvement of human lives through the provision of better health care. The obstacles emanate from the demand (i.e., the problem) as well as the supply (i.e., the solution) side. In some cases, the nature of the problems might not have been correctly identified. In others, a solution to a problem could be known only to a small niche of the global population. Thus, from the demand perspective, the variety of health care issues can range from the quest for a cure for a rare illness to the inability to successfully implement verifiable preventive measures for a disease that affects particular pockets of the global population. Alternatively, from the supply perspective, the approach to a host of health issues might vary because of fundamental differences in both medical philosophies and organizational policies.

In many instances, effective solutions to health care problems are lacking because of inadequate global knowledge about the particular disease. Alternatively, in other cases, a solution might exist but

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the relevant knowledge about it might only be available to selected pockets of the global medical community. Sometimes, the barriers to the transfer of knowledge might have their root causes in ignorance or prejudice about the initiator of the cure or solution. However, the advent of information technology has now provided an opportunity for individuals located at different geographical locations to collaborate on solutions to various problems. These crowdsourcing projects now have the potential to extract the "wisdom of crowds" for tackling problems which previously could not be solved by a group of experts (Surowiecki 2014). Anecdotal evidence suggests that crowdsourcing has achieved some success in providing solutions for a rare medical disease (Arnold 2014). This chapter discusses crowdsourcing's potential to solve medical problems by designing a framework to evaluate its promises and also suggest recommended future paths of actions.

The chapter consists of five sections. The first section builds on a phrase used by former US Defense Secretary, Mr. Donald Rumsfeld, in the context of Iraq, to devise a classification scheme for all possible medical issues likely to be faced by health care professionals. This categorization provides a convenient way to evaluate the myriad health care problems affecting the global population. The next section summarizes the relevant dimensions that differentiate the various medical approaches to health care problems. These are rooted in either different medical philosophies, governmental approaches, ingredients used, etc. The third section compares some existing popular medical crowdsourcing sites. The fourth section discusses the various challenges facing the dissemination of knowledge in the health care industry. The section suggests solutions for overcoming these problems related to these knowledge-based deficiencies. The recommendations include expanding the crowd and building appropriate algorithms that effectively identify the most efficient medical solutions. The final section concludes the chapter with a discussion of crowdsourcing's potential to evolve beyond the initial stages and be a force for positive changes for the quality of life around the world as well as an engine for disruptive innovation.

A CLASSIFICATION OF HEALTH CARE INDUSTRY CHALLENGES

In February 2002, the then US Defense Secretary, Donald Rumsfeld (2002) used the terms the "known knowns," the "known unknowns" and the "unknown unknowns" when discussing the situation in Iraq. Later, philosopher Slavoj Zizek (2004) added another term, the "unknown knowns" as a fourth classification. While, both Rumsfeld and Zizek used the terms to discuss the US involvement in Iraq, this classification scheme is used as a springboard in our chapter to classify the myriad problems facing the global health care industry. These four classes allow us to evaluate the different types of challenges facing the health care industry and help evaluate how modern methods of knowledge sharing in crowdsourcing can provide solutions to these problems.

1. **The "Known Knowns":** "Known knowns" describe situations in which the solutions to a common health problem or issue might already be known. However, the applications of the solution to different situations might come up against myriad obstacles. Examples include the presence of malaria in geographic areas, which are adjacent to places from which the disease has been eradicated. Similarly, while one government can provide better health care to its citizens, another with more investments might be lagging behind on most measures. In some instances, an effective solution is available (hence the term "known knowns"), but unfortunately the results cannot be easily duplicated for different regions or populations. Sometimes, the answers might lie in adjusting the

incentive/disincentive programs through specific government policies. In other cases, the programs might have to be fine-tuned in order to combat pockets of ignorance based on either tradition or misinformation. While the solutions to these problems might not involve breakthroughs in the basic field of medicine, health care professionals cannot be left out of this dialogue as their own discipline is inextricably linked with the process of solving the "known knowns" generalization problem.

2. **The "Known Unknowns":** In the field of medicine, there are some instances when failures occur because the disease was not detected earlier. This is illustrated with the problems of early detection of pancreatic cancer (American Cancer Society 2014). It is currently a "known unknown". Once a test is validated under stringent laboratory conditions, this problem will then transform to a "known". However, till such a test gains broad acceptance via the medical community, the problem will remain a "known unknown," still waiting to be solved.
3. **The "Unknown Unknowns":** While future predictions for any industry are always difficult to make, it is likely that a company can introduce a future drug whose potential harmful side effects can only be discovered years later. As of today, both the drug and its side effects are "unknowns". When both the drug and side effects are "unknown," it is tempting to relegate this problem to the realms of science fiction. However, the history of sulfonamide drugs provides an interesting insight into what the future might hold for the medical community. Sulfonamide based drugs were a popular antibiotic in the 1930's. However, the introduction of the drug in a liquid form, called 'elixir sulfanilamide' caused the deaths of more than a hundred consumers (Akst 2013). Later, the side effects of sulfa drugs, particularly taken in large doses were discovered (More 2014). Although, current rules of drug testing are more stringent than during the 1930's, competitive pressures to bring 'new elixirs' to the market could cause future unknown problems.
4. **The "Unknown Knowns":** Zizek (2004) contends that there are some facts that a culture might intentionally refuse to acknowledge. These psychological barriers are likely to be present in the health care industry. While traditional Western medicine has dominated the delivery of medical solutions, in many instances other alternative methods acquired through generations by specific population groups or based on alternative treatment philosophies might also exist. These alternative medical approaches include but are not restricted to Acupuncture, Ayurveda, Unani, Homeopathy systems, etc. This list is incomplete as various groups of indigenous people such as the Aborigines, American Indians, Tibetans, etc. also have their own medical traditions. While such alternative medical practices have long historical traditions, they might not be known to a large audience because of various factors. One of these could be the lack of medical solutions validated under controlled laboratory conditions, expected in traditional Western medicine. Another could be prejudices rooted in attitudes towards the indigenous people who originated the cure. Here the history of the fight against malaria provides an interesting insight. In 1898, Ronald Ross discovered the link between the mosquito and malaria. However, in the seventeenth century, a Jesuit missionary in South America had already discovered the remedial use of the bark of the cinchona tree in treating malaria. Reportedly, he in turn, had learnt about this from the indigenous population in Peru, who knew of the cure for many years (Parker 2013). Like the cinchona bark, "known" solutions to medical problems which are "unknown" to a wider population might still exist. Another example of an "unknown known" is the confidential results of a test for a new drug. The wider audience might be ignorant of these results, particularly if they revealed undesirable side effects. Thus, various barriers, psychological or profit-driven, might effectively change the "known" problem to an "unknown" one for a wider population.

SALIENT DIFFERENCES IN MEDICAL TRADITIONS

To provide solutions to the problems facing the health care industry, an effective crowdsourcing service must be able to identify and then effectively tap different pools of medical knowledge in the world. Subbarayappa (2001) in his survey of ancient remedies identifies the Ayurveda, Chinese and Greek medical systems as the three early ones that existed in the first millennia. This is in contrast to the twenty first century, where multi-billion-dollar pharmaceutical companies promote drugs which have been ostensibly tested under stringent laboratory conditions. However, the history of recalls in the drug and pharmaceutical sector suggests that information about some of these drugs might be incomplete or inaccurate in certain cases. These incidents underscore the importance of sharing knowledge about all available solutions to health care problems and emphasize the need for a crowdsourcing service. However, for a crowdsourcing service to be successful, a proper understanding of the nature of the information to be shared is essential. This is only possible if the underlying dimensions that differentiate the various approaches to medicine are identified.

1. **Empiricism versus Rationalism:** Coulter (1995) identifies the empirical and rationalist philosophies as a conflict between traditional Western medicine, usually termed as "allopathy," with other approaches to medicine such as Homeopathy, Acupuncture, etc. Many of the alternatives to traditional Western medicine adopt an empirical approach. This is based on a long experience of studying both the symptoms of the disease and a range of possible treatments. Traditional Western medicine on the other hand usually bases its diagnosis on theoretical insights backed up by tests conducted under stringent laboratory conditions. The difference in the two approaches is related to other differences in medical traditions as well.
2. **Holistic versus Atomistic:** Numerous medical traditions are based on a unified approach. This is the underlying construct used in combating health issues. An example is the principle of *Qi* in Acupuncture (Finando and Finando, 2012). These holistic philosophies are markedly different from an atomistic approach. Here, each health care problem is tackled in disconnected bits and portions. In case of solutions derived from holistic medical traditions, the actual application can be appreciated better by understanding the fundamental philosophy it originated from.
3. **Structured versus Unstructured:** A large component of Western traditional medicine is based on knowledge recorded in encyclopedias, medical journals and books. Exceptions exist in the case of more modern treatments whose actual impact has only been accepted in a few countries (Schrotenboer 2015). In contrast, many indigenous treatments, which are often based on the skill and individual knowledge of the medical practitioner, follow an unstructured path. In several cases, a corollary to this dimension is that the more structured medical solutions are sometimes also more transparent and easier to access. Accessibility and transferability are often more difficult in the case of medical traditions where the knowledge base is unstructured.
4. **Natural versus Synthetic:** The drugs prescribed or bought over the counter as part of traditional Western medicine are in most cases mass produced in high volumes. Each drug is expected to be identical to another. This mode of delivery is in contrast to that followed in some medical traditions where the dosage is designed with a specific patient in mind. In some cases, the dosage is composed of naturally occurring ingredients extracted from herbs and plants. In the continuum on the natural to the synthetic approaches, treatments are easier to be fine-tuned for individual patients when the medical traditions are closer to the "natural" end of this dimension.

5. **Regulated versus Unregulated:** In addition to variances in philosophical approaches, the different medical traditions can also be distinguished by the diverse rules and regulations of the environment in which they operate. For example, a naturally occurring substance can be regulated by rules covering medicine in some countries while being regarded as a food product in others. Here, it is important to be cognizant of the variances in the global regulation of particular medical remedies, as well as appreciate the rationale behind the underlying reasons for the differences.

In order to efficiently tackle the four types of problems described in the second section, it is important for a crowdsourcing medical service to recognize the above dimensions that differentiate various medical approaches to treating health care problems.

CROWDSOURCING'S ROLE AS A SOLUTION PROVIDER

Existing Crowdsourcing Services

Crowdsourcing is often considered as a virtual production and collaboration platform for enabling collective idea generation and problem solving. It resembles an open call for intellectual contributions pitched to an undefined group. It is also a means by which experts can receive a call to brainstorm, assess, evaluate and consult on specific projects (Jain 2010). In the health care industry, crowdsourcing enabled by the Internet and 'backed' by the collective knowledge of large groups of individuals, is supporting health-related research collaboration, enabling prediction of disease outbreaks, and allowing diagnosis of rare medical conditions. With the advent of crowdsourcing and human computation, new and innovative approaches to health care are emerging to tackle open problems via crowd-based Internet services (Cheng et al. 2015). For example, community question answering and specialized medical sites offer new ways of solving medical cases. There are several examples of crowdsourcing initiatives currently underway in the health care domain. The salient features of some of the popular services are described below.

1. **CrowdMed:** Physicians are trained to identify common causes behind symptoms and then develop treatment plans. However, there are cases that challenge common causes. At that point, specialists are called in to provide their expertise. Even so, there are some cases so rare that both the health care providers and patients end up spending extraordinary amounts of time and money trying to provide a precise diagnosis and effective treatment strategy—with 7,000 currently known rare and/or difficult-to-diagnose diseases. On CrowdMed, patients with rare (or difficult-to-diagnose) diseases list their case to seek consultation for possible diagnosis from contributors; a broad pool of individuals (including physicians). These "Medical Detectives" review patients' symptoms, medical histories, and other pertinent data before recommending their diagnoses and expert opinions. Prediction market algorithms aggregate medical solutions provided by the crowd and filter them to a probable list of diagnostic suggestions for each patient. It then sends patients the top diagnostic recommendations, stating the estimated probability of accuracy for each one. Patients can then discuss those findings with their personal physicians and/or health care teams. To date, CrowdMed reports an accuracy rate of more than ninety percent (Kamajian 2015).
2. **PatientsLikeMe:** PatientsLikeMe, is an online community enabling health information exchange between patients. The site provides visualization tools to allow patients to understand and share

information about their health condition and uncover new knowledge. Patients can connect conveniently with other patients that have the same conditions, experiencing the same symptoms or using similar treatments (Cheng et al. 2015). Most join the site based on the recommendation of their health providers, other patients, or patient blogs, or after finding the site through online searches. Patients that join the website can choose to share their detailed health and treatment data. These data sets are presented as "health profiles" and aggregated as reports, accessible to other individuals on the site. Members can then discuss these data sets either within a group forum or individually through private messages. The resources on the site are designed to help members answer the questions such as: "Given my status, what is the best outcome I can hope to achieve, and how do I get there?" PatientsLikeMe is gaining recognition for its clinical research in areas such as patient-reported outcomes, identification of symptoms in neurological diseases, patient education and decision-making, and patient-lead clinical trials.

3. **CureCrowd:** Founded by doctors, CureCrowd is a "medically" guided search engine. It invites visitors to complete a survey of their experiences with various medical conditions and treatments. Collective wisdom of users is aggregated to offer ratings of the effectiveness of various medical-treatment alternatives. The "medical team" of CureCrowd reviews all user treatment suggestions before adding them to its database. Users can search the database and find the most dependable evaluations and answers regarding their medical conditions and/or treatment questions. An individual can type a medical condition or treatment into CureCrowd's search bar which will return results provided by users and reviewed by medical professionals. CureCrowd will not make recommendations by itself. Instead, it provides user-based statistics in graphs, allowing individuals to make their own interpretations of the data. The CureCrowd privacy policy states that the site doesn't share personally identifiable information with third parties. Unlike many health-information exchange websites, one can access the treatment survey results without having to provide any personal information.
4. **SERMO:** SERMO is a social networking platform exclusively meant for certified physicians. Doctors across the world can share information online anonymously on patient cases with the intention of obtaining recommendation from their peers. The contributing physician(s) can ask follow-up questions, post advice, and vote on the best treatment options for patients. The networking site also allows doctors to discuss topics unrelated to patient care without having to reveal their identity. This crowdsourcing platform is unique since it brings together physicians from eighty countries spread across five continents. These doctors have several millions of years of combined medical education and experience. Sharing of cumulative medical expertise improves the 'odds' of solving difficult medical cases and enhances quality of patient care at significantly lower cost to the health care system.

Table 1 compares the salient features of these crowdsourcing services.

Table 1. A comparison of some crowdsourcing services in the health care industry

	CrowdMed	Patients Like Me	CureCrowd	SERMO
Concept	Patients with rare diseases list their case to seek consultation for possible diagnosis from contributors who provide medical advice.	Health information sharing website for patients. Patients share personal stories and health data about conditions to uncover great ideas and new knowledge.	Founded by doctors. Medically guided search engine that allows users to find the most authentic answers regarding their medical conditions and/or treatment questions.	A private social network that allows doctors to share their medical wisdom and insights with peers, anonymously across geographical borders. Sometimes referred to as 'virtual lounge' for doctors.
Contributor Community:	Contributors are not necessarily medical experts. They are 54% males and 46% females, 56% work in or study medicine, across 23 different job titles or specialties. The average age is 35 years representing 22 countries of which 68% are in the US.	Patients	Participants and Medical Doctors	About 500,000 verified and licensed physicians that form a global community of doctors from eighty countries spread across five continents.
Revenue Model	In addition to a free case submission option, three paid packages are offered: Lite ($99/mo), Standard ($149/mo), and Premium ($249/mo). Some of these packages also include monetary incentives to attract the best case-solvers.	Takes information that patients share and sell it to companies that are developing or selling products to patients.	Non-profit	Physicians do not charge fees.
Problem Solving Mechanism	Prediction market algorithms are used to filter solutions provided by the crowd to a probable list of diagnostic suggestions for each patient.	By sharing information online, patients connect easily with other patients that have similar conditions, experiencing the same symptoms or using similar treatments.	User simply types medical condition or treatment into CureCrowd's search bar and will receive results provided by other users and vetted by medical professionals. CureCrowd does not make its own recommendations. Instead, visitors are provided user-based statistics in graphs, allowing them to have their own interpretations of the data.	Physicians can post patient cases online from anywhere. Posted patient information including images, test results, etc., can be anonymous. The submitting doctor usually requests for recommendations. Contributing physicians can ask additional questions, provide advice, and recommend treatment. Most patient cases receive a response within 1.5 hours and are solved within 24 hours.

DESIGNING THE IDEAL HEALTH CARE CROWDSOURCING SERVICE

The Knowledge Based Challenges

The promise of crowdsourcing hinges on accumulating knowledge from a global population and arriving at an effective solution to an existing health care problem. In most cases, there could be many possible answers. The challenge for a crowdsourcing service is to select the correct solution from myriad provided answers. This is a particularly important issue since a wrong selection could result in fatalities in

extreme cases. Given the impetus to have a zero defect process, it is important to understand the underlying reasons why mistakes occur. In almost all cases, the root cause is lack of perfect knowledge about the appropriate solution. This lack of perfect knowledge can be termed as nescience about the problem at hand. Three different types of failures can lead to nescience.

1. **Failure to Identify the Median:** Surowiecki (2004) summarizes the inherent advantages of the "wisdom of crowds" when he describes scientist Francis Galton's analysis of a crowd's guesstimate of the final weight of a slaughtered ox. Galton found that the average guess of the crowd, who were essentially fair-goers, was on the mark. The challenge for a crowdsourcing service dealing with health care problems is to hone in on the median solution. In most cases, particularly for "known" problems, the correct remedy might be known to a significant number of people. However, in some cases, vested interests can lead portions of a crowd to resort to "block" voting. In these instances, the crowd's wisdom is limited as the individual members of the crowd are not independent of one another (Surowiecki 2004). Here, a possible solution is to expand the width of the crowd in order to combat the problems of lack of individual independence.
2. **Failure to Recognize an Uneven Distribution of Knowledge:** In case of the guestimates of the weight of a slaughtered ox (Surowiecki 2004), every participant, even if they were not experts, had an opportunity to actually see the ox. In contrast, there might be cases, where vast pools of the available population are completely unaware of a cure or the potential side effects of a drug. However, a few small segments of the crowd could still have detailed knowledge about the product in question. For example, a few individuals who were treated with it might only know the benefits of an herbal remedy. These are therefore examples of "unknown known" problems. In these cases, the challenge for crowdsourcing is to avoid large swaths of ignorance but instead identify and utilize small isolated pools of knowledge. Here, preliminary questions can be designed to ascertain the responder's extent of knowledge about the particular herb in question. Budescu and Chen (2015) have shown that it is possible to derive a method that identifies a smaller crowd of premium contributors that outperforms the aggregate crowd. Thus, instead of expanding the crowd's width, the crowdsourcing service should concentrate on utilizing the depth of knowledge of particular sections of the crowd. Here, the crowdsourcing service provider should be careful to avoid any bias, conscious or sub-conscious, to affect their judgment about the differential weightage of crowd opinion. Thus, the utilization of the depth of crowd strategy should only be adopted in cases where there is a definite call for the application of rare, specialized knowledge about a new drug or hitherto unknown remedy.
3. **Failure to Recognize Idiosyncratic Knowledge:** Hayek (1945) describes the existence of a kind of knowledge which cannot be easily condensed into statistics. This type of knowledge is only available to the individual at the scene, i.e., as Hayek states to the "man on the spot." Knowledge which is difficult to transfer across different persons has been called "tacit" (Polanyi 1958). Jensen and Meckling (1990) describe the knowledge of specific skills, peculiarities of specific machines, etc., as idiosyncratic. Transfer costs for idiosyncratic knowledge are often high as it is impossible to know in advance what particular piece of knowledge is the critical portion (Jensen and Meckling 1990). In the field of health care, medical traditions that have an unstructured knowledge base have a wealth of information that can be termed as idiosyncratic. In these cases, sharing it with others through a crowdsourcing service becomes difficult. However, one way to recognize

the salient aspects of this knowledge is to use an ethnographic approach for developing a better understanding of its intricacies. Thus, a crowdsourcing service can use an algorithm which gives more weightage to the opinions of individuals who have an underlying appreciation of the social and cultural background of the particular medical tradition from which knowledge is being tapped. As idiosyncratic knowledge might be available in unexpected quarters, the crowdsourcing service should attempt to attract members from many disciplines and backgrounds in order to assimilate it. While transferring idiosyncratic knowledge is likely to remain expensive, the world-wide access to internet technology provides a chance of selectively utilizing the depth of knowledge of certain sections of the crowd. However, a crowdsourcing service must be cognizant of the various nuances that inhibit the transfer of medical practices that contain idiosyncratic knowledge. It should therefore strive to patiently build a heuristic model that improves with experience over time.

The three different types of failures call for the design of a crowd sourcing service which has the appropriate algorithms in place. For the failure to identify the median, the algorithm should give equal weightage to individual opinions. This must be linked to a process which attempts to solicit responses from the broadest swath of the population possible. However, when the relevant knowledge about a cure or a drug is limited, the algorithm should be based on a vetting process that first identifies the particular pockets of the population which have the knowledge relevant to the medical problem at hand. The next step should attempt to find the popular consensus from these small pools of knowledge within the respondents. However, when the knowledge is idiosyncratic, the crowd sourcing service should make an effort to first identify all the dimensions that come into play when discussing a possible remedy or cure. It should then solicit responses on these relevant dimensions to arrive at the correct answer. Here, the process is likely to take more time as the relevant knowledge might be tacit and difficult to share across the internet. The success of the crowd sourcing service might hinge not only on the design of its algorithms, but also on its ability to distinguish between the three different types of failures.

CROWDSOURCING IN THE HEALTH CARE INDUSTRY

In the information age, business entities as well as individuals can benefit from innumerable talents via open-ended networks, which provide access to accumulated individual experience. This aggregate knowledge, termed as collective intelligence, has immense potential in the health care industry. In this context, crowdsourcing can enable medical providers and other stakeholders for using their collective intelligence to deliver higher quality health care. In addition to efficiently selecting the correct medical solution, crowdsourcing can also break down the barriers that exist between different medical disciplines and traditions. Thus, it has the potential to disrupt old ideas and herald in new ones (Peisl et. al. 2014). In addition, if crowdsourcing in the health care industry brings to light effective medical remedies that were originally based on the wisdom of indigenous people, it will empower these groups through world-wide social recognition and the provision of both intrinsic and extrinsic rewards. Thus, the efficient use of information and communications technology, in addition to providing effective medical solutions, has the potential to highlight the contributions of hitherto neglected pockets of the global population (Wallace 2012).

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Chapter 25
Trends of Social Media Applications in Healthcare: A Managerial Perspective

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ABSTRACT

The twenty-first century has witnessed social media taking firm root into business and economic activity. It can no longer be considered as a tool for 'social' activity alone. Even governments have taken to it in order to open up communication channels with citizens and provide more effective services. The healthcare sector is a unique field where information sources and uses need to be handled with utmost care, as the risks extend not only to the healthcare provider, but more so to the recipient and others such as prospective recipients, the broader community, and regulators. Therefore, responsible use of social media in healthcare is critical, whether it be with respect to 'customer' relationship, marketing, education, recruitment or community building. This chapter scrutinizes relevant literature, which has been published in various disciplines, to provide significant insight into the question of how social media can improve healthcare administration. Practical implications and opportunities for further research are also highlighted.

INTRODUCTION

Use of social media has become an unavoidable trend over the last decade with three billion people predicted to own social media accounts in 2015 (Huang and Dunbar, 2013). Although it is a broad and evolving term, "social media" may be construed to represent internet-based technologies and social networking tools that allow individuals and communities to communicate, share and collaborate in a

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social dialogue through sharing information, ideas, personal messages, images, and other content in real time (Peck, 2014; Chauhan, 2012). These technologies and tools provide a variety of features that serve different user needs including social networking (e.g., Facebook, MySpace, Google Plus, Twitter), professional networking (e.g., LinkedIn), sharing media files like videos (e.g., YouTube, Flickr), producing content (e.g., Blogger, Twitter), aggregating information (e.g., Wikipedia) and virtual reality environments (e.g., Second Life).

This substantial growth reshapes the way organizations are functioning and operating. First, scholars have noted that social media increases the visibility of users' thoughts, choices, behaviors and knowledge to others in the same organization. Brown and Duguid (2001) demonstrated that people will ignore seeking information if they do not know which type of information is there for them to use, or perceive information as hard to access. Moreover, individuals may not have particular knowledge to understand other work domains (Cross et al. 2003). In this regard, social media enables ideas about work that were previously silent or hidden, become visible, interlinked, and searchable. Displaying text, video, audio and graphic content contributions, list of edits to entries, status updates, allowing comments and opinion expression, indexing entries by search engines, social tagging, display of number of people who bookmarked same content, pushing content to subscribers, showing others with similar entries, are examples of visibility mechanisms used in social media (Treem and Leonardi, 2012). This helps users know the type of people in the organization, e.g., competent or strategic, what they may know, and the status of ongoing activities in the organization.

Offering current knowledge that remains accessible, reviewable and recordable in the same original form of display is another way by which social media can reshape organizations. Persisting features can impact organizational actions due to sustaining knowledge over time, creating robust forms of communication as content can be reused and reanalyzed over time, and growing knowledge content within nearly limitless spaces. Examples of features that afford persistence include history of activity and discussion recorded, indexed entries and profiles, displaying recent activity, linking to past content of individuals on site, reversing chronological formats, cataloging history of bookmarking activity (Grudin and Poole, 2010; Mejova et al., 2011).

Social media have allowed organizations to exchange and integrate diverse knowledge internally and externally, and across traditional boundaries, with other organizations, customers and stakeholders, so that greater opportunities for excellence, employee mobility and specialization, outsourcing, managing costs, and globalization are created to change fundamental aspects of how organizations are managed. IBM, for example, has been transformed from a traditional organization to a virtual entity, with about 40% of employees working outside of physical IBM offices, and from a traditional computer manufacturer to a giant knowledge management player.

Among others, healthcare organizations started to realize the benefits of social media for primary stakeholders in healthcare, namely, healthcare providers and recipients. Healthcare providers can be identified as doctors, nurses, pharmacists, counselors, caregivers, support groups and academicians, while healthcare recipients are the patient and family members. A study by a global technology-enabled business solutions firm CSC (2012) identified social media best practices for healthcare organizations relating to marketing and brand management, recruitment, reputation management, customer relations, consumer/patient education, professional education, collaboration, creation of communities, wellness, patient and population monitoring, care management and coordination. Similarly, Panahi et al. (2014) specified a number of social media benefits for physicians ranging from staying connected, reaching out, networking and sharing knowledge, to engaging in continued medical education, benchmarking and

branding. A descriptive survey by Antheunis et al. (2013) showed that patients used Twitter (59.9%) especially for increasing knowledge and Facebook (52.3%) for social support and exchanging advice. Professionals depended on LinkedIn (70.7%) and Twitter (51.2%), for communication with colleagues and for marketing purposes. Moreover, Panahi et al. (2014) indicated that blogs and Twitter were the two main social media tools that attracted physicians and stood out for their popularity among the clinical community. They added that Twitter had mainly been used by the participants for keeping up-to-date with advanced information and news in the field. After Twitter, blogs were the main social media tools that the majority of healthcare professionals used for case reporting and case-based discussions, providing literature summaries, sharing clinical tips, introducing controversial topics, and developing in-depth discussions. In addition, Lipp et al. (2014) assert that Twitter and YouTube are the top social media platforms adopted and effectively utilized by health professionals from diverse settings. These platforms are of great benefit in facilitating communication with patients and colleagues and healthcare providers are gaining confidence in using them (Lipp, 2014).

The purpose of this chapter is to review the managerial aspects of social media applications in healthcare, and to identify risks and recommend practical steps for mitigation. The following section describes the method of the study.

METHOD

The methodology used is a qualitative review of previous research of social media in healthcare, that has been published by academics and practitioners in peer-review journals to ensure the quality of the research findings. Consequently, book reviews, viewpoints, conference papers, editorials, were excluded. Also, master's and doctoral dissertations, and textbooks were beyond the scope of the survey. Major online databases were searched to provide a comprehensive bibliography on social media in healthcare. The literature contributions were primarily of articles from research databases including ProQuest, PubMed, Science Direct, (Elsevier), EBSCO, Ingenta, Emerald, Wiley Interscience, Inderscience, ASQ, Springer and IEEE-Xplore. In addition to database search, extensive internet search and reference checking have been carried out. The purpose was to cover literature that is not listed in databases, as well as to check missing referencing data. 'Social Media', 'Social Computing' or 'Healthcare' associated with 'Hospital' or 'Medical', and with 'Management' or 'Managerial' were the terms used to guide the search theme in titles or abstracts of papers that have been published in 2015 and backwards. These criteria allowed a comprehensive set of papers on social media in healthcare across various fields including healthcare management, economics, human recourses, and information technology to be reviewed. Considering the diverse nature of social media research, it would be difficult to categorize the literature under any specific theme. However, the search yielded 102 papers that have been screened for their relevance to the topic of this chapter since many articles have misleading titles or are purely technical, covering only health science with trivial indication to social media applications. The final screening process yielded 48 papers. Each paper was carefully reviewed and classified (see Table 1). Although this research is not exhaustive and possibly there is an article which is not surveyed, it serves as a comprehensive base for gaining robust insight into social media in healthcare. The review yields seven categories that highlight the trends of social media in healthcare including its role in healthcare education, research, marketing, quality, internal healthcare communications, community groups, and risks and precautions. These categories are presented in the following sections.

Table 1. Classification of previous research on social media in healthcare

Author(s)	Year	Social Media	Findings	Research Method
Anon	2008	Various tools	Services to help clients – medical professionals, caregivers, other stakeholders, practice safe consumer engagement	Report
Anonymous (Business Wire)	2010	Twitter, LinkedIn and others	New tool to monitor behavior of followers, respond quickly and push information to a larger audience	Report
Atsushi et al.	2014	Twitter	The cancer patients share information via Twitter. This information could prove useful to health care providers.	Survey
Attai et al.	2015	Twitter	Breast cancer patients' perceived knowledge increases and their anxiety decreases by participation in a Twitter social media support group.	Survey
Bahkali et al.	2015	Twitter	The success of the Twitter account was the result of being passionate about the health promotion campaign, being knowledgeable about the health promotion area, developing trust between Twitter accounts users and the healthcare provider.	Content analysis
Batchelor et al.	2012	Various tools	Study on dementia patients; highlighting the ethicolegal responsibilities of technology providers	Case study
Betts	2014	Various tools	Benefits should be measured not only in terms of ROI but also in terms of social returns	Survey
Boyer	2011	Various tools	Basic principles to ensure effective use	Review
Cole-Lewis et al.	2015	Twitter	Twitter can uncover real-time snapshots of personal sentiment, knowledge, attitudes, and behavior that are not as accessible, at this scale, through any other offline platform.	Quantitative
Cox and Park	2014	Facebook	A Facebook page may be a useful marketing tool and a valuable addition to other marketing approaches.	Survey
Das et al.	2014	Various tools	The increase in the number of young people with distorted body images in the social media led to an increased number of people resorting to sometimes drastic weight loss programs.	Content analysis
Deluca and Enmark	2000	Various tools	Responsibility of healthcare providers to proactively incorporate social media tools into healthcare	Survey
Fernández-Luque and Bau	2015	Various tools	Analytics tools need to be developed to analyze data from various sources to help professionals and authorities	Case studies
Fuoco and Leveridge	2015	YouTube, Facebook, Twitter	Maximum benefit in inter-professional communication, but professionals lack awareness of published guidelines in patient interaction; professionals apprehensive about privacy and boundary issues	Survey
Gagnon and Sabus	2015	Various tools	Best practices that physical therapy professionals can use to provide authentic healthcare support but at the same time avoid risks	Review
Gold	2013	YouTube	Healthcare communicators preferred YouTube over other modes, not clear whether this communication was among professionals or between healthcare providers and users	Survey
Grajales et al.	2014	All social media	Critical need to adhere to guidelines in professional use	Review
Gunes et al.	2015	YouTube	The official institutions/associations should be encouraged to produce and upload videos including up-to-date and comprehensive information regarding the disease. Likewise, additional search tools would be useful to locate videos uploaded by academic figures and institutions.	Content analysis

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Table 1. Continued

Author(s)	Year	Social Media	Findings	Research Method
Horowitz	2014	Facebook, Twitter, blogs and YouTube	Employee engagement, unlawful policies and drafting good social media policies for the organization	Descriptive review
Huang and Dunbar	2013	Facebook and Twitter	Using of Facebook and Twitter as a two-way communication channel seems to be much more effective for hospitals to connect to their visitors than using them as a one-way marketing tool.	Content analysis
Huang and Dunbar	2013	Facebook and Twitter	Facebook an indispensable medium for visitor interaction; Twitter primarily as a marketing tool	Survey
Knight et al.	2015	Various tools	Critical to incorporate social media in designing and delivering care to improve treatment outcomes in physical therapy	Conceptual
Koumpouros et al.	2015	Various tools	There is a clear need to measure the effectiveness of any such media marketing effort. In Greece Most adopters are not yet-taking maximum advantage of the technology. Social networks are prevalent and several paradigms support their adoption for marketing purposes in the sensitive healthcare domain	Survey
Lee et al.	2014	Twitter	Twitter users in health-related fields tweet about both testable claims and personal experiences	Content analysis
Madathil et al.	2015	YouTube	YouTube is used as a medium for promoting unscientific therapies and drugs that are yet to be approved by the appropriate agencies and has the potential to change the beliefs of patients concerning controversial topics such as vaccinations.	Review
Maher et al.	2014	Various tools	There is very modest evidence that interventions incorporating online social networks may be effective; however, this field of research is in its infancy.	Review
Marjolijn and Antheunis	2013	Twitter, Facebook, LinkedIn	Patients' uses were for knowledge and social support; professionals' uses were for communication with their colleagues and marketing. Patients' main barriers were privacy concerns and unreliability of the information. Professionals' main barriers were inefficiency and lack of skills.	Descriptive survey
Muncy et al.	2014	YouTube	There is possibility that YouTube pharmaceutical advertisements actually drive consumers away from proper medical care. The medical community may be better served by developing longer, more content base advertisements for the medium of video-on-demand	Content analysis
Neiger et al.	2013	Twitter	As public health transitions to more dialogic conversation and engagement, Twitter's potential to help form partnerships with audiences and involve them as program participants may lead to action for improved health.	Survey
Newborn	2013	Tweets, Facebook, LinkedIn, Google+, YouTube, Pinterest, blogs	Healthcare providers believe use of social media improves the quality of healthcare delivered, and patients – including 50% of the senior population are active users of social media to help manage their health	Survey
Pal	2014	Various tools	Social media can be recognized as delivering up-to- date health information effectively, and should ensure there is no bias in selective communication, or disadvantage to isolated patient groups.	Review
Pitts	2009	Various tools	The responsibility of pharmaceutical companies to play a greater role in putting up reliable content on social media, given their expertise	Review

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Table 1. Continued

Author(s)	Year	Social Media	Findings	Research Method
PR Newswire	2014	Facebook, Twitter and YouTube	Importance of pushing social media – case of online quit smoking program. Participants felt happier than when they smoked – their feedback encouraged others to quit.	Experiment
Puljak	2015	Facebook	Facebook enables multiple possibilities to engage with target audience and to disseminate the evidence-based medicine content	Review
Rader et al.	2014	Various tools	Social media and pharmaceutical marketing: Significant impactful and pervasive bonding among consumers, bloggers and unofficial "experts" about pharmaceutical offerings is widespread.	Grounded
Sarringhaus	2011	Facebook, Twitter	Generational shift in medical services environment can be managed by recruiting and retaining tech-savvy personnel, and this is the need of the hour	Review
Sharp	2011	Facebook, Twitter, YouTube	Social media a necessity in healthcare, lists best practices such as having a social media policy in place, minimizing response time to complaints and so on	Review
Squazzo	2010	Blogs and other social media	Blog maintained by the company for its patients, the community and another blog separately for its employees to post comments and suggestions	Case study
Squazzo	2010	Blogs and other social media	Blog maintained by the company for its patients, the community and another blog separately for its employees to post comments and suggestions	Case Study
Strychowsky et al.	2013	YouTube	YouTube has a large number of videos on pediatric tonsillectomy with a variety of content ranging from very useful to not useful, and misleading. Health care professionals must recognize the potential influence that these video Web sites may have on patient attitudes.	Content analysis
Thielst	2011	Various tools	Highlights how careful ('secure') use of social networking helps managers give effective support to patients recovering from addiction	Review
Tyrawski and DeAndrea,	2015	Facebook, Twitter and YouTube	Pharmaceutical companies avoid making drug product claims on their social media accounts but frequently post content for help-seeking "Direct-To-Consumer Advertising" (DTCA).	Content analysis
Van de Belt et al.	2015	Twitter, Facebook, Healthcare rating sites	Social media should be used to include patients' perspectives in healthcare supervision	Case study
Vecchione	2012	Various tools	Benefits of training and professional support groups	Survey
Verhoef et al.	2014	Healthcare rating sites	Strong relationship between information on social media and selection of healthcare provider; social media should be used as a complementary tool because of its limitations	Review
Weiss	2012	Various tools	Mitigation of risk	Survey
Zowawi et al.	2015	Twitter, Facebook, and YouTube	Social media platforms seem to be a valuable platform for delivering awareness messages.	Case study

SOCIAL MEDIA AND HEALTHCARE EDUCATION

Social media allows patients to engage in informative dialogue with the community when they face a health issue. Through this process, patients gain knowledge and social support that allow them to maintain psychological and physical capabilities. Research shows that as patients readily and frequently access social media as a forum for discussion of personal health issues, healthcare providers began considering ways of harnessing social media as a tool for learning and teaching (Pal, 2014). Zowawi et al. (2015) discussed the potential for using social media tools (Twitter, Facebook, and YouTube) as cost-effective and mass education platforms to raise awareness of appropriate antibiotic use among the general public and in the medical communities of the Arabian Peninsula. They concluded that social media platforms are immensely beneficial for delivering awareness messages. Owing to social media popularity, awareness messages could reach a large number of users and the reach can be tracked. The use of social media can also enhance awareness campaigns delivered through traditional media channels. According to PWC's health research institute survey report (2012), a children's hospital in Boston had nearly 700,000 Facebook "likes" from prospective patients who use disease-specific support groups and other patients to learn more about the hospital's treatment or clinical divisions. Social media serves as a real-time referral and validating network for new patients regarding a hospital's patient care standards. According to the survey, a majority of patients (42%) used social media to access health-related consumer reviews, 32% of patients used social media to view family/friend health experiences, and 29% have sought information related to other patients' experiences with their disease (PWC, 2012). In another study, user profile and content of Croatian Cochrane Branch Facebook page were analyzed (Puljak 2015). He pointed out that most of the followers (1441) are women aged 25 to 44 and the most popular content is related to pregnancy, childbirth and breastfeeding which enable patients and other followers to engage in and disseminate evidence-based medical content.

Similar to Facebook, Twitter has also gained considerable popularity in health education. Atsushi et al. (2014) examine Twitter use by cancer patients in Japan to understand cancer patients' social media usage and gain insight into patient needs. Through searching every publicly available cancer user profile (i.e., breast cancer, leukemia, colon cancer, rectal cancer, colorectal cancer, uterine cancer, cervical cancer, stomach cancer, lung cancer, and ovarian cancer) on Twitter in Japan, they demonstrated that cancer patients share information about their underlying disease, including diagnosis, symptoms, and treatments, via Twitter that could prove useful to patients and healthcare providers. In the same vein, Attai et al. (2015) used the results of a Twitter breast cancer support community participant survey to indicate that 92.7% of patients reported increased knowledge about breast cancer and improved anxiety level concerning the disease.

In another study, Neiger et al. (2013) examined how health departments in USA use Twitter to share information, engage with followers, and promote action in a sample of 1000 tweets. The findings indicate that Twitter is being adopted by health departments for disseminating personal-health topics and organization-related information as well as engaging the audiences in conversation. As public health transitions to more dialogic conversation and engagement, Twitter's potential to help form partnerships with audiences and involve them as program participants may lead to action for improved health (Neiger et al., 2013). In an in-depth analysis of 700 tweets by health professionals, Lee et al. (2014) found that a majority of the tweets were about testable claims and personal experiences that were gained by health professionals.

With regard to YouTube, Gunes et al. (2015) investigated the characteristics and scientific accuracy of the videos about problems related to varicose veins which were uploaded to the youtube.com website. The YouTube site was searched using the keywords varicose vein, varicose veins, and varicose with no filter. The contents of the reviewed videos were assigned to three groups as useful, partly useful, and not useful by using the criteria including the scientific contents of the videos, contemporariness and accuracy of the insight, and presentation of the data particularly regarding the visual features. The statistical analysis was based only on the videos rated as 'useful'. The rated usefulness was significantly higher for videos uploaded by official institutions/associations than those uploaded by others. The study concluded that official institutions/associations should be encouraged to produce and upload videos including up-to-date and comprehensive information regarding the disease, as a teaching and learning mechanism. Likewise, additional search tools would be useful to locate videos uploaded by academic figures and institutions (Gunes et al., 2015).

Strychowsky et al. (2013) discussed the usefulness of YouTube as a source of information on pediatric tonsillectomy through analyzing one hundred fifty-six videos. Although the predominant source of videos was the patient (66%), half of them were categorized as not useful or misleading (50%). Other videos were related to physician sourced information (19%), surgical technique (9%), and news report (6%). The study reveals that YouTube has a large number of videos on pediatric tonsillectomy with a variety of content ranging from very useful to not useful, and misleading. Healthcare professionals must recognize the potential influence that these video websites may have on patient attitudes (Strychowsky et al., 2013).

SOCIAL MEDIA AND HEALTHCARE RESEARCH

Employing the vast data available through social media tools offers great opportunity for health research methodologies to be enhanced and health development and practice to be expanded. For example, electronic cigarettes (e-cigarettes) continue to be a growing topic among social media users. Cole-Lewis et al. (2015) established a supervised machine learning algorithm to build predictive classification models that assess Twitter data for a range of factors related to e-cigarettes. In their study, 17,098 tweets were coded for five categories: e-cigarette relevance, sentiment, user description, genre, and theme. Policy/government, relevance, promotion, and marketing emerged as they achieved the highest performance and improvement scores over a random baseline. Cole-Lewis et al. (2015) revealed that Twitter can uncover real-time snapshots of personal sentiment, knowledge, attitudes, and behavior that are not as accessible through any other offline platform. Bahkali et al. (2015) analyzed the combined experiences of five researchers in the development of Twitter accounts. The shared experiences were thematically transcribed, coded, matched and grouped under six key themes identified as the main driving forces for the development of a successful health promotion Twitter account. Findings revealed that the success of the Twitter account was the result of defining clear goals, being passionate about the health promotion campaign, being motivated and creative, being knowledgeable about the health promotion area, developing trust between Twitter accounts users and the healthcare provider, and being patient in communicating with Twitter account users. They recommended that future research needs to focus on a more detailed analysis of the twitter feeds shared between the users and the health practitioners which can enhance the understanding of social media based public health educational interventions.

SOCIAL MEDIA AND HEALTHCARE MARKETING

Current trends show that social media advertising has turned out to be the natural choice for organizations, particularly after the decline of banner advertising. It helps organizations find new potential clients by using their own shared information to identify interested individuals and proactively targeting them before they even begin their search. Establishing communities around products and services has been a well-known method of building brand loyalty, establishing exit barriers, and facilitating viral marketing through self-emergent customer testimonials (Waad and Jorge, 2011). In the healthcare context, Das et al. (2014) discuss how social media advertising is influencing diabetes prevention and management with particular focus on weight perception, weight management and eating behaviors. They explored the concept of how the advertising of Size 0 models and photo-shopping of images which are easily available online and via social media is causing an increase in the number of young people with distorted body images which may lead to an increased risk for developing diabetes or worsening the complications of diabetes. Viju and Joshua (2013) examined the role of advertisements on Facebook and their influence on consumer purchases of weight-loss products. The study concluded that the perception of benevolence of the opinion leader, and social norms and intentions of the user have an increasing influence on the odds of purchasing a weight-loss product, while behavior control of the user in seeking additional information about a product has a decreasing influence on purchase behavior.

Through a content analysis of 23,300 posts/tweets on 172 US hospitals' Facebook and Twitter pages in a systematic probability sample, Huang and Dunbar (2013) indicated that the flow of information on both pages is dominantly one-way; nevertheless, larger hospitals have made great effort to interact with their Facebook visitors while marketing themselves. The study also found that it is very important for hospitals to encourage a large visitor base on Facebook because the more visitors a hospital attracts to its Facebook page, and the more 'likes' and 'posts' the hospital attracts, the more people comment on the hospital posts, and the more the hospital gets recommended. The comparison between the traffic on Facebook and Twitter demonstrates that using social media as a two-way communication channel seems to be much more effective for hospitals to connect to their visitors than using them as a one-way marketing tool. Besides, Muncy et al. (2014) presented the results of a content analysis of 100 pharmaceutical advertisements found on YouTube. From the analysis, concerns arose over mismatches in terms of the content and style of the advertisements. The possibility that YouTube pharmaceutical advertisements actually drive consumers away from proper medical care is explored. The study concluded that, rather than having broadcast advertisements cross-over to YouTube, the medical community may be better served by developing longer, more content base advertisements for the medium of video-on-demand.

Within the orthodontic practice, Cox and Park (2014) examined which features of orthodontists' Facebook pages are the most effective in attracting patients. The findings indicated that there were important elements of Facebook that would attract patient attention and help them make their decision about where to receive treatment. The most important Facebook marketing components according to Cox and Park (2014) involve:

1. An orthodontist's credentials,
2. Before-and-after photographs,
3. Consumer-focused content,
4. The orthodontist's photograph,
5. A link to the practice's Web site,

6. Links to oral health–related educational articles,
7. The presence of Facebook "likes" and "recommendations".

Tyrawski and DeAndrea (2015) analyzed the nature of information that appears in search results for widely used pharmaceutical drugs in the United States on Facebook, Twitter, and YouTube with a particular emphasis on the presence of illegal pharmacies. The authors analyzed the content of Facebook, Twitter, and YouTube accounts of the top 15 pharmaceutical companies as well as the content that appears when searching on Facebook, Twitter, and YouTube for the top 20 drugs purchased in the United States. For the company-specific analysis, the study revealed that advertising that help consumer seeking behavior were found in 40.7% of posts while drug product claims were present in only 1.6% of posts. For the drug-specific analysis, the result indicated that the majority of search results contained drug product claims. Pharmaceutical companies avoid making drug product claims on their social media accounts but frequently post content that is consistent with US Food and Drug Administration (FDA) definitions for help-seeking direct-to-consumer advertising (DTCA) (Tyrawski and DeAndrea, 2015).

Rader et al. (2014) assessed the state of the art social media and pharmaceutical marketing through empirical analysis of online consumer conversations. They demonstrated that pervasive bonding among consumers, bloggers and unofficial "experts" about pharmaceutical offerings is widespread, and occur regardless of pharmaceutical companies' involvement. Therefore, considering the structure and nature of online consumer bonding arising from disease and healthcare education is fundamental for pharmaceutical companies when implementing social media strategies as part of their pharmaceutical marketing and DTCA efforts.

SOCIAL MEDIA AND HEALTHCARE QUALITY

Traditionally, doctors' face-to-face conversation, written prescription, the pharmacist's detailed description and the patient's feedback during visits were the only forms of communication that occurred in heathcare consultations. As technologies developed, these possibilities have expanded and communications now include emails, telephone calls, counseling, support group communications, and the most powerful of them all – social media. Today, social media include a wide gamut of tools that facilitate real-time communication across the globe without a heavy drain on personal resources. At heart, social media is an opportunity to build relationships, start conversations, and learn from customers (CSC 2012). The way social media works and the way in which they are used by practitioner and patient, depends a great deal on the users themselves, whether they would like to use it extensively, and are adept at using it, or whether they limit its use due to lack of skills, fear of incursion on privacy or fear of being given wrong information. Instant response from healthcare organizations to patients' concerns, reactions, and operations such as registration and appointment reservation through the social media is a crucial element. According to a PWC report (2012), the vast majority of patients would expect healthcare organizations to respond within a few hours to a request for an appointment (78%), a request for information (64%), and a complaint post about a service, product, or experiences (61%) made via social media. Social media has, thus, increased patient expectations concerning healthcare services.

Wicks et al. (2010) suggested that use of the platforms improves patient outcomes. They found that 72% of patients with ALS, Parkinson's disease, HIV, fibromyalgia, and mood disorders have learnt about the symptoms they had experienced through their online interactions. In addition, social media helped

patients understand the side-effects of a treatment (57%) and find another patient like them (42%). Wicks et al. (2012) found that different platforms helped patients with epilepsy to better understand their symptoms, seizures, and treatments. Social media networks influence patients' treatments choices and selection of healthcare providers. The PWC survey (2012) also found that about 45% of respondents are affected by social networks when they decide to seek a second opinion regarding treatment, while more than 40% reported that information found via social media would affect the way they coped with a chronic condition, their approach to diet and exercise, and even their selection of a specific doctor.

Newborn's (2013) survey revealed some very interesting data about the use of social media in healthcare. Both physicians and patients – including 50% of the 'senior' population were happy to use social media in communications and in the management of their healthcare. 60% of the doctors surveyed said that social media improve the quality of healthcare delivered to the patients. Verhoef et al. (2014) concluded that a strong relation exists between information shared by patients on social media and healthcare quality, as patients provide feedback about the quality of their healthcare providers on physician-rating sites. Authentic information could be invaluable in the decision-making of future patients in comparatively evaluating health providers and ultimately selecting the best and most suited for them. However, there were some drawbacks especially with respect to the use of rating sites that were not adjusted for risk which could result in it being vulnerable to fraud, and that the sample may not be representative of all healthcare users as patients using social media may be only a small segment of the population (Verhoef et al., 2014).

In another study, Van de Belt et al. (2015) followed the use of feedback of Dutch patients given on social media, by authorities to regulate healthcare services. This was compared to the supervision initiated on a regular risk-assessment basis. The analysis was based on a pre-developed scale to determine the added value for each individual result. Only in 6 out of 40 cases, social media feedback was used whereas risk-based supervision was carried out in 72 out of 116 cases. The study concluded that social media could be used to include patients' perspectives in supervision (Van de Belt et al., 2015). Similarly, Knight et al. (2015) reiterate that it is critical to incorporate social media in designing and delivering care to improve outcomes in physical therapy as patients are ready to use social media in the management of their treatment.

Grajales et al. (2014), in an extensive narrative review, identified 10 major categories of social media being used. They highlight the critical need to adhere to guidelines in professional use, and recommend that organizational policies be put in place to prevent misuse and errors, and to engage with healthcare users in a safe and ethical manner. They suggest that future research focus on understanding the synergies between social media and practice.

SOCIAL MEDIA AND INTERNAL HEALTHCARE COMMUNICATIONS

Healthcare providers are well aware of the changed communications scenario and the influence of technology on current business and management practices. The goal is to be aware and up-to-date and to provide the best service possible to ensure better health of the recipient but they recognize too that the organization has a steep learning curve to go through before the full benefits are realized. The question most relevant for practitioners is whether the use of social media in healthcare adds value, or whether it confuses and derails the treatment. In spite of the risks perceived, it is their recommendation that busi-

nesses take a proactive approach by framing a social media policy at the organizational level and then creating online platforms to present authentic and authoritative information.

Anon (2011) found that Facebook and Twitter are the most popular social media platforms among users. There is great scope to use these tools in patient care and for internal communications and collaboration. Similarly, Fuoco and Leveridge (2015) conducted an extensive study on the attitude of urologists towards the most popular social media platforms (i.e., Facebook, YouTube and Twitter). The analysis showed that the most commonly perceived role of social media in healthcare were for inter professional communications (67%) or as a simple information repository (59%). However, very few physicians had read or were even aware of published guidelines for online interaction with patients; 73% felt that online interaction with patients would become unavoidable in the future; and most respondents agreed on the need for physicians to exercise caution in professional social media postings. They concluded that though online interaction with patients seemed inevitable or even desirable, complete integration into medical practice will be "impossible" due to privacy and boundary issues.

Huang and Dunbar (2013) asserted that using social media as a 2-way communications channel, as in the case of Facebook, is a much more effective for hospitals to connect with their visitors than using them as a 1-way marketing tool, which takes away the visitors' engagement. Gold (2013) studied the different social media channel preferences and concluded that healthcare communicators preferred YouTube over others. It was not clear from the study whether this was only among healthcare professionals, or also professional to recipients and others. In fact, the IMS Institute for healthcare informatics study (2014) stressed the importance of pushing social media in the case of an online quit smoking program. Participants felt happier than when they smoked – their feedback encouraged others to quit. Malette et al. (2014) highlighted the case for social media to be used extensively but effectively in professional communications to inform and spread awareness of latest developments and innovations in the field of medicine. Pitts (2009) pointed out to the responsibility of pharmaceutical companies to play a greater role in putting up reliable content on social media, given their expertise in the field and as repositories of data.

SOCIAL MEDIA AND HEALTH COMMUNITY GROUPS

The role of social media in support groups is enormous. Support groups for patients can be set up based on specific health conditions or issues. Such networking enables healthcare users to benefit from the experiences of one another and to offer emotional support and advice. Social media platforms such as *PatientsLikeMe* connect patients with each other and help access relevant health information about cost, value, and outcomes of alternative treatment plans as well as real-world data on health conditions, treatment history, side effects, hospitalizations, symptoms, disease-specific functional scores, weight, mood, quality of life and more, on an ongoing basis. This information allows the average patients to gain insight about their health concerns, evaluate and improve their condition as well as keep a check on the system's performance. On the other hand, online networks or "communities" are formed by physicians to benefit from each others' experiences in their practice. For example, online physician communities such as Sermo.com and Floatingdoctors.com allow physicians to share knowledge, maintain collaboration and interact for learning and treatment purposes to enable better patient outcomes (PWC, 2012). According to Vecchione (2012), physicians in remote areas who are not part of a large practice, though isolated physically can still get all the information they need from the 'community'. The author describes the push by

frontrunners in healthcare services to train internal and external participants including doctors, nurses, and others in various positions in healthcare organizations through a social media residency course.

Thielst (2011) explains how social media technologies are applied by healthcare organizations to optimize the patient's experience during treatment and follow-up through creating a 'secure' social networking community that helps mangers support patients recovering from addiction. A report by PR Newswire (2014) of a 'quit-smoking' program that asked participants to share on social media their reason for quitting smoking illustrated that smokers who quit, not only experienced improvement in health but also felt happier than when they smoked. Trends studied indicated that such online surveys and feedback could encourage the smokers' community to follow the lead. Likewise, CSC (2012) pointed out the role played by social media in community creation among health groups through Facebook and Twitter. Specific sites based on some medical conditions are also being created to encourage information sharing and to provide a context for giving and getting support which highlights some advantages of these communities such as fewer unscheduled hospital visits, higher levels of patient satisfaction and more confident young patients.

SOCIAL MEDIA IN HEALTHCARE: RISKS AND PRECAUTIONS

Barriers to effective use of social media that researchers perceive are language, culture, insufficient return on investment, consumer, legal and regulatory (CSC 2012). Some of the risks, they predict, could be control of message, misinterpretation, incorrect information, off-label information, negative feedback and comments, privacy and security breaches, ethical issues, malpractice lawsuits and legal repercussions. Batchelor et al. (2012) made a strong case for clarification of legal responsibilities of technology providers, healthcare professionals, regulators and policy makers. The authors take up the pertinent cause of dementia patients and question how data leaks, identity theft, and intrusion into privacy can be guarded against. Decision making capacity in healthcare cannot be assumed. In addition, Sharp (2011), in his case study, suggested that providers should have a policy in place and guard against improper use of social media. For instance, Twitter can help healthcare providers to be proactive about complaints received. In one case, response time was reduced to just two hours. Some best practices such as actively tracking public comments and opinion, and charting the course of action based on user needs and preferences, can be adopted easily by other healthcare organizations too.

Trusting all information found on social media is another risk that faces the healthcare community. Madathil et al. (2015) review the peer-reviewed literature addressing the healthcare information available on YouTube. 18 articles were reviewed, with the results suggesting that:

1. YouTube is increasingly being used as a platform for disseminating health information;
2. Content and frame analysis were the primary techniques employed by researchers to analyze the characteristics of this information;
3. YouTube often contains misleading information, primarily anecdotal, that contradicts the reference standards, and the probability of a lay user finding such content is relatively high;
4. The retrieval of relevant videos is dependent on the search term used; and
5. Videos from government organizations and professional associations contained trustworthy and high-quality information.

YouTube is used as a medium for promoting unscientific therapies and drugs that are yet to be approved by the appropriate agencies and has the potential to change the beliefs of patients concerning controversial topics such as vaccinations. This review recognizes the need to design interventions to enable consumers to critically assimilate the information posted on YouTube with more authoritative information sources to make effective healthcare decisions).

Betts (2014) puts forth the case that social media benefits should be measured not only in terms of ROI but also in terms of social returns. Though profitability may be of great importance in that no organization can survive and prosper unless it is self-sustaining, the cost of entry into social media is low, allowing for cost-effective experimentation and pilot tests to measure the effectiveness of various platforms. Indeed, analytics tools need to be applied to analyze data from various sources to help professionals and authorities. In the same vein, Maher A et al. (2014) review the current level of evidence regarding the effectiveness of online social network health behavior interventions. Eight databases were searched from 2000 to 2014 using a comprehensive search strategy. The findings concluded that there is very modest evidence that interventions incorporating online social networks may be effective; however, this field of research is in its infancy. Further research is needed to determine how to maximize retention and engagement, whether behavior change can be sustained in the longer term, and to determine how to exploit online social networks to achieve mass dissemination. Specific recommendations for future research are provided. Koumpouros et al. (2015) investigated the status of healthcare marketing via social media applications in Greece compared to other countries. The research conducted took into account the individualities of the Greek environment and revealed that both physicians and healthcare organizations have to move forward in order to engage with their customers. The study also demonstrates that there is a clear need to measure the effectiveness of any such media marketing effort.

Healthcare managers can no longer afford to ignore patient's support from networking communities –friends and family, and other healthcare providers during treatment (Boyer, 2011). This generational shift in medical services environment can be managed by recruiting and retaining tech-savvy personnel, and this is the need of the hour (Sarringhaus, 2011).

Healthcare managers should take all precautions into account to ensure legal and ethical use of social media by the organization. Horowitz (2014) described the special guidelines of the AMA for professionals' use of social media as it could bring up new challenges in the relationship between physician and patient. For example, inappropriate and incorrect content posted by employees on social media could lead to dire consequences for the patient and legal complications for the organization. Indeed, all healthcare providers and regulators including hospitals, governments, and pharmaceutical groups can play an active role in educating stakeholders on appropriate use of social media to avoid the risks and ensure adherence to high ethical and professional standards to maximize the benefits of this powerful tool. From technical perspective, various software are being developed by to mitigate the risks faced in this field so that healthcare organizations can even get alerts about online content related to itself (e.g., negative comments, ethical or confidentiality violations, information about kickbacks) and other content that could pose a serious threat to them (Weiss, 2012).

CONCLUSION AND IMPLICATIONS FOR HELATHCARE PROVIDERS

This chapter contributes to the on-going research on social media in healthcare. It scrutinizes the managerial perspective on social media in healthcare literature that has been published in various disciplines

including medicine, healthcare, management and information systems. Although this review does not claim to be exhaustive, it does provide significant practical insights into the appropriate use of social media applications in healthcare. First, healthcare providers have to recognize the implicit benefits and the competitive advantages associated with social media implementation over the long term in order to provide impetus for its adoption. In addition, successful adoption of social media within the healthcare context requires important internal facilitators such as creating awareness of its value across the firm; addressing all concerns relating to rules and regulations; encouraging feedback and continuing education and training for staff who are managing the social media applications; measuring metrics for effectiveness and efficiency of social media communications in real-time; and developing a content base for legal and compliance approval before posting it on social media. These actions may increase active social media participation among physicians, nurses and other staff and counter the negative perception of social media as a waste of time and effort. Second, healthcare managers need to develop strategies that are built around fostering the optimum level of social media infrastructure, knowledge, skills, and practice across the health organization. Third, healthcare providers should involve their clients to portray their social media needs on a personal level since cultural and demographic diversity could limit the reach of awareness massages. Zowawi et al. (2015) stated that measuring the impact of the social media–based awareness campaigns on the general public's understanding and behavioral change is a challenge and needs further research. Fourth, social media facilitate self-education and self-management of patients (Pal 2014). Therefore, healthcare providers should rigorously assess this facility to ensure safe education and up-to- date knowledge are effectively provided. Finally, compliance with policies, rules and regulations that govern communications within the healthcare sector is a key requirement to ensure protection and privacy of patient. Noncompliance could damage a firm's reputation, negatively impact it operations and make physicians stay passive on social media, since their positions might be jeopardized. So, electronic records must be complete and secured, with a controlled and supervised access, real patient identity should not be revealed by physicians on social media, and users must be careful not to harm their colleagues or organizations through sharing information on the social media.

The managerial perspective in this chapter presents a basis for theoretical, empirical or conceptual foundation and the methodological core for more investigation into social media in various healthcare settings. However, as with any review, the findings of this paper need to be tested with the help of appropriate empirical and multiple case studies. Another key limitation of this review is the heterogeneity of the identified literature. Literature on social media in healthcare is diverse. It covers various contexts, cultures, populations, study designs, social media applications and interventions. As a result, a relatively limited number of eligible studies of a general nature were categorized and reviewed. Therefore, future research on management of social media in healthcare may highlight the following issues:

- Investigating the use of one social media application (e.g., Facebook or Twitter) in healthcare management context across different interventions.
- Antecedents of successful adoption of social media in healthcare management context.
- How social media strategy enables core business processes in healthcare.
- The link between social media and healthcare knowledge management.
- Measuring healthcare quality before and after the adoption of social media.
- Cultural differences in using social media in healthcare, and the managerial implications.
- Risks associated with social media within different health interventions and contexts.
- Value analysis of social media contribution in healthcare operations and functions.

Although use of social media was mostly viewed as a personal endeavor, with its rising popularity, it has now become a notable force in the professional world of healthcare management as well. However, research on social media in healthcare is still in its early stages of development and, while several studies show promise, much is still to be learned about how to increase efficiency, effectiveness, and engagement on the longer term to achieve maximum benefits from a managerial perspective.

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Chapter 26
Preventing Occupational Stress in Railway Engine Pilots: Issues at a Glance

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ABSTRACT

Traffic volume and speed is going to be increased in Indian Railways successively leading to higher stress in train operations. The jobs of railway pilots come under the category of high strain jobs, necessitating a need to conduct study to unfold factors associated with occupational stress. OSI test, questionnaire of specific stressors and laboratory test battery were used as tools. Means of OSI of railway pilots was significantly higher than OSI of train operation staff. Mean of OSI of goods train pilots was higher to means to those of high speed and passenger train pilots. Study revealed positive correlation of speed perception and complex reaction time tests, and negative correlation of other constituent tests of laboratory test battery to OSI test. Highest stressor observed is role overload followed by role conflict. These findings provide evidence of higher occupational stress among railway pilots because of identified specific stressors. Significant correlation noticed between OSI and laboratory test results indicates its utility in preliminary psychological screening.

INTRODUCTION

Indian Railways is taken to be locomotive of national development. In addition to the socio-economic services, productivity of this organisation is also dependent on how prompt and how safely the trains are run. The 21st century is likely to throw more challenges in dealing not only with incessant and continuous increase of volume of traffic but also acceleration of speeds of trains. In fast growing economy of India, traffic volume and speed in railways is going to be increased successively with the passage of time, it is ought to create stress in staff connected with train operations. The role of train operating staff

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is of crucial importance for organisation as well as for public safety. At present train drivers (known as railway pilots) working in Indian railways have responsibility to run trains meant for transportation of passenger as well as goods. Train drivers running train in the speed of more than 130 km/hr are designated high speed train pilots, they qualify for this job only after getting essential fitness from Psych-technical Directorate of Research Design and Standards Organisation (RDSO), Lucknow.

The term stress is derived from a Latin word "string ere" meaning to draw tight. It has been used in English language since fifteenth century with a meaning of pressure or physical strain and by late twentieth century stress was connected with psychosomatic medicine to be a cause of ill health or mental disease (Dunbar, 1947). Stress has been defined in many ways in research and professional literature. Stress, which is a general term used for pressure that people are exposed to in life (Jepson and Forrest, 2006) may be defined as the individual harmony effort that the person displays against a stimulant which has excessive psychological and physical pressure on the person (Griffin, 1990). Stress is the abnormal reaction that the organism displays against threaten environmental elements (Luthans, 1994). When a person feels insufficient in dealing with demands and challenges faced in life, she/he experiences stress. Being harmed by this situation or taking advantage odd it mainly depends on the person because stress may either be a factor threatening the organism physically or psychologically or a power which gives energy in dealing with life (Baltaş, 2002). Cox (1987) has defined occupational stress as "a person's recognition of his inability to cope with demands to his work". Randall and Altmaier, (1994) defined organizational stress as the interaction between working conditions and the working person in environments in which the work demand exceeds the skills of the worker.

BACKGROUND

Karsek and Theorel (1990) have rated the occupations into four categories- active jobs, low strain jobs, passive jobs and high strain jobs. The jobs of railway engine pilots prima-facie come under the fourth category as they have to perform long hours of duty, and have to follow rigid procedures and are allowed little latitude for taking breaks or time off for personal needs. It becomes necessary for each organisation to identify stressors of their employee in relation to the organisational setup and categories of jobs. It is also necessary that strategies for reducing stress at both macro and micro levels are designed. Hence it is imperative for the Indian Railways to develop stress management strategies that can equip the human resource with effective coping styles. Moreover, findings of previous studies conducted at Research Design and Standards Organisation (RDSO), Lucknow presenting variations in results, tend to attract attention to make more detailed probe into the prevailing state of affairs in the job of drivers. It is also necessary to identify predictors of stress amongst drivers and its related variables and study specific stressors to their job. For developing effective stress management strategies, it is desirable to analyze the occupational stress among railway engine pilots, as they are directly related to train operations, keeping following objectives into consideration:

1. To empirically verify if there is higher level of occupational stress in the jobs of railway engine pilots in comparison to that of office clerks and train operation staff (station master, guard and gateman) in Indian Railways.
2. To compare the level of occupational stressors among railway engine pilots, office clerks and train operation staff.

3. To compare the level of occupational stress and occupational stressors among Indian railway engine pilots according to their different job conditions.
4. To identify typical sources of specific stressors for railway engine pilots in Indian Railways.
5. To find the correlations between laboratory test battery results and occupational stress index (OSI) of high speed train pilots in Indian Railways.
6. To explore the possible intervention strategies for reduction of stress in Indian Railways.

LITERATURE REVIEW

Hans Selye (1956), the pioneer in the stress research, refers the concept of "stress" to a characteristic non-specific physiological response. Stress is generally conceptualized as the altered state of an organism moderated by individual differences and produced by the agents (stressors) in the social, psychological, cultural and/or physical environment. Hans's General Adaptation Syndrome (GAS) has been widely held as a comprehensive model to explain the nature and person's response to stress. GAS is a three stages model- Alarm Stage, Stage of Resistance and Stage of Exhaustion. Hans also adds that stressors are additive. Each new and persistent stress may seem relatively unimportant in itself but it can be the straw that breaks the camel's back. In view of such revelations, greater attention is being paid in identifying macro-level (organisation related) and micro-level (individual related) stressors for reduction of stress at work place. Parasuraman (1992) observed that social support both organisational and extra-organisational have potential for moderating and attenuating detrimental effects of stress. Major functions of social support include health sustaining, stress preventing, and buffering.

Pestonjee (1992) identified jobs on the organisation, the social sector, and intro-psychic sector as important sectors of the life in which stress originates. The most common causes of stress can be classified as organisational stressors and life stressors. Life stressors outside the organisation settings are generally categorized in terms of life change and life trauma. Organisational stressors comprise of four general sets of stressors- task demands, physical demands, role demands and inter-personal demands. Task demands stressors include occupation, security and overload. Physical demands stressors are associated with the job's physical settings such as office/work place design, temperature, lighting, physical requirements. Inter-personal demands include group pressures, leadership style and personality. A role is a set of expected behaviours associated with a particular position in group or organisation. The causes and consequences of stress are related in complex ways. Common consequences of stress include individual and organisational consequences as well as burnout. Individual consequences are:

1. Emotional reactions like anxiety, sorrow, apathy, alienation, hypochondria resulting in organic disorders;
2. Cognitive reactions like difficulty in perception, concentration, memory functions, decision making, creativity leading to decreased output;
3. Behavioural presentations such as alcohol and drug abuse, marital discard, violence, antisocial behaviour; and
4. Psychological such as sleep disturbance, depression and physiological presentation such as medical ailments like headache, neuro-endocrinal, cardio-vascular diseases. Organisational consequences present as decline in performance, withdrawal (absenteeism and quitting) and turnover, decreased motivation and satisfaction. Stress related problems contribute to absenteeism and lost productiv-

ity (Carayon, 1993). Perhaps the biggest and incalculable costs of occupational stress are human causality due to errors made by workers.

Pareek (1980) pioneer in research on stress in India identified ten stressors related to role demands. These stressors are Inter Role Distance (IRD), Role Stagnation (RS), Role Expectation Conflict (REC), Role Erosion (RE), Role Overload (RO), Role Isolation (RI), Personal Inadequacy (PIN), Self Role Distance (SRD), Role Ambiguity (RA) and Resource Inadequacy (RIN).

RDSO Report (1997) concludes that driver's job has the higher level of stress in comparison to job categories like assistant station masters, train examiners and office clerks. But in contrast, mean of OSI among assistant station masters was found significantly higher in comparison to that of drivers as per RDSO Report (1999). These differences tend to attract attention to make detailed probe into the prevailing state of affairs in the job of drivers. Pandey (1999) in his works at Indian Railways background has emphasized the individual perception on the sources of stressors. A positive perception on the stress brings out 'Eustress' or glow up and negative perception brings out 'Distress' or burn out. It is comparable to a model on stress proposed by Pestonjee and Pareek (1997) where effective coping lead to glow up and ineffective coping lead to burn out.

METHODOLOGY

- To assess occupational stress and occupational stressors, Occupational Stress Index (OSI) test developed by Srivastva and Singh (2000) consisting of 46 items of specific sub-scales (occupational stressors) rated with 5 point scales was used by investigators. Test is convenient and suitable to administer in target subjects. Reliability index by split half method is 0.93 for OSI and 0.60 to 0.84 for sub-scales. Validity of test in relation to various measures including ill mental health indices is positively correlated (2 to 4.9). All study participants (n 408) were subjected to the OSI test in present multi-centric study conducted at RDSO Lucknow; North Eastern Railway Izzatnagar, Lucknow, Gonda, Gorakhpur; Northern Railway Lucknow, North Central Railway Kanpur, Allahabad; and East Central Railway Sonepur, Samastipur.
- To identify typical sources of specific stressors for railway engine pilots, questionnaire of specific stressors for the job of pilots containing 50 items of organisational role stress was constructed by investigators based on conclusions made in brain storming session where each subject was asked to give specific conditions relating to his experience in his job which created that type of stress in his mind. The questionnaire was rated with 'yes' or 'no' option. Validity of the questionnaire was rated satisfactory by the target group and managers. All railway engine pilots (n 134) were subjected to this questionnaire.
- To find the correlations between laboratory test battery results and OSI, high speed train pilots (n 20) were also subjected to laboratory test battery (being used by RDSO for psychological screening for high speed train locomotive pilots). The battery consists of test of form perception and perceptual speed (Fp), test of complex reaction time (Crt), test of speed perception (Spt), test of visual differentiating attention (Vda-f and Vda-s), test of concentration (Gbt) and composite T-score calculated on parameters.

RESULT AND DISCUSSION

1. **Comparison of Occupational Stress among Railway Staff:** Mean of OSI of railway engine pilots (156.47) is higher to those of office clerks (115.47) and train operation staff (station masters-125.12, guards-122.40 and gatemen-115.40) and differences are highly significant (Table 1, Appendix). It is verified that there is higher level of occupational stress in the jobs of railway engine pilots in comparison to those of office clerks and train operation staff. This observation is in conformity with the classification of occupation by stress by Karsek and Theorel (1990).
2. **Comparison of Occupational Stressors among Railway Staff:** Means of all the twelve occupational stressors (role overload, role ambiguity, role conflict, unreasonable group pressure, responsibility for other persons, under participation, powerlessness, poor peer relations, intrinsic impoverishment, low status, strenuous working condition and unprofitability) are comparatively higher in engine pilots (Table 2, Appendix). There is higher level of occupational stressors in the jobs of railway engine pilots in comparison to those of office clerks and train operation staff. There is existence of difference of sources of stress or dominant stressors from job to job in the organisation.
3. **Comparison of Occupational Stress and Occupational Stressors in Different Category of Railway Engine Pilots:** Mean value of OSI of goods train pilots (175.27) is higher to means of OSI of high speed train pilots and passenger train pilots (141.3 and 148.52) and differences (Critical Ratios 5.25 and 5.31) are highly significant. However, the difference of OSI between high speed train pilots and passenger train pilots (Critical Ratio 1.11) was found statistically insignificant (Table 3, Appendix). Mean values of all the twelve occupational stressors were found highest in goods train pilots followed by passenger train pilots and lowest in high speed train pilots. First highest stressor for the Railway pilots irrespective of their different categories is role overload. So OSI and means of all the twelve occupational stressors are comparatively higher in goods train pilots than high speed train pilots and passenger train pilots.
4. **Typical Sources of Specific Stressors for Railway Engine Pilots:** First highest stressor for the railway pilots irrespective of their different categories is role overload. Highest numbers of identified specific stressors are related to role overload like excessive strain on drivers in sighting signals (79.85% response) due to defect in signaling system, dim light of signals, changing position of signals abruptly, poor visibility; pressure and punishment without adequate training (78.35%) responsibility related to carriage department being shouldered by drivers (77.61% response); calling for duty without assuring exact arrival (73.31%), no respect by supervisors and operating staff (72.38%); long hours of duty and being away from home for long hours (71.64%) ; more strain in midway due to wrong marshalling or poor law and orders, insecure life, family problems, refusal to leave, lack of proper facilities (more than 60% pilots giving response). These findings are in conformity with the component of role overload, the first highest occupational stressor for the railway pilots irrespective of different categories. Moreover, identification of these stressors are in conformity with the observation made by Pandey (1999) emphasizing the need of the individual perception on the sources of stressors in view of reduction of occupational stress and its consequences.
5. **Correlations between Laboratory Test Battery Results and OSI of High Speed Train Pilots:** To find the correlations between laboratory test battery results and OSI, results of various subtests (Complex reaction time-Crt, Form perception-Fp, Group Borde test-Gbt, Speed perception test-Spt, Visual differentiating attention field-Vda fast, slow & series and composite T-scores) of all the high speed train pilots were compared by coefficient of correlations, and varying degrees

of correlations were found between the laboratory test battery results and OSI. High degree positive correlation of Spt, low but definite positive correlation of Crt, low but definite negative correlation of Gbt, Vda(f) & Vda(s), moderate (substantial) negative correlation of Fp & composite T-score were found in present study. Train pilots presented with low composite T-score (<40) are not considered fit for high speed train. Here in this study, they also had high OSI. Thus OSI test is correlated to laboratory test results.

ISSUES, PROBLEMS, AND INTERVENTION STRATEGIES

1. Railway engine pilots have higher level of occupational stress. Their jobs come under the category of high strain jobs, it necessitates a need to unfold factors associated with occupational stress and to improve intervention strategies.
2. Railway engine pilots have higher level of occupational stressors. There is also existence of difference of sources of stress or dominant stressors from job to job in the organisation. It points need of suitable macro level strategy.
3. Goods train pilots have higher occupational stress than high speed train pilots and passenger train pilots. High speed train pilots and passenger train pilots have almost equal occupational stress. Similarly, they have presence of all the twelve occupational stressors. It points that source of dominant stressors differ due to job conditions within different work categories of train pilots. There is need of suitable macro level strategy for prevention and reduction of occupational stress among different category of railway pilots.
4. First highest stressor for the railway pilots irrespective of their different categories is role overload. Although by introduction of diesel and electric traction, physical load has been considerably reduced, other factors are pressing heavy load of strain on them. Microanalyses of these stressors help in identifying predominant causes in stress. Actions need to be taken for various facets as identified here.
5. OSI test is correlated to laboratory test results. Moreover, OSI is simple and convenient to administer. Thus OSI may be helpful as preliminary psychological screening of railway engine pilots before sending them for complex laboratory tests.

SOLUTIONS AND RECOMMENDATIONS

- The present study offers empirical evidence towards possibility of railway pilots working under conditions of occupational stress. Management must try to keep employees free from various role stresses and stress management programme should be implemented at work places to improve quality of life and health.
- In order to alleviate staff from occupational stress, strategy to reduce stress both at Macro (Organisational) and Micro (Individual) levels are to be designed, testified for practical usability and carried out in such a way that as for as possible stressors relating to organisation are removed and stress tolerance threshold of individuals are enhanced to enable them to withstand the possible future stressors.
- The most dominant occupational stressors and typical originating conditions for railway pilots identified in present study should be addressed for stress reduction. Stress management pro-

gramme needs to be widened in scope to include staff of train operations wherein particular problems should get priority. Stress management programme in collaboration with leading consultants on stress audit, research and management along with active involvement of officers, supervisors, workers should be undertaken. A system of regular feed-back should be developed which may influence future policy and programmes as per need. Other than organisational coping strategies, individual coping strategies such as exercise, relaxation, transcendental meditation, time management, role management; support group of family/friends are other important component of stress management programme and it must be incorporated in present practice. Social support both organisational and extra-organisational have potential for moderating and attenuating detrimental effects of stress. Major functions of social support include health sustaining, stress preventing, and buffering.

- Stress is usually seen as phenomena when it occurs and leads to adverse consequences and approach is reactive. But approach should be preventive. On Indian Railways, Periodical Medical Examination (PME) is held at regular interval. PME must incorporate particular reference to psycho somatic complaints as preventive approach for stress reduction in employees having high strain jobs.
- Indian Railways provides financial incentives and allowances to train operation staff including railway engine pilots as per their demands. In spite of these benefits, these groups are suffering from higher stress and strain. Applicability of financial support needs to be examined carefully.
- OSI test is correlated to laboratory test results to some extent and it is simple to administer. OSI may be helpful as preliminary psychological screening of railway engine pilots before sending them for complex laboratory Tests.

FUTURE RESEARCH DIRECTIONS

The present study was specifically designed to identify macro level stressors through scientific method. The intervention was conducted on a limited sample of 408 railway employees. Generalisations made on the basis of this study should be carefully considered and further studies needs to be undertaken to replicate the findings.

CONCLUSION

To conclude, there is higher level of occupational stress in the jobs of railway engine pilots in comparison to other train operation staff necessitating a need to unfold factors associated with occupational stress and intervention strategies. There is existence of difference of sources of stress or dominant stressors from job to job and, source of dominant stressors within different categories of train pilots. It points to the need of a suitable macro-level strategy. Microanalysis of typical conditions leading to stress prevailing in the job of railway engine pilots helps in identifying the predominant causes. Hence there is also need of suitable micro level strategy to prevent occupational stress. Present on -going preventive organisational strategies needs careful examination and it must be supplemented with social support, individual coping strategies and regular feedback and corrective measures.

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KEY TERMS AND DEFINITIONS

Gateman: Person employed at level crossing of railways responsible for rail and road traffic.

Guard: A crew member in rear part of the train responsible for operational and safety duties.

High Speed Train Pilot: Loco pilot running train more than 130 km/hour speed in Indian Railways.

Indian Railways: An Indian state-owned enterprise owned and operated by the Government of India through the Ministry of Railways, the world's largest network under a single management.

Laboratory Test Battery: Series of tests used by RDSO for psychological screening for high speed train locomotive pilots.

Occupation Stress Index (OSI): Acceptable scale for measuring job stress.

Occupational Stress: Stress related to one's job, often stems from unexpected responsibilities and pressures that do not align with a person's knowledge, skills, or expectations, inhibiting one's ability to cope.

Questionnaire: A norm containing a set of questions submitted to people to gain statistical information.

Train Operation Staff: Basic functioning team responsible for train operations. Indian Railways consists of more than 100,000 Train (loco) pilots/Assistant pilots /Guards/Station masters/Gateman responsible for train operations.

APPENDIX: TABLES

Table 1. Differences of OSI among office clerks, train operation staff, and railway engine pilots

Group	Employee Category	N	Mean	SD	Critical Ratio
1.	Railway Engine Pilots	134	156.47	29.64	9.466*
	Office Clerks	51	115.47	25.01	
2.	Railway Engine Pilots	134	156.47	29.64	15.89*
	Station Masters	72	125.12	25.01	
3.	Railway Engine Pilots	134	156.47	29.64	14.72*
	Guards	76	122.40	26.14	
4.	Railway Engine Pilots	134	156.47	29.64	15.58*
	Gatemen	75	115.40	24.18	

* Statistically significant at 0.01 level.

Table 2. Difference of occupational stressors between railway engine pilots and office clerks

Occupational Stressors	Railway Engine Pilots		Office Clerks	
	Mean	SD	Mean	SD
Role Overload	23.26	4.61	18.25	5.27
Role Ambiguity	13.07	3.84	9.03	3.14
Role Conflict	15.51	3.51	11.05	3.70
Unreasonable Group Pressure	12.39	3.49	9.88	3.37
Responsibility for Persons	11.79	2.20	8.84	2.66
Under Participation	14.61	3.67	12.05	3.33
Powerlessness	10.76	2.84	9.32	2.65
Poor Peer Relations	12.40	2.93	10.07	1.87
Intrinsic Impoverishment	12.28	4.06	8.25	2.95
Low Status	9.48	3.14	5.49	2.26
Strenuous Working Condition	12.94	4.11	8.11	3.05
Unprofitability	7.82	2.29	4.98	1.97

Table 3. Differences of OSI among different categories of railway engine pilots

Group	Category of Railway Engine Pilots	N	Mean	SD	Critical Ratio
1.	Passenger Train Pilots	67	148.52	29.02	1.11
	High speed Train Pilots	20	141.3	24.26	
2.	Goods Train Pilots	47	175.27	24.45	5.31*
	Passenger Train Pilots	67	148.52	29.02	
3.	Goods Train Pilots	47	175.27	24.45	5.25*
	High speed Train Pilots	20	141.3	24.26	

*Statistically significant at 0.01 level.

Chapter 27
Hospital Social Media Strategies:
Patient or Organization Centric?

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ABSTRACT

This chapter describes the role social media plays in patient communication at hospitals. The chapter explores how social media platforms are used by national and local hospitals to deliver higher quality healthcare and increase patient engagement. Using an in-depth literature review and semi-structured interviews at two local hospitals, the chapter assesses how hospitals approach traditional and social media strategies. The chapter identifies the importance of using both online and offline communication strategies for the most comprehensive and effective delivery of healthcare. The chapter also includes a discussion of how social media has the ability to influence health information seeking and the patient-physician relationship.

INTRODUCTION

Hospitals are increasingly using social media as a strategic platform to communicate with patients and increase this engagement. Social media has been shown to increase hospital revenue, improve quality of care, and strengthen patient recruitment and retention (Harris et al, 2013). Yet, traditional communication strategies are still powerful in engaging patients and should not be put on the back burner. The authors propose that effective patient engagement strategies need to include both online and offline avenues. Healthcare institutions with strategies that do not address both these avenues risk overlooking and under-serving (or not effectively serving) a significant demographic of their patient population.

This chapter will begin by examining the social media and patient engagement strategies employed by two hospitals. This will include a discussion of the social media best practices used by these hospital

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systems. The authors will then explore, via in-depth interviews, how the two local hospitals implement traditional and social media strategies on a smaller scale. The chapter will highlight how these local hospitals engage patients and healthcare providers both online and offline. The authors will describe some of the difficulties these hospitals face and their efforts to address these challenges. Finally, the authors will discuss how value-based healthcare can impact the digital marketing and patient engagement strategies of these organizations.

BACKGROUND

This chapter seeks to uncover best practices used by hospitals in their efforts to engage health information seekers and inform their communities while attempting to meet their strategic objectives. This resulted in our analysis of social media, hospital and patient engagement studies as noted below.

Surveys indicate that social media is used by 65 percent of US adults who are online, and this represents nearly half of all US adults (Harris et al, 2013). Facebook and Twitter are the most commonly used social media platforms with avenues, such as Vine and Instagram, gaining increasing popularity, particularly among younger adults. Social media use in the US does vary by age, but is independent of education level, health care access and race. There is no significant difference in use based on education or income among Twitter users. Black non-Hispanic Internet users (28 percent), however, are more frequent Twitter users than Hispanics (14 percent) and White non-Hispanics (12 percent). Twitter is also used far more by young adults and by those in urban and suburban areas compared to those in rural areas (Harris et al, 2013).

Given these trends, it is understandable that an increasing number of people turn to social media for health information. In the US, 80 percent of Internet users (who represent 59 percent of all US adults) seek health information online. Moreover, nearly 20 percent of users turn to social media platforms for health information—whether it is to gather information for personal conditions or to learn about family and friends' health experiences. For these individuals, the Internet is a crucial source of health information (Harris et al, 2013). Early research by the Pew Internet and American Life (2006) reported that health information seekers indicated that eight of ten Internet users, or roughly 113 million adults, have sought health information online.

Given these statistics as well as challenges and opportunities associated with technology disruptions, healthcare providers and institutions have also increasingly turned to social media to disseminate health information to patients and share information with each other. Although healthcare entities grapple with how best to deliver relevant information to patients and how to stay abreast of rapidly evolving social media trends, research indicates that between 60 to 82 percent of US state health departments use at least one social media platform. Those who are proponents of healthcare providers using social media believe they can engage in meaningful dialogue with patients and use the platforms as a way to effectively communicate time-sensitive health information (Harris et al, 2013; Richter et al, 2014).

With this communication context as the backdrop, healthcare reform has brought changes to the way both healthcare providers and patients view the provider-patient encounter. Patient care no longer means a fixation on isolated encounters; instead, the focus has shifted to long-term goals with prevention and wellness at their core (Axial Patient Engagement, 2014). This transformation means that health providers must work to develop stronger relationships with patients and be proactive about communicating with them. This shift not only affects positive behavioral change in patients, but also has the potential

to improve the profitability of the healthcare enterprise. Increased patient engagement through online and offline avenues can reduce hospital readmissions, increase hospital revenue, improve quality of care and strengthen patient loyalty (Axial, 2014).

United States hospitals have already started to understand the value of using popular social media platforms to inform and educate their patients. Disseminating health information through social media, however, can be valuable if it promotes behavior change and improves public health. Hospitals should not engage in social media just for the sake of doing so, but should be mindful and actively seeking to improve health, wellness and healthy behaviors (Harris et al, 2013). To that end, institutions need to equally emphasize both online and offline communication strategies. As Dr. Tom Valente of the Department of Preventive Medicine at University of Southern California describes:

To be most effective, the online component of any strategy needs to be organized and coordinated with other behavioral promotion, services and follow-up. (GE Healthcare, 2012)

Traditional avenues of communication, such as personal networks, direct mail, face-to-face interactions, still play an important role in meaningful and effective patient engagement, and should not be disregarded.

Social media has indeed been effective in public health initiatives, such as pediatric health and smoke cessation in new mothers (Harris et al, 2013). Tweets, likes and posts on social media platforms about new moms staying smoke-free, nonetheless, are more effective if a trained professional is available to communicate with patients during face-to-face encounters. While online behaviors can result in positive health-related actions, offline (positive) behavioral change is probable and result in improved wellness. Hence, comprehensive patient social and communication strategies can be most effective in the presence of online and offline engagements with patients, physicians and other healthcare providers.

While the online encounter can reinforce patient-physician relationships, treatment plans and adherence, the rationale for the offline portion of any strategy should recognize the educational, digital and content divides among patient populations. Tu and Cohen (2008) of The Center for Studying Health System Change examined the idea that educational attainment was strongly associated with the likelihood of seeking health information via the Internet. While persons with a graduate education sought health information at the rate of 72 percent, only 42 percent of those without a high school diploma engaged in health information seeking in their study of 18,000 people (Tu & Cohen, 2008). With regard to the digital divide, their research showed an even wider gap for Internet use (52 percent to 10 percent). Relative to the content divide, the notion of cultural identity and competency challenges healthcare organizations to be cognizant of the how, what, why. Organizations must also be aware of how health messages and information resonates with the diversity and plurality among the populations targeted and served (Payton, et al., 2014).

Healthcare institutions also are confronted with the tension of "social media balancing". That is, what degree of online content should be institution-centric content versus patient-centric content? In a 2012 study of US healthcare organizations, nearly 75 percent of the social media content posted by health institutions highlighted recent institutional achievements and focused on targeting hospital employees rather than patients (Miller & Tucker, 2013). This type of content, albeit valuable for employee engagement, does not induce patient engagement. Rather, these types of social media post essentially focus on the institution's own strategic direction, mission and institutional competencies. Such content can be likened to the "vanity metrics" described by Madison (2012) in the *Harvard Business Review*. Madison

describes vanity metrics as those social media metrics that make an enterprise appear exceptional, but fail the "So what?" test. These metrics, such as number of page views, click streams, Facebook likes and Twitter followers, are often highlighted to demonstrate organizational success. As Madison emphasizes, such vanity metrics might be accurate, but they are irrelevant. For example, a healthcare department can generate several posts and tweets that are inevitably going to be viewed and clicked on by patients because of the sheer volume of content generated. Yet, a major question remains: how many of those posts actually contain content that is directly relevant to patients? Hospitals must go beyond generating content that gives a desirable organizational appearance within the industry and instead focus on what actually can engage patients, improve the patient experience and improve hospital efficiency.

This is why hospitals should consider shifting their focus toward alternative metrics of success—patient engagement scores. One such score is the Axial Becker metric. While hospital rankings, such as US News and World Report, provide some metric of hospital performance, these reports do not specifically measure patient engagement. Patient engagement occurs when patients become more involved and invested in their personal health (Axial, 2014). Health entities with strong patient engagement programs equip patients with the appropriate tools and information they need to take ownership of their health. Moreover, hospitals with excellent patient engagement have better clinical outcomes and improvements in cost of care (Axial, 2014).

For these reasons, we examined the Axial Becker patient engagement score when assessing the key similarities and differences between the two hospitals in our study. The Axial Becker score evaluates hospitals based on four main outcome measures: 1) readmissions, 2) patient satisfaction, 3) patient education and self-care tools and 4) social media engagement. By combining these factors, the Axial Becker score goes beyond hospital rankings based on the amount of research funding received or the number of social media posts generated (Axial, 2014).

Axial Becker accounts for these four factors as follows. The number of hospital readmissions is incorporated into the scoring methodology. Nearly twenty-five percent of Medicare costs for inpatient care are due to readmissions. The goal here is more efficient resource utilization. Accordingly, the Centers for Medicare and Medicaid Services lists a reduction in readmission rates among one of its key outcome measures for improved patient care. The Axial Becker score does take into account a hospital's social media presence, but readmission reduction, self-care tools and patient satisfaction are equally weighted at 25 percent in determining overall patient engagement (Axial, 2014).

In sum, the literature offers that social media is an important metric in patient engagement for hospitals. Hospitals, however, must find a delicate balance between the social good and the strategic balance to identify what social media metrics are relevant to their context. To explore this balance, this chapter provides our research methodology, results and conclusions in the following sections.

SOCIAL MEDIA STRATEGIES AT TWO LOCAL HOSPITALS

Our research methodology consisted of a literature review and semi-structured interviews at two local hospitals. These hospitals were identified based on a convenience sample and prior professional contacts of the first author. The hospital interviews were primarily conducted to gain a deeper understanding of the experiences and challenges these local hospitals have with their social media and patient engagement strategies. The hospitals had some goals and strategies in common in terms of social media and patient

engagement, but differ in some key areas, such as hospital size/number of beds, number of admissions, inpatient and outpatient surgeries. Table 1 provides a profile of the two organizations based on these key characteristics.

Both hospitals described a desire to be a resource with a strong voice for community and health advocacy. The researchers interviewed four healthcare professionals who worked in social media, marketing or communication departments from both organizations. Initial interviews were 30 minutes via telephone with a second round of one-hour face-to-face-interviews. Both authors were involved in the initial interviews to establish direction and connect with the appropriate organizational professionals from both hospitals. The second author conducted the second round interviews and took detailed notes during each interview. The initial interviews consisted of the authors and healthcare professionals exchanging background information and explanation of why this research is important. The second round interviews were guided by the following questions: *How has patient engagement evolved given the proliferation of social media? How important is social media to the hospital's patient engagement?*

The interviewees emphasized consistency and establishing a clear voice as crucial elements of a successful social media strategy. One organization described a strong sense of pride in having roots as a community hospital that has staff members who participate in civic events outside of work hours. Accordingly, one of the main goals of the social media strategy at this hospital is incorporating this community outreach into the hospital's social media platform. The hospital uses patient stories as a primary mode of delivering content and believes that heightened online engagement will result in increased community and patient engagement.

One interviewee, however, emphasized that the hospital's goal is not to focus on the number of "Likes" and "Followers" on social media, but rather on patient engagement. The interviewee believed that transparency is a key factor in promoting patient engagement—developing platforms that allow open and frank communication between patients and health care providers, honestly listening to and acting on feedback, and making changes that increase the transparency of healthcare encounters. For instance, by allowing patients to leave comments on the hospital's social media pages, the hospital has been able to respond to patient feedback in a timely manner and be more proactive. Moreover, increased traditional forms of communication, such as telephone calls or in-person meetings, to continue the conversation started on-line, often follow these social media interactions. As described by the interviewee, some patients became, "more loyal and more invested in our hospital because we showed them we care about their (experiences) and wanted to learn from it so we can improve."

Interestingly, a willingness to interact via social media is not just limited to the younger patient population at these hospitals. Interviewees have found the older patient population is their fastest growing

Table 1. Profiles of hospitals in this study

	Hospital A	**Hospital B**
Number of Beds	148	660
Hospital Type	General medical and surgical	General medical and surgical
Number of Admissions Last Year	7,000 +	27,000+
Number of Inpatient Surgeries	3,900+	9,000+
Number of Outpatient Surgeries	12,400+	27,000+

age demographic for Facebook. Meanwhile, those in their 20s and 30s are reaching beyond Facebook and into spaces, such as Twitter, Instagram, Vine and Pinterest. One hospital in particular described how "young mommies" are an important patient segment that is very engaged on several social media platforms. This patient segment has been increasingly reaching out to these local hospitals online and sharing their health information on hospital-sponsored webpages. This has resulted in the hospital marketing and communication teams increasingly keeping abreast of changing social media trends and topics.

We determined that the evolving social media trends meant that healthcare professionals often must leverage resources external to the industry and examine areas, such as digital marketing and technology, to stay abreast of emerging online developments. As one communication strategist describes, this allows the team to keep a pulse on what social media trend is around the corner and where they might find a significant portion of their patient population interacting with and seeking health information. For instance, two years ago, one hospital experimented with both Vine and Twitter when it noticed that these two social media platforms were gaining ground in the general digital marketing landscape. After some time, the organization found that Vine did not pick up much speed with their patient population, but Twitter gained a following that has continued to grow over time.

Despite these outcomes, the hospitals also realize that social media platforms that may have success today can easily become obsolete due to changing communication trends. For example, organizations focused on Facebook "likes" because it actually meant something—if someone "liked" a post, it showed up on their Facebook page and other Facebook users would view the content as well. Currently, likes hold less relevance because Facebook has developed filters that prevent a majority of likes and similar actions from appearing on users' pages easily. Organizations that want to have their posts and "likes" appear at the top of users' Facebook streams must pay to have the content boosted. Not only does this increase the potential costs incurred by hospital marketing departments, but it also decreases the organic word-of-mouth marketing potential generated from users sharing posts about the hospital with each other.

Due to changing privacy controls instituted by social media companies and the constant shifts in the potential reach of a social media platform, these hospitals are turning back to incorporating more traditional communication strategies into their patient engagement endeavors. For example, one of the local hospitals described how they instituted "patient navigators" to help patients through their entire health experience and to communicate with them both online and offline. They have also developed self-care tools (videos and online chats) that help patients reach out to health care professionals after they were discharged from the hospital. These hospitals have also taken measures to encourage greater online and offline involvement by their physicians, nurses and other healthcare providers. As one interviewee described it, "our goal is to also employ an inside-out strategy and get our physicians and nurses involved on social media so that their knowledge and interest radiates out into the patient community (for engagement)".

Unfortunately, the marketing and communication departments do not always find it easy to get busy healthcare providers involved in social media. While some physicians who are self-motivated to engage online and write blogs, create Facebook posts and generate Tweets, others are neither interested in social media nor see the relevance of social media engagement. With these health care professionals, the hospitals have seemed to find some success in using platforms, such as "My Chart," which are still electronic platforms, but remain distinct from social media platforms. One hospital described how implementing "My Chart" has become a great way for patients to access their health records online and get messages from their health care providers, and vice versa. Though the professionals were not entirely certain of the full impact of "My Chart" given its recent launch, the affiliated hospital has already seen

an improvement in the communication and engagement between patients and healthcare providers. Their goal is to increase utilization of the "My Chart" tool and to develop sustained and "meaningful use."

FUTURE RESEARCH DIRECTIONS

Social media can be a beneficial tool in the patient-physical communication process and enhance patient engagement. Hospitals must implement holistic approaches to social media frameworks and include traditional forms of communication strategies. This can better enable those patients who are digitally connected as well as those less apt to use social media platforms, or who simply choose to opt-out online interactions.

While social media metrics, albeit vanity and/or operational in nature, hospitals will continue to be challenged by providing both health care information and care delivery simultaneously

(Payton, et al 2014). This means developing social media and communicate strategies that are appreciative of culture competence, relevance and community needs while aligning the balance of conventional performance metrics. These points become increasingly more significant as the Affordable Care Act (ACA) takes effect. In light of the patient experience, social media, technology, cultural dynamics and national legislation, we need to understand how these emerging issues will impact hospitals evolving communication strategies. While these strategies are often "confidential", we need some level of understanding in order to capture promising practices and potentially study their implementation relative to organizational context and institutional collaboration.

CONCLUSION

Both hospitals describe how terms such as 'meaningful use,' 'utilization,' and 'patient engagement' have become fairly prevalent in conversations and meetings relative to current and future communication strategies. We contend that the Affordable Care Act (ACA) has brought a change in the marketplace and the way that these hospitals approach their communication strategies. Nevertheless, the professionals believe that while there might be new terminology and definitions for the standards, collaboration and best practice sharing can be of benefit to healthcare stakeholders. As one interviewee expressed, "We should have been focusing on reducing readmissions, engaging patients and meaningful use a long time ago. The ACA requirements just provide structure and a greater incentive for the hospital to improve things we should have been working on all along." It is these requirements that lend themselves to how hospitals will engage patients and will impact both online social and offline in-person communication strategies. This research concludes that this is not a binary proposition. Rather, patient engagement is a continual process and a blended strategy can further improve meaningful use and the patient-physician or patient-healthcare provider relationship.

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KEY TERMS AND DEFINITIONS

Health Information Seeking: The act of proactively searching for information related to one's health issues, either online or through one's personal network.

Patient Engagement: A state in which patients are actively involved in their health care decisions and take on a greater role in influencing their personal health outcomes.

Patient-Physician Relationship: The interactions between a patient and physician that impact a patient's overall health experience and medical outcomes.

Social Media: The sphere of online communication and associated platforms that allow users to interact with each other virtually, exchange ideas and share content.

Social Media Balancing: The act of reaching a balance between the amount of social media content that is institution-centric versus patient-centric.

Vanity Metrics: Statistics that are gathered and reported for the purpose of boosting an organization's image, but do not necessarily provide information about truly important measures.

Section 5

Policy Implications

Chapter 28
A Factor Analytical Study of Safety and Health Issues in Select Small and Medium Manufacturing Concerns

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ABSTRACT

Safety and health are the important issues which must be taken up by the organizations to ensure satisfaction of the employees and also to ensure productivity in the organization. Particularly in small and medium enterprises, these issues demand more concern as due to small size of firm, they are often neglected. This chapter gives an overview of small and medium enterprises in India, their role in the development of economy. Moreover, this chapter focuses on the importance of Safety and Health in the organization, how they are taken up as major concerns of the organization by International Labor Organization in the form of providing various conventions and ratifications and what are the various provisions regarding the same in the Factories Act in India. The outcome of the chapter is the factors which are particularly relevant for ensuring safety and health of employees in small and medium enterprises. For determining the factors, Factor analysis was performed on the data collected from the respondents with the help of questionnaire comprising of statements on Likert scale.

INTRODUCTION TO SMALL AND MEDIUM ENTERPRISES

Small and medium enterprises are emerging as an important sector of the economy over the last five decades. (Rana, 2014) This sector can be considered as one of the most vibrant sector of the economy. Small and medium enterprises have a vital role to play in the economic development of the country. They can be considered as the backbone of Indian economy. They are the major contributors towards the

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gross domestic product as far as India is concerned. They not only help in industrialization of the rural and urban areas but also help in creating employment opportunities to the people of the country, thereby combating regional imbalances. (Rana, 2014). With the growing importance of Small and medium enterprises in the economy as a major contributor to the economy, Micro, Small and Medium Enterprises Act came into being in the year 2006. With the promulgation of Micro, Small and Medium Enterprises Act in 2006, the Small and Medium enterprises are all set to revamp with a large number of facilities provided to them by the government. Moreover, with the formation of the Act, scope of erstwhile small enterprises has expanded to Micro, Small and Medium Enterprises. It has thus broadened the scope in terms of production, exports and employment, thereby facilitating a breeding ground for entrepreneurship at grass root level.

Small and medium Enterprises are defined in different ways in different parts of the world. Some define them in terms of employment, some in terms of assets, sales or other. The definition of Small and medium enterprises is a contentious issue in India. In India, they are defined in terms of investment in Plant and machinery. Small and medium enterprises hold a special place in Indian economy.

As per MSMED Act 2006, the definition of Small and medium enterprises, most commonly referred to in as SMEs, in manufacturing sector can be broadly put as:

- Small enterprise is the one in which investment in plant and machinery is 2.5 million with a maximum ceiling of 5o million.
- Medium enterprise is the one in which the investment in plant and machinery is between 50 million to 100 million.

Small and Medium Enterprises in India

Small and medium enterprises hold special place in the Indian economy as they contribute to 45% of industrial output, 40% of export, 42 million in employment generation, create one million jobs every year and produces more than 8000 quality products for Indian and International markets (The Role of SME Sector in Nation Development).

Small and medium enterprises in India contribute to 7.28 percent to the Gross Domestic Product. (Report of All India Fourth Census of MSME, 2013-14)

As per the Fourth All India Consensus of Small and Medium enterprises, the SME'S have increased from about 80000 units in 1940's to1.564 million. They employ 2.775 million people (2.343 million in small and .432 million in medium enterprises) and contribute to 7075100 million production including highly technological products. Their contribution to exports is about 6791.4 million. The numbers are grossly adequate and apply to registered Small and medium enterprises.

As per All India Fourth Census of Micro Medium and Small enterprises (MSME), the sector contributes to 7% of GDP of India. The estimated value of manufacturing output of MSME and its share in total manufacturing output is given the Table 1.

The Table 1 shows the estimated value of manufacturing output of MSME sector and its share in total manufacturing output. The Table shows that the percentage contribution of MSME has decreased from 42.02% in 2006-07 to 37.52% in 2011-12 which represent the change in last six years. The Table also shows that GDP contribution has fallen from 7.73% in 2006-07 to 7.28% in 2011-12. This can be attributed to the fall in manufacturing sector of the nation But despite the fact that the percentage contribution towards GDP and total manufacturing output has fallen, the sector has performed extremely

Table 1. Total output of MSME, contribution of MSME towards total manufacturing and gross domestic product

Year	Output (in Million)	Percentage Share of MSME	
		Total Manufacturing Output	Gross Domestic Product
2006-07	11988175.5	42.02	7.73
2007-08	13229604.1	41.98	7.81
2008-09	13756986.0	40.79	7.52
2009-10	14883902.3	39.63	7.49
2010-11	16555806	38.48	7.42
2011-12	17908046.7	37.52	7.28

Source: Report of All India Fourth Census of MSME, 2013-14.

Table 2. Employment in MSME and market value of fixed assets from 2001 to 2012

Year	Employment (Million)	Market Value of Fixed Assets (Million)
2001-2002	24.933	1543490
2002-2003	26.021	1623170
2003-2004	27.142	1702190
2004-2005	28.257	17869910
2005-2006	29.491	1881130
2006-2007	80.523	8685437.90
2007-2008	88.42	9204598.40
2008-2009	88.808	9771147.2
2009-2010	92.179	10385480.8
2010-2011	96.515	11059340.9
2011-2012	101.180	11833320
2012-2013	106.152	12693380

Source: Annual report of All India Fourth Census of Small and medium enterprises, 2013-2014.

well in certain parameters. The performance of this sector can be evaluated in terms of some important parameters such as number of units, employment in this sector and Market value of fixed assets. It is further supported by the Table 2. From the table it can be established that this sector has contributed tremendously to the employment generation and it can be seen that market value of assets has also gone up from 1543490 million in 2001-02 to 12693380 million in 2012-13.

Role of Small and Medium Enterprises in Uttarakhand

The state of Uttarakhand was carved out of Uttar Pradesh in the month of November 2000. Kumaon region and Garhwal region formed 2 main parts of Uttarakhand. The state has 13 districts namely:

- Kumaon region:
  - Almora,
  - Pithoragarh,
  - Nainital,
  - Udham Singh Nagar,
  - Champawat Bageshwar.
- Garwal region:
  - Pauri,
  - Tehri,
  - Uttarkashi,
  - Dehradun,
  - Rudraprayag,
  - Chamoli,
  - Haridwar.

Of these 13 districts, Nainital, Haridwar, Dehradun and Udham Singh Nagar have large areas in the plains while other districts comprise the hill region of state (Shishir, 2010). When the state was formed, it had to meet the expectations of a lot of people in terms of providing them with good standard of living and development of the local regions. Due to State Infrastructure and Industrial Corporation of Uttarakhand came into incorporation as a limited year to promote the industrial development of the state. Besides providing infrastructure to some of the major projects of the same in growth centre at Pauri, Industrial estate at Sitarganj, Integrated Industrial estate at Haridwar, Pharma city in Dehradun. State Infrastructural Corporation of Uttarakhand Limited helps in setting up of projects at short duration of time (Shishir, 2010).

All the promotional schemes of the government are promoted through single window system. Facility that allows parties involved in trade and transport to lodge standardized information and documents with a single entry point to fulfill all import, export, and transit-related regulatory requirements is single window system. If information is electronic then individual data elements should only be submitted once (Shishir, 2010). The state has witnessed massive industrialization in past 2 decades. But the major focus was put on plains in Industrial Policy of 2003.Thus an effort was made to put focus on development and industrialization of the hilly areas as well which further led to formation of Integrated Policy of 2008. The major objective of the policy was to foster economic development and growth prosperity especially to the hilly areas of the state. It aimed at providing employment opportunity to many, removing economic disparities, and curbing the migration of people from hilly areas to the plains in search of jobs and better quality of living. These steps are taken in addition to the Industrial Policy 2003, which aimed at providing a comprehensive framework in enabling an investor-friendly environment to make sure that industrial development takes place at accelerating pace and is sustainable also. Through this, a lot many employment opportunities will be in fray and would further lead to significant increase in the State domestic product and eventually may lead to broadening the scope. To promote single window facilitation in the state and providing conducive environment to the investment was also the motto of the Industrial policy.

Not only is the objective of the policy being to offer assured, qualitative, uninterrupted and affordable power for industries but also to simplify and rationalize labour laws and procedures in line with current requirements while ensuring that workers get their due share in the economic development of the state.

It will also assist small scale industries like khadi and village industries, handicraft and silk, handloom etc. in modernization and technological up gradation and provide all necessary help in the form of backward and forward linkages, product design and marketing support so as to make them globally competitive and revenue generating (Shishir, 2010).

The Table 3 represents the accelerating growth of Small enterprises in Uttarakhand and India in 2001 and 2012. Uttarakhand shows an increase of more than 200% in terms of growth of enterprises and if we see the increase in the total enterprises in India, the growth has been 400% ie. from 1,05,21,190 in 2001-02 to 4,67,56,000 in the year 2012-13. The increase in number of units in Uttarakhand can be attributed to Industrial Policy.

Introduction to Safety and Health

Safety and Health are important issues that almost every manufacturing organisation face. The employees are adversely affected if these are not taken due care of. Also it has an impact on the overall organisational productivity. It has been established that negligence in providing safety and health of employees can be detrimental to the nation at large. (Lamm, Messy Perry, 2006). India is a vast country with a population of over 1.2 billion, out of which 13.1% of population is involved in employment in manufacturing concerns of small and medium size. (Annual Report of Ministry of Micro Small and Medium enterprises, Govt. of India).

The research was conducted keeping in mind the growing need of safety and health in the organisations. The prime objective of the research was to find out the various issues of safety and health which are required to be taken care of, especially in manufacturing concerns of small and medium type.

Occupational safety and health (OSH) is an area related to protecting the safety, health and welfare of people engaged in work or employment. The objective of occupational safety and health programs is to foster a safe and healthy work environment. Occupational Health and Safety is not just for providing safety and health protection to employees but also concerned with protecting the family, coworkers and other stakeholders of the society. (Husain, N. H. 2010).

Health and safety are grave risks that most of the manufacturing organizations face. These risks can adversely affect the operations and productivity of businesses directly or indirectly. If an organization is looking ahead to grow and prosper, it becomes important for them to manage the risks in an efficient manner, because by managing business risks, an organization's health, assets and opportunities are secured and best taken advantage of (Fuller, 1997)

Table 3. Small and medium enterprises in Uttarakhand along with India in 2001 and 2012

	Uttarakhand		**India**	
Year	2001-02	2012-13	2001-02	2012-13
Total Number of Units	1,06,484	2,23,000	1,05,21,190	4,67,56,000

Source: Annual Report of Ministry of Micro Small and Medium enterprises, Govt. of India.

Provisions Related to Heath, Safety, and Welfare of Employees in Factories as per Factories Act 1948

There is various provision related to Health, Safety and welfare mentioned in Factories Act, which forms the bible to manufacturing organizations.

Provisions related to HEALTH as per Factories Act, 1948:

- **Section 11 Cleanliness:** This provision talks about cleanliness of floor, walls, doors, windows and railings. It also states that there should be well maintained register keeping a track of all cleanliness related activities.
- **Section 12 Waste and Affluent:** There should be proper provision of removal of dust and fumes generated in the factories and adequate treatment of the same has to be there.
- **Section 13 Temperature and Ventilation:** The temperature of the workplace should be adequate and efforts should be made to maintain the temperature. Excessive heat should not be produced at the workplace. There should also be proper ventilation.
- **Section 14 Dust and Fumes:** The work place should be free from dust and fumes and provision for exhaustion of the dust and fume should be there.
- **Section 15 Artificial Humidity:** There should be a proper provision of instrument for recording the artificial humidity and there should be appropriate method to control artificial humidity also.
- **Section 16 Overcrowding:** There has to be around 14.4 cubic meters of space of an employee. The Act says that the maximum capacity of the room should be put outside the room and a log should be maintained in this regard.
- **Section 17 Lighting:** Lighting arrangements have to be made in the premises in the matter that they don't cause glare in the eyes. Shadow should not be created in the work area due to light.
- **Section 18 Drinking Water:** Safe and hygienic provision of water should be there and the drinking water should be kept away from urinals and latrines. The drinking water should be legible make in the language which the employees understand.
- **Section 19 Latrines and Urinals:** There should be separate place created for men and women. The walls and floor of the place should be properly tiled and height should be appropriate. Hygiene must be maintained therein and they must be cleaned on everyday basis.

Provisions related to safety of employees:

- **Section 21 Fencing of Machinery:** This section prescribes that the machinery should be properly fenced and especially the dangerous part of machinery should be adequately fenced
- **Section 23 Employment of Young Person:** This section deals with prescription of not allowing the young person on dangerous machinery. It also says that he can only do so if he is instructed properly in this regard and working under the supervision.
- **Section 24:** This provision deals with providing special devices for cutting off the power especially in case of emergency. For moving belts, there has to be provision for striking gears as well
- **Section 28:** The section says that women and children should be prohibited from working on specific machineries especially cotton openers.
- **Section 32:** This section deals with properly constructing and maintaining the stairs, passages, floors and gangways, so that there is no chance of slip.

- **Section 34**: The section deals with not allowing employees to lift load or carry any load beyond the permitted limits, which are prescribed by the State Government.
- **Section 35:** Adequate provisions for safety and protection of eyes of workers must be there. It states that goggles and glasses must be provided to the employees involved in any such manufacturing process, which may cause harm to the eyes of the employees
- **Section 36:** This section prohibits the employees to enter any vat, pipe, pit, chamber, or any such place on the factory where any gas, fume, dust or vapor is present, which is risky for the employee.
- **Section 38:** This section talks about precautionary measures for fire and the provisions for extinguishing the fire in the factory.

Occupational health and safety mainly has to focus on 3 different objectives:

1. Maintaining and promoting workers' health and enhancing their capacity,
2. Improving the work environment and work to become conducive to safety and health, and
3. Developing the work organizations and working cultures in order to support health and safety at work. The concept of working culture here means a reflection of the important values adopted by the undertakings. Such kind of culture reflects in the managerial systems, participation, training policies and quality management of the undertaking.

Reasons for Safety and Health of Employees

As mentioned in the Factories Act 1948, Safety, health and welfare assume significance for the organizations and the provisions given under it are mandatory to be followed by the manufacturing concerns. Moreover; they are the important issues of moral, legal and Economic concern.

- **Moral Reason:** They are duty of reasonable care and are morally the important aspect to be taken care of by the management.
- **Legal:** Theses facilities, if not provided to the employees, can bring grave consequences to the employees. So it needs to be there through compensatory, punitive and preventive effects of law.
- **Economic:** It is important because of the direct and indirect cost associated with accidents and injuries at workplace.

Legislative Framework for Safety and Health in Manufacturing Sector in India

Legislative framework exists in India for safety and health of employees for long but its implementation is in slipshod. The formal units falling under it comprise of only 10% of the total units.

Occupational Safety and Health fall under the purview of the following acts:

1. **Factories Act 1948:** This Act contains 120 sections, and is divided into Chapters concerning inspection staff, health, safety, hazardous processes, welfare, working hours of adults, employment of young persons, annual leave with wage, and penalties and procedures. This act has the provisions for Safety, Health and Welfare and special chapters on Hazardous processes added after the catastrophic Bhopal Gas Tragedy, which took away lot many lives. This Act places talks about

formation of safety committees with equal number of representatives from management and workers and consultation with employees for framing Occupational Safety and Health Policy.

2. **Worker's Compensation Act:** It is an act to provide for payment by certain classes of employers to their workmen of compensation for injury. It's an Act meant to protect the rights of injured workers. It aims at securing the right of injured workers so that they get appropriate medical care, necessary training and rehabilitation. If the workers die due to injury at work, the family is entitled for compensation.
3. **Employees' State Insurance Act (ESIC Act):** This Act deals with protection of workers in case of sickness, maternity, injuries and loss of wages due to work.

Besides this, keeping in the view the urgent and unavoidable need of Occupational Safety and Health, in February 2009, The Government of India has declared *National Policy on Safety, Health and Environment* at Work place and has set to build and maintain national preventive and safety & health culture, as a goal. In order to achieve the aforesaid goal in the national agenda, government has stressed to promote inclusion of safety, health and environment improvement at the workplace as an important component for quality of working life (Fuller, 1997).

The main focus of National Policy on Safety and Health at workplace is placed on Compliance, awareness, Occupational Safety and Health, skill capacity building and research. The national policy on OSH has the following objectives:

- Continuous reduction in incidence of work related injuries, fatalities, diseases, disasters and loss of national assets.
- Maintain comprehensive database of the above for better performance and monitoring.
- Continuous enhancement of community awareness on Safety, Health and Environment (SHE) issues at work related areas.
- Improving SHE at workplace by creation of green jobs contributing to sustainable development. (Health and Safety Executive 2000)

Some Important Certifications and Standards for Safety and Health

There are a number of international certifications and standards framed on Occupational Safety and Health which are gaining prominence in the recent times. Some of them are here below.

1. **OHSAS 18001:** It is a British standard for Occupational Safety and Health Management systems. The main reason why it exists is to help all kinds of organisations to put in place demonstrably sound Occupational Safety and Health performance. It puts special focus on forming OSH objectives to help organisations develop policies and objectives keeping into account legal requirements and information about Occupational Safety and Health risks. It was updated in the year 2007 and new specifications are more closely aligned with structured ISO 9000 and 14000 so that organisations can more easily align with existing management systems.
2. **Integrated Management Systems:** These are written generally so that they can be applied to all kinds and all types of organisations. Its major focus is on Environment Health and Safety elements that the organisations can reasonably be expected to control. The basic elements which it includes

are environmental aspects, hazard identification, risk assessment, objective formulation, performance measurement and monitoring

3. **IS-18001:** It is standard of Bureau of Indian Standards started with an aim to maintain and continuously improving the Occupational Safety and Health Management Systems. It does not state the criteria for Objective setting as such but its unique feature is the stipulation of initial OSH review, design and engineering, purchasing and critical incident recovery plan which are considered to be critical for the success of OSHMS.

Besides these standards, International Labour Organisation (ILO) and Health Safety Executive (HSE) provide the guidelines on this critical and very important issue. Some notable points are as mentioned below:

1. **HSG65:** It is a popular guide of Health and Safety executive, mainly developed for line managers, leaders and owners who want to oversee their organisations Health and Safety arrangement. It extends guidelines to enable organisations strike a balance between systems and behavioural aspects of OSH.
2. **ILO Guidelines:** These guidelines on Occupational Safety and Health exist to provide a unique international model which is compatible with other management systems, standards and guidelines at national levels and international levels.

ILO Initiatives on Occupational Safety and Health

India is a founder member of International Labour Organisation (ILO) which came into existence in 1919. The most important means of action in ILO is setting up of International Labour standards in form of conventions and recommendations. Conventions are legally bound International treaties which may be ratified by member states. There are a number of conventions and recommendations passed by ILO.

Although India has always been very positive to the standards of International Labour organisation yet out of 18 ILO conventions which are there to cater to Occupational Safety and Health (OSH) in different sectors, India has till now ratified only 3 conventions. Convention no. 155 on Safety and Health has not been ratified yet. (Mohan Babu Yarlagadda et al.)

The reason for the same is that India follows the policy of ratifying only those conventions which are in conformity with provision of said conventions.

Literature Review

Husain 2010 elaborates that Occupational safety is a key element of social responsibility. Definition of safety is freedom from injury and danger, quality or insuring against hurt, danger of risk. The definition from New English Dictionary shows the same negative ideas, “exemption from hurt or injury mean freedom from harm and others.” Hence, the importance or target of safety is to reduce the accidents among employee at the workplace

According to Terry E. Sween (2003) unsecure work behaviour is referring to the result of physical environment, the social environment and workers’ experience within these. Meanwhile, the safety triangle

shows relationships between the unsecure work situation and injuries that influence safety condition in automotive industry. Safety not only focus on the bottom line workers but it also influence the top management, manager and staff to become more responsibility and accountability in their efforts to provide the safe environment.

The Tables 4 and 5 show the dimension identified by various authors with respect to Safety and health of employees.

Table 4. Dimensions identified by various authors with respect to safety and health of employees

Dimensions	Author	Definition of the Dimension Identified and the FDINGS
Safety Training	Shan 2011	It acts as a tool to motivate and encourage safe behavior of employees at the workplace
	Prakash 2010	A proactive safety measure to enable workers to handle unforeseen hazards
Safety culture	Sukadarin et al. 2012	A feasible and practical solution to control the attitude, beliefs, behavior of employees to safety in organization.
	Richer and Koch 2004, Sukadarin et al. 2012	The shared and learned meaning, experiences and interpretation of work and safety, expressed symbolically and which guides people
	Fitzgerald, 2005	It includes values and beliefs which interact with an organizational system to create behavioral norms.
	Fleming	Culture needs to be worked upon, especially in case when accidents are causing due to cultural and behavioral issues in the organization
	Toft and Reynold	Safety culture is the set of norms, beliefs, attitudes, technical and social practices within an organization which are concerned with minimizing the vulnerability to the conditions which are measured to be dangerous.
	Davies et al (2001)	Safety climate can be described as current variation or nuances of long term culture as the tangible outputs of an organization's health and safety culture, as perceived by individuals or work groups, at some point in time.
	Mearns, K et al (1997)	Safety climate in the organization can be evaluated typically using employee questionnaires to assess the attitude and that is further explained using exploratory and then confirmatory factor analysis.
	Back and Woolfson (1999)	It is argued at times safety culture introduction in the organization can defeat its own purpose of bringing in better safety performance.
Employee involvement	Child et al	It was advocated that organizational culture should be assessed individually in the organization which are in alliance and should integrate it in a management system for cooperative ventures.
	Apostolou (2000)	It means that employee should be made to participate and involve in helping the organization to achieve its objectives.
	Husain (2009)	Employee involvement is basically a behavior-oriented technique involved in the employees in the upward communication flow and decision making process of the organization
	Beatrice (2011)	It can be defined as the summation of processes which are designed to connect support, understanding and effective contribution of all employees of the organization and commitment to the objectives.
	Gordon and Yukl (2006)	It comprises of the efforts of the management to attain objectives in organization.

continued on following page

Table 4. Continued

Dimensions	Author	Definition of the Dimension Identified and the FDINGS
Leadership	HSC, 2001a	It is advised that the safety commitment should become part of management and should be there for all levels.
	Health and Safety Executive	Dedication of management towards safety could be seen by. • The status given to health and safety (HSE, 1999a). •The amount of resources allocated to health and safety management (HSE, 1997). •workforce dedicated towards safety (Reason, 1997). • Safety leadership training (HSC, 2003).
	Fleming (2001)	In his study four factors were found to be having a positive impact on how people perceive safety. • Valuing subordinates • Visiting the worksite frequently • Workers participation in management • Effective safety communication.
Two-Way Communication	Guest et al (1994)	In the study an examination of safety culture and safety performance took place and it was found that communication is big issue to enforce safety. Effective 2-way communication was found to be important for ensuring safety culture
	Mearns et al (1998)	The study found that likelihood of accident is more in absence of job communication and thus it supported the view that safety communication is important for reducing risk of safety and for ensuring safety culture.
Safety reporting	Reason (1997)	He studied the importance of reporting in the organization and thus identified some issues which need to be addressed for the purpose of safety reporting.
	Clarke (1998)	The study suggested that negative perceptions of managers' commitment to safety can have a negative impact on the employees' safety behavior.
Involvement and Participation of Staff	Guest et al 1994	The study pinpointed the existence of "macho" attitude among the workers towards safety and they gave low importance to safety representatives. The responsibility of accidents was found to put to others.
	HSE	The evaluation by way of test, organization of workshops, consultation group formation should be viewed as best practice to ensure safety in the organization.
Existence of learning culture	Reason 1997	The literature emphasized the importance of reviewing not only the problems that can occur but also the losses caused by such unsafe acts and accidents
	HSE	Emphasized the importance of involvement of employees in not only filling the questionnaire but also in making them a part of continuous improvement.

MATERIALS AND METHODS

Research Design

The framework within which the research was conducted was basically descriptive in nature and the target population in this regard is defined as consisting of the shop floor employees working in manufacturing concerns of small and medium type.

Sampling Design

Sample was collected from the small and medium enterprises situated in Sitarganj area of SIDCUL (State Infrastructure Development Corporation of Uttarakhand). The sample size was 215.

The sampling technique adopted was Stratified Random sampling.

Table 5. Authors and their respective findings in the area of safety and health in the organizations

Authors	Research Findings
Lewin (1958), Likert (1967).	The difference in interdepartmental accidental rate can be attributed to the difference in psychological climate. The social processes existing within the organization are found to influence attitudes towards safety and health.
Bigos (1986), Greenwood and Wolf (1987)	According to the authors, job satisfaction is very important in the same manner as eliminating physical hazards in the workplace is. It was found that job satisfaction ensures safe behavior of the employees which in turn reduces the number of accidents.
Brian (1988)	The research pays emphasis on attitudinal factors which lead to betterment in the safety performance of a large number of chemical companies and it was found that positive safety and health management system in the organization actually lead to reductions in lost-time injuries.
Green (1980)	The study demonstrated how attitudes towards accidents are influenced by previous experience. It was found that frequency of accidents and knowledge of the ways in which accidents happen contribute to the attitude towards them, and may also be instrumental in affecting attitudinal change.
Canter et al(1989)	In this study, a correlation of all accidents and lost-time accidents at 16 plants of one British Steel site with attitudes towards various aspects of safety was studied. The safety attitude was assessed with the help of a survey questionnaire. The result showed that safety attitude of employees can actually help predict the level of accident in a plant. This not only showed the close linkage between the two but also showed the possibility of creating a reliable measurement of tools.
Donald and Canter (1993)	This study showed 3 facets of safety attitude: • Safety climate present in the organization • Attitude of employees towards safety in the organization • Safety behavior of the employees. The scale was found to be highly reliable and demonstrated negative correlation between self reported accident rate and safety representative scale.
Bailey (1989)	The study used Minnesota Safety Perception Survey used in the study to identify those factors which positively influence the injury reduction within the railroad industry. The study showed that the companies which had low injury rate had positive management commitment to safety. It was negative for organization with high injury rate.
Simonds and Shafari-Sahrai (1977)	The study analyzed the relationship between injury frequency rates and factors thought to influence injury rates, such as management involvement in the safety effort, workforce characteristics, and physical conditions. In studying these matched pairs of companies with high and low injury rates, it was found that in the companies which had low injury rate, involvement of top management is there.
Cohen (1977)	The study found that organization with low accident rates had some factors in common like. Awareness of employees' problem related to safety among the management and management's belief that the high standards of safety were attainable and formal or informal contact of employees with the management on safety issues and mechanism of training of employees.
Smith et at. (1978)	It was a follow-up study whose major finding included the presence of management's commitment to safety and health for low injury rates.
Schneider (1975)	The study found that the employees had different perception of safety climate of the environment with respect to age.
Payne et al. (1976)	The study stated that performance of an individual and measurement of attitude can be better described using organizational climate and it serves a s a basis for managing and changing the behavior of employees.
Seppala (1992)	The study focused on factories and construction concerns and found out 4 factors on which safety and health climate of the organization is dependent on • Responsibility of the organization. • Employees' concern for safety • Level of precautions in the organization • Worker's indifference with respect to safety.
Williamson et al. (1997)	The study revealed 5 factors of key importance for ensuring safety culture and the factors are personal motivation for ensuring safety, justifying the risk and optimistic attitude towards safety.

continued on following page

Table 5. Continued

Authors	Research Findings
Diaz and Cabrera (1997)	In the study conducted, six factors were identified on applying factor analysis ie. Companies policy towards safety, Priority of safety over productivity, Attitude of Group towards safety, preventive attitude towards safety and perceived level of safety.
Blair (1999)	It concluded saying that most of the researchers often believe that job satisfaction comes first and it is proved that usually the safe workers are more committed to safety but not all safe workers are always satisfied.
Varonen and Mattila (2000)	The study showed that some factors pertaining to safety accounted for 40% of variance and they were identified as worker's safety attitude, precautions followed by organization with respect to safety and supervision. The factors showed negative correlation with accident rates.
Carder and Ragan (2003)	The study was conducted on chemical plants in United States of America and it came out with a model based on confirmatory factor analysis and the factors are: • Education of the workforce, • Involvement of employees and commitment, • Effective supervisory process.
Silva et al. (2004)	An inventory of questions with 4 dimensions and 78 items was prepared and the research was carried out across 15 Portugese organizations in different sectors. The Structural Equation modeling testified that the model fitted well the data. There was existence of correlation between scale scores and accident data for proving the prediction of accident on the basis of test score.
Shannon et al. (1966)	The research was conducted in manufacturing organizations, each having at least 50 employees. It was found that the organizations which had low rate of injuries had these features in common: • Managers valuing participation in decision-making by the workforce, • Conducive relationship between employer and employee, • Encouragement of long term career commitment, • Provision of plans for short and long term disability.
Vredenburgh (2002)	The study highlighted the contribution made by various management practices on Health and Safety programs. The factors were: • Training and participation, • Management commitment, • Rewards, • Communication and Feedback, • Hiring and practices.
Smith et al (2003)	The study found that safety knowledge and safety performance is moderated especially by safety management practices such as safety training
Gyekye SA (2005)	The study focused on perception of safety workplace and job satisfaction and it was found that those employees who had more satisfaction with the job were more committed to safety management policies and the accident rate was also low. The results were consistent with the notion that workers' perception of organizational climate influences their perception of safety at work.

Data Collection

260 self-administered questionnaires were used for gathering the data from respondents, out of which the response rate was around 90% which means 215 employees responded. The questionnaires were personally administered by approaching them and talking to them. The process of data collection from shop floor workers took a period of over 3 months. Likert's 5-point scale was used for data collection.

- **Analysis of Data:** The statements were narrowed using multivariate analysis technique called as Factor Analysis. Before applying Factor Analysis, the KMO and Bartlett's Test of Sphericity was run. KMO test was found to be .8 and Barlett's Test result came out to be .00 which means the basic precondition of test was met.
- **Results and Discussion:** Factor Analysis is a multivariate analysis technique used for data reduction. Factor Analysis was used to determine the Factors important to ensure Safety and Health in the organisation. For this purpose, around 29 statements were used and on applying Principal component Analysis method for factor extraction and Varimax rotation for rotating the variables, 7 factors were identified.

The safety issues were named as below in the Factor name column and the names assigned are on the basis of the close linkage of the statement falling under each construct. The rationale for grouping the statements is the correlation which statements have with each other (Table 6).

Table 6. The following table shows the list of Factors with the set of statement under each factor

Factor No.	Factor Name	Statements
1	Management Concern for employee safety	• Safety training is given at frequent intervals • The managers involve us in the designing the framework of safety policy • We are encouraged to give our suggestions for the safety • The supervisor tries to reinforce the training imparted to us by assuring the use of work methods after resuming work at actual place • Risk assessment is normally done when we start a new procedure • Safety team meetings are held at frequent intervals
2	Safety reporting culture	• We do have safety procedures in the organisation and we use them • We are encouraged to report the safety incidents • There is a provision of follow up of the safety measures regularly • Accident analysis is usually a part of the system after something happens. • There is a provision of effective Safety Information system in the organisation • There is enough opportunities for safety communication to the people
3	Task based procedural approach for safety	• My organisation has safe procedures for all task based activities in my area which are prone to safety risk • . We have safety procedures well implemented in the organisation • There is a high visibility of management commitment towards the safety in form of leaflets, posters, safety briefing and open door safety policy
4	Safety training and reinforcement	• Training is imparted to me right at the time of induction • The supervisor observes that whether I am following safety practices or not. • The supervisor reinforces the training practices learnt after returning back to the actual workplace.
5	Employee participation involvement	• If I don't follow safety norms, I fear to be punished • My organisation has adequate means and provisions for first aid • I am given the opportunity to be a part of safety meetings.
6	Instantaneous safety mechanisms	• Safety issues are fixed instantaneously • Management puts enough time in devising safety policies and safety is not a mere formality.
7	Safety communication	• Safety Policy statement is displayed at several places in the factory • I am aware of the first aid facilities present within the factories for immediate check

CONCLUSION

It can be concluded that the organisations needs to address the following issues effectively in order to ensure safety and health in the organisation and the issues are

1. **Management Concern for Employee Safety:** In order to ensure health and safety of the employees in the organisation, it's important that the management sets it as prime agenda. It includes reinforcing the training, imparting the training and creating a safe and healthy workplace for the employees. It basically refers to the top to down approach.
2. **Safety Reporting Culture:** In case of any accident, the employees should not feel hesitant to report the matter to the management. After the incident is reported, proper accident analysis needs to be done so that the same cause does not become the reason for accident again. In some progressive countries IT integrated accident reporting system is there.
3. **Task Based Procedural Approach to Safety:** For it, the organisations need to have safe procedures for task based activities which are prone to risk. The effective implementation of safe procedures is a must. Moreover, there needs to be a high visibility of management commitment towards the safety in form of leaflets, posters, safety briefing and open door safety policy
4. **Safety Training and Reinforcement:** For ensuring safety in the organisation, training is very important. Training needs to be imparted at frequent intervals. Beside this, training practices learnt are required to be reinforced even at the actual workplace setting.
5. **Employee Participation and Involvement:** Employees need to be made a part of the safety system. This can be ensured by the participation and involvement of employees in the decision making. This also increases the likelihood of employees assuming safety as their responsibility in the organisation, thereby fostering a safe culture.
6. **Mechanism for Fixing Safety Issues Instantaneously:** The safety issues need to be fixed instantaneously and the platform for the same is built when the management and employees together spend enough time in devising the safety policies of the organisation.
7. **Proper Safety Related Communication to People:** The employees working in the organisation should be aware of the first aid present in the organisation and they should be informed about the safety precautions to be taken care of.

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Chapter 29
Promoting Health Literacy in Global Health Care

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ABSTRACT

This chapter emphasizes the prospect of health literacy; the evaluation of health literacy level; health literacy and health communication; health literacy and health information; and the current issues of health literacy in global health care. Good health literacy is important because patients are living longer and experiencing a wider range of health issues. Health professionals must commit to promoting for improved health literacy in health care organizations and should establish the specific health care goals toward improving health literacy in strategic plans, performance plans, programs, and educational initiatives. Health professionals can utilize a broad range of health communication strategies to ensure patients understand their options and share their health care decisions. Through health education and training, effective health information can help promote patients' health literacy level in global health care.

INTRODUCTION

Health literacy is recognized as the important domain in a conceptual model of health promotion (Šramová, 2015) and is related to the effective health indicators that include self-reported health, daily functioning, risk for hospitalization and death, and use of health care services (Bostock & Steptoe, 2012). Nowadays, reliable health information is essential and currently easily available to most patients in the health care industry (van der Vaart et al., 2012). Low health literacy is the important problem in low and middle-income countries as these countries have high poverty rates and low rates of health education (Keikelame & Swartz, 2013). Patients with low health literacy have poor knowledge about their illness, experience difficulties in accessing health care, have poor self-care, have lower levels of quality of life, and have poor health outcomes (Elliot & Shneker, 2009), including higher risk for premature deaths (Barnett & Kaske, 2012).

The communication between health care professionals and patients should encompass educating patients about the knowledge and the processes to enhance the quality of care in health care settings

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(Kazandjian, 2012). To prepare for the transition from pediatric to adult-oriented health care systems, adolescents must develop the ability to obtain, process, and understand basic health information; make appropriate health decisions; and effectively interact with health care professionals (Huang, Tobin, & Tompane, 2012). Health literacy is an important factor in health disparities (Morrison, Brousseau, Brazauskas, & Levas, 2015). Al Sayah et al. (2013) stated that inadequate health literacy has been found to adversely affect health outcomes, especially in low-income patients with chronic diseases. Berkman et al. (2011) indicated that routine screening for inadequate health literacy in health care settings has led to an increased interest in health literacy evaluations.

Suitable health care interventions (e.g., materials written in plain language and brief counseling approaches) effectively improve the parent's health knowledge and medical adherence (DeWalt & Hink, 2009). Low health literacy is associated with individuals from lower socioeconomic groups, among older persons and racial minorities (Bautista, Glen, Shetty, & Wludyka, 2009), and from those living in rural areas because of low education levels, high unemployment rates, low wages, and lack of health insurance (Wood, 2005). Patients must have the ability to obtain, process, and understand the basic health information and services through health education and training regarding health literacy (Peerson & Saunders, 2009).

This chapter aims to bridge the gap in the literature on the thorough literature consolidation of health literacy. The extensive literature of health literacy provides a contribution to practitioners and researchers by describing the current trends and issues of health literacy in order to promote the health care literacy in global health care.

BACKGROUND

Health literacy first appeared in the 1974 paper calling for minimal health education standards for all grade levels in the United States (Mancuso, 2009). Since then, a stream of descriptive research has sought to examine the concept of health literacy, its measurement, and the problem of low health literacy in the health care industry (Schulz & Nakamoto, 2013). There has been a growing interest in the concept of health literacy, together with an increased emphasis on the individual's responsibility for health and self-management of chronic illness (Salmon & Hall, 2004). While health information has the potential to increase patients' knowledge and equalize the effective communication between patient and health care provider, availability of information does not automatically lead to the involved patients (McCray, 2005).

Inadequate health literacy is more extensive among the elderly, those with lower levels of educational attainment (Kutner, Greenberg, Jin, & Paulsen, 2006) and with chronic disease (DeWalt, Berkman, Sheridan, Lohr, & Pignone, 2004). Omachi et al. (2013) stated that limited health literacy is related to poor outcomes in many chronic diseases. Inadequate health literacy is associated with poorer self-management skills, less successful navigation of the health care system, and higher mortality (Herndon, Chaney, & Carden, 2011). Paiva et al. (2014) indicated that health literacy should be higher in physicians, followed by health researchers, people with a similar academic degree in areas which are non-related to health, and people with the lower levels of education attainment.

Although the skills of patients are important, health literacy also includes health care providers and caregivers (Grice et al., 2013). Low health literacy has been reported to have a great impact on the interactions between patients and health care providers (von Wagner, Steptoe, Wolf, & Wardle, 2008). Improving health literacy requires health care providers and health care organizations to clarify com-

munication, provide support for creating health-related skills, and organizational changes to reduce demands on patients. Health care providers should evaluate their patients' level of health literacy in an attempt to improve health outcomes by means of effective interventions (Lee, Lee, Kim, & Kang, 2012). Recognition of patient's health literacy ability can help health care providers find the communication approaches that fit their health-related needs.

SIGNIFICANT ASPECTS OF HEALTH LITERACY IN GLOBAL HEALTH CARE

This section highlights the prospect of health literacy; the evaluation of health literacy level; health literacy and health communication; health literacy and health information; and the current issues of health literacy in global health care.

Prospect of Health Literacy

Health literacy refers to a range of health literacy capacities that affect health-related behaviors and clinical decision making (Sharp et al., 2013) and is correlated with health status (Sentell & Braun, 2012) and health behavior in modern health care (Ishikawa, Nomura, Sato, & Yano, 2008). Social networks among health care providers and patients can provide health information that influence and support health behaviors in the health care industry (Goodman et al., 2012). High levels of health literacy without a high degree of patient empowerment creates an unnecessary dependence of patients on health professionals, while a high degree of empowerment without a corresponding degree of health literacy poses the risk of dangerous health choices (Schulz & Nakamoto, 2013).

Health literacy is a multidimensional phenomenon that involves the comprehension of oral as well as written information (Mazor et al., 2012). This is an important omission because oral communication is essential to most physician–patient encounters, as well as to media channels, such as television news (Mazor et al., 2012). The ability for self-care requires understanding and utilizing health-related information, as well as informed decision making (Lee et al., 2012). Variables, which have been shown to predict the higher health literacy levels are the presence of a chronic condition (Jovic-Vranes, Bjegovic-Mikanovic, & Marinkovic, 2009), income (Pizur-Barnekow, Doering, Cashin, Patrick, & Rhyner, 2010), and perception of individual's own health status (Jovic-Vranes et al., 2009).

Willis et al. (2014) indicated that strategies found to be associated with the improved organizational capacity for delivering the health literacy services are categorized into three perspectives (i.e., government action, organizational/practitioner action, and partnership action). Government action includes developing policies to reinforce social norms; setting standards for education; conducting research; and measuring health literacy levels. Organizational/practitioner action relates to the appropriate models of leadership regarding both high-level government engagement and distributed leadership. Partnership action includes collaborations with media outlets, those producing electronic materials, community organizations, and school-based programs (Willis et al., 2014).

Health literacy has been linked to disease self-management and various health outcomes, and can be separated into components of functional, communicative, and critical skills (Lai, Ishikawa, Kiuchi, Mooppil, & Griva, 2013). Functional health literacy is different by age, marital status, employment, education, material status, self-perception of health, and health status (Jovic-Vranes & Bjegovic-Mikanovic, 2013). In addition to the ability to read and write text, functional literacy includes the ability to apply the

content of the text to relevant activities (Sharp et al., 2013), information processing, working memory, problem-solving skills, and quantitative ability (Nutbeam, 2008).

Cancer is a complex and prevalent disease, and primary and secondary prevention are recognized as the major factors in controlling cancer morbidity and mortality (American Cancer Society, 2010). Understanding of cancer prevention and messages is essential if such messages are to be successful in helping individuals make decisions about health behaviors (Mazor et al., 2012). Inadequate health literacy predicts negative outcomes specific to cancer control, including poor understanding of cancer risk (Brewer et al., 2009) and the need for screening, as well as lower rates of participation in cancer prevention efforts (Lindau, Basu, & Leitsch, 2006). Cancer patients with poor health literacy tend to be diagnosed at a later stage (Bennett et al., 1998) and to have difficulty providing informed consent for treatment (Davis, Williams, Marin, Parker, & Glass, 2002).

Inadequate health literacy is most prevalent among those reporting poor health (Speros, 2005). Older people (Ginde, Weiner, Pallin, & Camargo, 2008), men (Parikh, Parker, Nurss, Baker, & Williams, 1996), people with a lower level of education (Downey & Zun, 2008) show lower levels of functional health literacy. Improved awareness of health literacy issues among adolescents with chronic disease is needed among health care providers and health care systems in modern health care (Huang et al., 2012). Patients with lower health literacy tend to have less understanding of their illness (Gazmararian et al., 2006). higher psychosocial distress (Sharp, Zurawski, Roland, O'Toole, & Hines, 2002), poorer self-reported health (Lindau, Tomori, McCarville, & Bennett, 2001), worse health outcomes (Schillinger et al., 2002), higher rates of hospitalization (Baker et al., 2002), higher health care costs (Eichler, Wieser, & Brugger, 2009), and higher risk of death (Sudore et al., 2006).

Evaluation of Health Literacy Level

To gain the insight into patients' health literacy level, it is essential to properly measure the health literacy skills (Shaw, Ibrahim, Reid, Ussher, & Rowlands, 2009). Most instruments of health literacy measures need to be evaluated by a health professional, which is time-consuming and unfeasible in clinical practice. Underlying constructs and content of the existing instruments vary, and only few instruments are based on the proposed definitions and underlying models of health literacy (Pleasant & McKinney, 2011). In addition, most existing health literacy measures focus primarily on reading health comprehension, while health literacy comprises more than only functional literacy, namely the skills to utilize health information in an effective manner (Jordan, Osborne, & Buchbinder, 2011).

An important trend toward developing the measures that capture health literacy level within a specific context has been growing (Kim et al., 2012). For example, there are the health literacy measures that focus on diabetes management (Nath, Sylvester, Yasek, & Gunel, 2001), asthma (Apter et al., 2006), and genetics (Erby, Roter, Larson, & Cho, 2008). The disease-specific health literacy tools are more useful when they are effectively applied to a group of patients in need of managing a specific chronic illness (Nielsen-Bohlman, Panzer, & Kindig, 2004). The disease-specific health literacy tools can provide health care providers with the useful assessments of patients' educational needs and can function as the effective evaluation tools for the targeted disease-specific interventions (Kim et al., 2012).

Evaluating health literacy is vital to design the health education program (Chang, Hsieh, & Liu, 2012). Han et al. (2011) stated that accurate evaluation of health literacy is the first step toward understanding and emphasizing health issues related to individual's low health literacy. Health professionals should

conduct the health literacy evaluation for adolescents before designing health education programs for those with low health literacy to develop health literacy skills toward performing health-promoting behaviors (Chang, 2011). Ownby et al. (2014) indicated that in order to evaluate intervention effectiveness and provide a method to evaluate health literacy as a construct, it is necessary to measure it.

The most broadly utilized measure of health literacy is the Test of Functional Health Literacy in Adults (TOFHLA) (Parker, Baker, Williams, & Nurss 1995). The Rapid Estimate of Adult Literacy in Medicine, or REALM (Murphy, Davis, Long, Jackson, & Decker, 1993), asks that patients read aloud a list of health-related words. The REALM is a word recognition test comprised of medical terms and is believed to capture a component of functional health literacy (Sharp et al., 2013). REALM requires less time to complete than the TOFHLA, but does not evaluate whether the patient understands what individual reads or numeracy skills (Ownby et al., 2014). Common measures of health literacy (e.g., TOFHLA and REALM) may introduce discomfort and embarrassment particularly in clinical settings, especially for those with inadequate health literacy (Al Sayah, Williams, & Johnson, 2012).

The TOFHLA has been found to be an effective tool for identifying people with inadequate functional health literacy, however it takes up to 22 minutes to conduct. (For a quicker evaluation of people's health literacy, the S-TOFHLA was developed, involving two prose passages with a total of 36 cloze items and four numeracy items. The total time to conduct the S-TOFHLA is 12 minutes or less (Baker, Williams, Parker, Gazmararian, & Nurss, 1999). Numerous studies have employed the S-TOFHLA to identify predictors of health literacy. In addition to the S-TOFHLA, the Newest Vital Sign (NVS) is the health literacy evaluation tool that is developed for utilizing in primary care settings (Heinrich, 2012) and requires three minutes to administer (Sharp et al., 2013).

Health Literacy and Health Communication

Health literacy researchers are currently examining other components of the health context, such as the complexity of health materials, the demands and assumptions of health institutions, and the communication skills of health professionals (Rudd, 2010). Research in health communication, specifically in patient-physician health communication, has greatly contributed to physician practice and training (Passalacqua & Segrin, 2012). The understanding of the relationship of health literacy to health status is essential to develop health communication and health education efforts for older adults in nursing practice (Kim, 2009).

Health communication between health professionals and patients, and between health educators and the public, is necessary in order to have the ability to improve health outcomes (Smith & Duman, 2009). The use of language which the patient is comfortable with is critical for improving health literacy level (Nemutanzhela & Iyamu, 2016). The increasing attention has been devoted to a patient-centered approach to health communication (Rosenthal, 2008). Several studies have found an association between high health literacy and better patient-physician health communication (Mancuso, 2010). Oral communication between physicians and patients has been shown to affect the patients' knowledge, motivation, decision making, engagement, empowerment, and health (Schonlau, Martin, Haas, Derose, & Rudd, 2011).

To improve patient-physician health communication, interventions must be tailored to the patients' health literacy level (Mullen, 2013). Many intervention studies have aimed to improve health outcomes by developing computer programs and establishing telephone follow-up systems aimed at patients with low health literacy (Long & Gambling, 2012). Innovations in health information technologies have en-

abled researchers in the patient-physician communication to expand beyond face-to-face interaction to include communication by phone and online between encounters (Fortney, Burgess, Bosworth, Booth, & Kaboli, 2011).

Health Literacy and Health Information

With the increasing availability of connected health care organizations through modern technology, important health information can be easily accessible at the point of care (Taweel, 2016). Health literacy is a complex phenomenon involving access to health-related information to improve the health-related decision making, behaviors, and outcomes (Wawrzyniak, Ownby, McCoy, & Waldrop-Valverde, 2013). Patients' inability to utilize health information for their own benefit causes a gap between the expectations laid on them to participate in their own health care, and their actual health literacy skills (Jordan, Buchbinder, & Osborne, 2010). This health care-related gap should be narrowed by adapting the reading level of the provided health information on the one hand, and by increasing patients' health literacy level through health education on the other hand (van der Vaart et al., 2012).

In health care organizations, there is an increasing amount of health information (Pereira, Portela, & Abelha, 2016). Health information is an important component of the health care services (Sriganesh, 2013) and for patients to understand and engage in the management of their health conditions (Ishikawa & Yano, 2008). Information behavior perspectives can enrich the conceptual base of health literacy, contributing a deeper understanding of people's use of health information in the context of their lived experience with health conditions (Souden & Rubenstein, 2010). Simmons et al. (2015) indicated that public health nurses should understand the high utilization of anonymous sources, particularly for mental health information, and focus efforts on helping individuals navigate the health care-related resources to ensure they obtain the accurate health information about symptoms.

The potential to collect, organize, integrate, and disseminate health information from a multitude of sources enables health analytics to improve the current health status of communities (Raghupathi & Raghupathi, 2013). The application of online health information empowers people to utilize the online health services (Mano, 2014). The incorporation of a credible online health information resource into school health education curricula is a promising approach for promoting health literacy (Ghaddar, Valerio, Garcia, & Hansen, 2012). Gutierrez et al. (2014) stated that despite the growing body of health information available online, patients with limited health literacy may lack either Internet access or skills necessary to utilize this information.

Gilmour et al. (2012) stated that developing patient competency in evaluating online health information should be recognized as an integral aspect of illness management education. Organizations that embed the practices of human capital and competency across a range of human resource management activities effectively create and develop a boundary spanning culture connecting with various organizational disciplines in the global knowledge economy (Kasemsap, 2016a). As health care services increase in significance, the knowledge acquired and used in executing its services becomes vital (Iyamu & Mkhomazi, 2016). The goal of health care knowledge management is to provide the effective, optimal, and timely health care knowledge to physicians and especially to patients whenever and wherever they need it, to support them in making effective patient care decision and promoting health literacy level (Akaichi & Mhadhbi, 2016).

Creating health information and make it readable by physicians has become the crucial task in modern health care (Peixoto, Domingues, & Fernandes, 2016). Health education is essential to enhance the

mental health knowledge, thus reducing the health literacy-related stigma and improving the effective access to health care (Kelly, Jorm, & Wright, 2007). Numerous approaches to providing literacy-sensitive health care have been proven effective, such as distributing health education materials written at 6th grade literacy levels or below (Robinson, Calmes, & Bazargam, 2008), providing visual information to explain medication regimens (Yin et al., 2008), and providing audio-recorded health instructions (Doak, Doak, & Root, 1996).

Health care-related education materials using pictographs provide the effective strategies in improving the discharge education for the low-literate older adults in the acute health care settings where nurses have primary responsibility as the first line of health care providers (Choi, 2011). Stigma around health literacy-related mental illness has two aspects (i.e., public stigma and self-stigma). Public stigma refers to the negative prejudicial attitudes and discrimination toward individuals with mental illness endorsed by the general population, while self-stigma describes an individuals' internalization of these negative attitudes and beliefs (Corrigan & Rao, 2012).

Health care-related illustrations are frequently utilized in health information, for example in materials about cancer (King, 2015). People typically learn better from text-illustrated information compared to text only (Mayer, 2002). Using illustrations is recognized to positively affect the individuals' attention to the health message (Delp & Jones, 1996) and understanding of information described in the message (Brotherstone, Miles, Robb, Atkin, & Wardle, 2006). People with limited health literacy have shown to benefit from the illustrated messages (Meppelink, Smit, Buurman, & van Weert, 2015), and the application of illustrations is recommended for this target group (Doak et al., 1996).

Current Issues of Health Literacy in Global Health Care

Health care policies and programs are needed to respond to the extent and impact of low health literacy in global health care (Jovic-Vranes & Bjegovic-Mikanovic, 2013). Low health literacy has been shown to be associated with a limited health vocabulary and it limits how individuals understand the concept of screening and their awareness of its benefits (Pagán et al., 2012). Low health literacy is widespread in the elderly, those with low socioeconomic status and minority groups (van der Heide et al., 2013) and is recognized as a strong contributor to health inequalities (Sudore et al., 2006). Socioeconomic status is strongly associated with health status (Hoffman-Goetz, Meissner, & Thomson, 2009). Lindquist et al. (2011) indicated that seniors themselves often have low health literacy, which suggests the greater requirement for caregivers to have adequate health literacy.

It is essential that health care providers understand the role that they have in the identification and promotion of health literacy to encourage the optimal health outcomes (Carollo, 2015). For the patient with low health literacy, the stigma associated with the condition has the potential to negatively impact communication with the clinician and staff, reduce the effectiveness of health care, and impact the quality of care and quality of life (Carollo, 2015). Successful health care management requires an effective partnering among clinicians and health care providers who have the responsibility to identify what is occurring with the patient regarding effective health care interventions, and the patient's responsibility to correctly adhere to the prescribed intervention (Mayer & Villaire, 2007).

To address health literacy in the technology-rich health care environment, there is a strong need for the effective computer-based tools to evaluate health literacy level (Collins, Currie, Bakken, Vawdrey, & Stone, 2012). Electronic health literacy is composed of two types of skills: general skills and specific skills (Institute of Medicine, 2009). General skills include traditional literacy (e.g., reading, writing,

and numeracy), media literacy (e.g., media analysis skills), and information literacy (e.g., information seeking and understanding). Specific skills include computer literacy (e.g., information technology skills), health literacy (e.g., health knowledge comprehension), and science literacy (Institute of Medicine, 2009). Electronic health information is emerging as a source to effectively manage own health (Yim, Khuntia, & Argyris, 2015). Increased public access to electronic health information and a shift in modern technology to more user-driven content significantly require communication technologies that support the patient as a partner at the center of the health care system by providing information access and assistance when and where it is needed (McCray, 2005).

Kamimura et al. (2013) indicated that health literacy education, mental health services, and social support are the significant health services needed by the free clinic patients to achieve better health. Health skills can be successfully introduced in adult learning environments (Diehl, 2011). However, the majority of online health information is difficult to read and understand, which is a problem for people with limited health literacy (McInnes & Haglund, 2011). Not everyone benefits from the abundance of information because selecting, understanding, and applying health information requires the adequate health-related knowledge and skills (Fransen, van Schaik, Twickler, & Essink-Bot, 2011). Smith et al. (2014) stated that health literacy skills are important for people affected by cancer as they are exposed to the complex treatment and follow-up care information.

Inadequate health literacy levels have been linked to a myriad of health-related outcomes, including increased mortality, lower physical functioning and quality of life, suboptimal utilization of health services, decreased capacity for disease self-management, elevated risks of medication errors, and increased health care costs. Low health literacy is related to inappropriate medication intake and an inability to understand health labels and health-related information (Berkman et al., 2011), and such health perspectives generate the poor treatment adherence. Across conditions of diabetes and cardiovascular disease, poor medication adherence and disease self-management have been recognized as the possible mediators between low health literacy and inadequate disease outcomes (Nam, Chesla, Stotts, Kroon, & Janson, 2011).

Fry-Bowers et al. (2013) indicated that comprehensible child health information is vital to any parent. Positive child health outcomes result from effective communication between a parent and their child's health care provider (Hart, Kelleher, Drotar, & Scholle, 2007). Effective communication encourages trust in the therapeutic relationship, improves parental satisfaction with care, promotes adherence to health care regimens, and increases the parental disclosure of psychosocial concerns (Rosenthal et al., 2007). Parent-provider communication, particularly within the context of pediatric ambulatory care, is not ideal. Parents with limited education and economic perspectives, members of racial minority groups, and non-English speakers are at risk for poor communication with health care providers (Bloom, Cohen, & Freeman, 2011). Substantial racial and ethnic disparities exist for the health care provider elicitation of parents' developmental concerns and for experiences of family-centered care (Guerrero, Rodriquez, & Flores, 2011).

FUTURE RESEARCH DIRECTIONS

The classification of the extensive literature in the domains of health literacy will provide the potential opportunities for future research. Limited health literacy affects patients of all ages, races, incomes, and education levels, but its greatest impact is among lower socioeconomic and minority groups, where it

underlies health disparities. Health education is a social science that draws from the biological, environmental, psychological, physical and medical sciences to promote health and prevent disease, disability and premature death through education-driven voluntary behavior change activities. Health education is the development of individual, group, institutional, community, and systematic strategies to improve health knowledge, attitudes, skills, and behavior.

Communities of practice (CoPs) help promote a growing cycle of knowledge sharing activities that allow for the members to regularly meet, reflect, and evolve in the knowledge management environment (Kasemsap, 2016b). The use of social media can result in better communication and collaboration (Kasemsap, 2016c). Total quality management (TQM) practices in quality performance has the potential to improve organizational performance (Kasemsap, 2015). Facilitating both health literacy and health education in the health care industry with the utilization of CoPs, social media, and TQM practices will be the valuable issue for future research direction.

CONCLUSION

This chapter explained the prospect of health literacy; the evaluation of health literacy level; health literacy and health communication; health literacy and health information; and the current issues of health literacy in global health care. Good health literacy is important because patients are living longer and experiencing a wider range of health issues. Health literacy measures to be conducted by health care providers are very important in order to know the patients' health literacy level and prepare the health care education toward increasing the patients' health literacy level and promoting the quality of care. Training health care staff will increase the awareness of the need for addressing health literacy and improve their health care-related skills for communicating with the public.

Health professionals must commit to promoting for improved health literacy in health care organizations and should establish the specific health care goals toward improving health literacy in strategic plans, performance plans, programs, and educational initiatives. Health professionals can utilize a broad range of health communication strategies to ensure patients understand their options and share their health care decisions. Implementing health care metrics for health care organizations will help establish the accountability for health literacy activities. Promoting patients' health literacy skills means they are better able to take care of their health and engage with the health care systems. Through health education and training, effective health information can help promote patients' health literacy level in global health care.

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KEY TERMS AND DEFINITIONS

Communication: The two-way process of reaching mutual understanding, in which participant not only exchange information, news, ideas, and feelings, but also create and share meaning.

Health Care: The act of taking the preventative or necessary medical procedures to improve a person's well-being.

Information: The data that is organized for a specific purpose and presented within a context that gives it meaning and relevance.

Knowledge: The understanding of a circumstance gained through experience.

Literacy: The ability to read and write.

Patient: A person who is receiving medical care, or who is cared for by a particular doctor or dentist when necessary.

Skill: The ability acquired through the deliberate, systematic, and sustained effort to smoothly and adaptively execute the complex activities.

Understanding: The knowledge about a situation.

Chapter 30
The Fundamentals of Health Literacy

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ABSTRACT

This chapter describes the overview of health literacy; the characteristics of functional health literacy, interactive health literacy, and critical health literacy; and the significance of health literacy in global health care. Health literacy is about how patients understand health information about health and health care, and how they apply that health information to their daily lives, utilize it to make health-related decisions, and act on it. Being able to understand health information and make decisions from that information is vital to patients' well-being. Health literacy can help patients prevent their health problems and protect their health, as well as better manage those problems and unexpected situations that happen. Patients with good health literacy make effective health decisions because they can find, understand, and evaluate the health information in global health care.

INTRODUCTION

Health literacy is established as a central concept in health communication and education (Dubowicz & Schulz, 2013). The concept of health literacy includes not only the ability of individuals to read and understand health care information, but also the ability to function within the health care system (Torres & Nichols, 2014). Health literacy is the degree to which individuals can obtain, process, understand, and communicate about health-related information needed to make health decisions (Berkman, Davis, & McCormack, 2010). Health literacy comprises skills in obtaining, understanding, and acting on information about health issues in ways that promote and maintain health (Mårtensson & Hensing, 2012).

Health literacy is the mechanism by which individuals obtain and utilize health information to make health decisions about individual treatments in the home, access care in the community, promote patient-health care provider interactions, structure self-care, and navigate health care programs both locally and nationally (Westlake, Sethares, & Davidson, 2013). Distributed health literacy is a potential resource for managing individual's health, thus communicating with health professionals and making health deci-

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sions (Edwards, Wood, Davies, & Edwards, 2015). Low health literacy is a burden to individuals and to health care-related society (Carollo, 2015).

Health information is created, updated, and exchanged by people, and electronic communication networks can distribute the health information to provide easy access to users (Yim, Khuntia, & Argyris, 2015). Health literacy provides the skills to effectively utilize the health information (Londono & Schulz, 2015). The effectiveness of health information largely depends on people's ability to understand and utilize information (Meppelink & Bol, 2015). Providing explicit health information to people with limited health literacy is necessary to reduce these health-related difficulties (Meppelink & Bol, 2015).

This chapter aims to bridge the gap in the literature on the thorough literature consolidation of health literacy. The extensive literature of health literacy provides a contribution to practitioners and researchers by describing theory and applications of health literacy in order to promote the health care literacy in global health care.

BACKGROUND

The term literacy is globally used and it is often used to separate a technical understanding of reading and writing on one hand, and a wider understanding of communication on the other hand (Lundvall, 2015). Health literacy has been prioritized in public health and rigorously studied since the 1990s (Leung, Cheung, & Chi, 2015). Public health is concerned with protecting the health of populations which can be as small as a local neighborhood or as large as an entire country (Raghupathi & Raghupathi, 2013). Early research on health literacy focused on health outcomes among individuals with low health literacy (Leung et al., 2015). As health care moves toward greater choice, with shared responsibility and decision making between doctors and patients, a wide variety of resources and skills are needed by individuals if they are to be active participants in their health (Manning & Dickens, 2006).

Early definitions focused on the ability to apply reading, writing, and numeracy skills to the health-related materials, such as prescriptions, appointment cards, and medicine labels (Parker, Baker, Williams, & Nurss, 1995), while later conceptualizations encompassed a range of skills, including social and communication skills that enable people to obtain, understand, and use the health information in ways that enhance health, well-being, and engagement in the medical decision making (Nutbeam, 2000). Health literacy has been conceptualized in various ways (Nielsen-Bohlman, Panzer, & Kindig, 2004), and its scope have been widened during the last decade (Estacio, 2013). Health literacy has become a topic of significant interest among health and medical researchers during the past two decades, particularly in regard to its explanatory role in health disparities (Reeve & Basalik, 2014).

Health illiteracy is a societal issue that, if successfully addressed, may help reduce health disparities (Brown, Teufel, & Birch, 2007). Health literacy, or the degree to which individuals have the capacity to obtain, communicate, process, and understand basic health information and services needed to make suitable health decisions, is an important predictor of health outcomes (Kaphingst, Goodman, MacMillan, Carpenter, & Griffey, 2014). Inadequate health literacy has been linked to increased health disparities, unsuccessful self-care, poor health outcomes, poor use of health care services, and among elderly persons, poor overall health status, and high mortality rates (Berkman, Sheridan, Donahue, Halpern, & Crotty, 2011).

Health literacy is recognized as an essential factor in optimizing health (Carollo, 2015). Malloy-Weir et al. (2015) indicated that ethical arguments for enabling people to participate in decision making

about their treatment are widely accepted. More recent definitions of health literacy include the ability to apply these skills in various settings and across the life span (Rootman & Gordon-El-Bihbety, 2008). Lower educational attainment is associated with suboptimal health literacy (Sentell, Braun, Davis, & Davis, 2013); however, those who have higher educational attainment may still have low health literacy (Institute of Medicine, 2004). Limited health literacy has been linked with higher incidence of chronic illness, poorer self-reported health, lower utilization of preventive health services, higher rates of hospitalization, and higher health care costs (Weiss & Palmer, 2004).

PERSPECTIVES ON HEALTH LITERACY IN GLOBAL HEALTH CARE

This section explains the overview of health literacy; the characteristics of functional health literacy, interactive health literacy, and critical health literacy; and the significance of health literacy in global health care.

Overview of Health Literacy

Health care is experiencing an exponential growth in the scientific understanding of diagnostic, diseases, and care pathways (Akaichi & Mhadhbi, 2016). Over the last decades, health care policies in many countries have shifted from a supply to a demand or consumer driven organization of health care services (Rademakers, Nijman, Brabers, de Jong, & Hendriks, 2014). Health care sector is a growing field and health conscience has been a major concern for everyone (Sankaranarayanan & Ganesan, 2016). Advances in medical technologies and medical services require adequate health literacy from patients in order to improve quality of life (Tung et al., 2014). Health information should be accessible everywhere and at any time to help with clinical decision and be available for clinical studies (Peixoto, Domingues, & Fernandes, 2016).

Health literacy has been conceptualized to explain how health information facilitates the maintenance of health (Freeman, 2015) regarding medical and public health contexts (Nutbeam, 2000). Knowledge-intensive industries regularly seek to improve positive relationships between forms of human capital and modes of competency (Kasemsap, 2016a). Health literacy is the range of skills and competencies that people develop to seek out, comprehend, evaluate, and utilize health information and concepts to make informed choices, reduce health risks, and increase quality of life (Nielsen-Bohlman et al., 2004). Both providing patients with health information and involving them in health decisions are the major components of patient-centered health care (Coulter, 2002). Active involvement in modern health care is unlikely to be achieved if patients have suboptimal health literacy (Jordan et al., 2013). Research linking health literacy to health knowledge, health behaviors, health outcomes, health disparity, and health status is prevalent across the globe (Mancuso, 2009).

Appropriate health information provision regarding diagnosis, treatment, long-term effects, and health care services can result in informed decision making, improved treatment adherence, lower levels of distress, and higher satisfaction with care (Mallinger, Griggs, & Shields, 2005). There is a growing recognition that inadequate health literacy contributes to health inequalities as it is more prevalent among lower socioeconomic groups, ethnic minorities, the elderly and those with long-term conditions or disabilities (Sihota & Lennard, 2004). Health literacy researches among adolescents are the developing fields and have established the independent associations among lower health literacy levels, poorer

understanding of preventive care information, among limited access to preventive care services (Shone, King, Doane, Wilson, & Wolf, 2011).

To become health literate, individuals need to mobilize their family, school, social, cultural, and professional assets, gathered over time through contact with knowledge, attitudes, and health behaviors (Zanchetta, Perreault, Kaszap, & Viens, 2007). Therefore, individuals need to be skilled in interpreting the health-related world, accessing knowledge (Barton & Hamilton, 1999), and communicating health messages (Institute of Medicine of the National Academies, 2004). It has a strong influence on communication in medical settings and consequences for the patients' health outcomes (Andrus & Roth, 2002). The necessity of the concept of health literacy as a link between communication and better health outcomes is demonstrated in the fact that low health literacy levels are a better predictor of an individual's health than the classical socio-demographic variables of age, income education, employment status, and race.

Many studies about health literacy measures (Ishikawa, Takeuchi, & Yano, 2008) focus on evaluating health information-related reading, comprehension, and numeracy skills (Jordan, Osborne, & Buchbinder, 2011). There is a growing consensus that health literacy encompasses a broader range of attributes other than only literacy skills, such as abilities to interact within broader social and environmental contexts (Lee, Arozullah, & Cho, 2004). Results from the available health literacy measures have shown that people with suboptimal health literacy have difficulty understanding health information (Schillinger, Bindman, Wang, Stewart, & Piette, 2004), poorer knowledge of their condition (Gazmararian, Williams, Peel, & Baker, 2003), and lower utilization of preventive health services (Guerra, Krumholz, & Shea, 2005).

Measuring health literacy is likely to be a particular challenge as it is an emerging and evolving construct (Nutbeam, 2008). Assessment of health literacy has yet to become the clearly established aspect of clinical practice or population-level health needs assessment (Chinn & McCarthy, 2013). A comprehensive model of health literacy was proposed by Schulz and Nakamoto (Rubinelli, Schulz, & Nakamoto, 2009). To emphasize the patient centeredness and component of health literacy concept, Schulz and Nakamoto added judgment skills to the concept, retaining the other components of functional health literacy, declarative knowledge, and procedural knowledge (Schulz & Nakamoto, 2013). Attention to judgment skills is driven by the idea that a patient, in new situations regarding the disease, needs to make autonomous decisions based on knowledge, personal competence, and practical intelligence in general (Dubowicz & Schulz, 2013).

Training in clear health communication improves resident knowledge, attitudes, and skills regarding health literacy (Green, Gonzaga, Cohen, & Spagnoletti, 2014). Researchers investigated how health literacy related to the individual's knowledge and motivation (Paasche-Orlow & Wolf, 2007) and whether health literacy is viewed as a set of health care skills as proposed by the Institute of Medicine (Nielsen-Bohlman et al., 2004). Tsai et al. (2014) indicated that health-related programs that are literacy sensitive and culturally appropriate are needed to teach and encourage individual's health-promoting behaviors. Knowledge and motivation are recognized as the important factors contributing to the development of health literacy (Leung et al., 2015).

The widespread low health literacy affects health and health service delivery (Canadian Council on Learning, 2008). For these reasons, health literacy needs to be extensively introduced and further developed in nursing education curricula (Zanchetta et al., 2013). Regarding nursing education, analyzing students' performance and self-criticism of their roles in promoting health literacy can inform nursing education in a social environment that expects new graduates to be health promoters (Zanchetta et al., 2013). Nurses play a key role in providing health care information to individuals in a wide variety of

health care settings; therefore, it is crucial that nurses are prepared to experience the challenges of working with patients who may have the limited literacy skills (Torres & Nichols, 2014).

The concept of health literacy is widely utilized for measuring the patients' abilities to obtain, process, and communicate information about their health condition, and lately major work in defining and theory-building has been done (Speros, 2005). Patient teaching and engagement are core nursing responsibilities (Sofaer & Schumann, 2013). However, if patients do not understand what nurses have taught them, effective communication has not taken place (Parker & Gazmararian, 2003). The socio-epidemiological relevance of health literacy as a social determinant of health (Raphael, 2009) requires nurses to update their professional knowledge, innovate within their scope of practice and generate new knowledge in the area of promotion of health literacy (Rootman, 2004). Nurses are in the privileged position of being able follow up clients' learning related to health literacy (Zanchetta et al., 2007).

The average American adult reads at the 8th grade level while most written health information materials, including medication guides, are written at the 12th grade level (Chen, Noureldin, & Plake, 2013). To assist students with health literacy-sensitive communication, pharmacy schools should incorporate educational activities addressing health literacy competencies (Chen et al., 2013). Despite the opportunity for pharmacists to reduce the health literacy demands placed on patients, there are many obstacles to making such improvements in retail pharmacies, such as the hectic pace of pharmacies, high prescription volumes, low profit margins limiting pharmacy resources for the improvement activities, a workflow designed to dispense medications, and physical layouts limiting communication between pharmacists and patients (Shoemaker, Staub-DeLong, Wasserman, & Spranca, 2013).

Limited health literacy is associated with increased use of emergency care services, elevated risks for several chronic diseases and overall mortality, and poorer utilization of preventive health services, such as cancer screening (Bennett, Chen, Soroui, & White, 2009). Factors contributing to the decrease in cancer mortality rates include increases in cancer screening rates, appropriate abnormal screening test follow-up, and treatment advances (Oldach & Katz, 2014). Regarding health literacy, the provision of appropriate information is one of the most important aspects of the support for cancer survivors (Verkissen et al., 2014). Limited health literacy skills may explain the overall low uptake of screening and social inequalities in screening, and they may inhibit the individuals' capacity to understand, and subsequently engage with the written screening information (von Wagner, Semmler, Good, & Wardle, 2009).

Characteristics of Functional Health Literacy, Interactive Health Literacy, and Critical Health Literacy

Nutbeam (2000) emphasized the significance of obtaining health literacy at the functional, interactive, and critical levels. Functional health literacy is concerned with the use of general literacy skills (e.g., reading and writing) to clearly understand the basic health messages (Velardo, 2015). Toci et al. (2014) indicate that functional health literacy is related to individual characteristics, ill health, and disease knowledge. Functional health literacy has been shown to be linked with the demographic and socioeconomic characteristics of individuals (von Wagner, Knight, Steptoe, & Wardle, 2007).

Many studies have reported the significant associations of functional health literacy with age (Jovic-Vranes, Bjegovic-Mikanovic, & Marinkovic, 2009), education (Artinian, Lange, Templin, Stallwood, & Hermann, 2003), and income (von Wagner et al., 2007). The limited or marginal functional health literacy has been linked with worse or less favorable health outcomes or disease knowledge (DeWalt, Berkman, Sheridan, Lohr, & Pignone, 2004). Nakagami et al. (2014) stated that both inadequate and

marginal functional health literacy are associated with older age, lower income, lower educational attainment, and poor health knowledge. People with limited functional health literacy are significantly less likely to perceive the lifestyle factors as cancer risks (Adams et al., 2013).

Interactive health literacy focuses on the ability to understand and utilize the information for prevention and self-management. The terms interactive health literacy and communicative health literacy have both been used in literature to refer to the skills that can be used to actively participate in everyday situations, extract health information, and derive meaning from the different patterns of health communication, and apply this perspective to the changing health care circumstances (Chinn, 2011). The increasing amounts of attention are being paid to the interactive and critical health literacy (Sykes, Wills, Rowlands, & Popple, 2013). van der Heide et al. (2015) indicated that interactive health literacy is associated with patients' perceived ability to organize care, interact with the health care providers and perform self-care, whereas only functional health literacy is associated with a number of general practitioner visits.

Most studies on health literacy have focused on functional health literacy, which reflects the basic skills in reading and writing (Chinn, 2011). Age has been found to be a significant inverse predictor of health literacy, both in general populations (Paasche-Orlow, Parker, Gazmararian, Nielsen-Bohlman, & Rudd, 2005) and among older individuals (Benson & Forman, 2002). Regarding cognitive ability perspectives, individuals with inadequate health literacy have lower verbal ability for oral expression and verbal communication; lower mental processing ability for speed and efficiency of thought, comprehension of text and numerical information; poorer memory ability for recalling spoken instructions; lower perceptual speed ability for performance of electronic health searches; and poorer executive function ability for critical thinking, weighing options, and making decisions and inferences (Wilson & Wolf, 2009).

Reading and numeracy are recognized as the fundamental cognitive abilities necessary for navigating and understanding the health care system (Wolf et al., 2009). Because poor cognitive function may undermine health literacy, efforts to target older adults on improving health literacy should consider cognitive function as a risk factor (Nguyen et al., 2013). Overall cognitive ability and education are positively related to health literacy (Yost, DeWalt, Lindquist, & Hahn, 2013). Cognitive status has been shown to be a significant predictor of health literacy among older adults (Federman, Sano, Wolf, Siu, & Halm, 2009).

Critical literacy refers to more advanced cognitive skills that allow individuals to extract information, derive meaning from the different patterns of communication, and utilize this information (Nutbeam, 2000). Critical health literacy is the cognitive and social skills needed to critically assess the applicability of health information to personal situations or its reliability, such as information about the performance of health care providers (Chinn, 2011). Heijmans et al. (2015) indicated that communicative and critical health literacy play a role in successful self-management of chronic disease but the impact differs by the health-related context.

Significance of Health Literacy in Global Health Care

Addressing health literacy as a theory of behavior change can generate the positive gains in individual, health care community, and global health care (Pleasant, 2011). Rehabilitating a debilitated health care system is essential to public, social, and economic health (Ridpath, Larson, & Greene, 2012). Health literacy is a multidimensional construct that bridges basic literacy skills and various health and illness contexts (Yamashita & Kart, 2011). Studies of adults have shown an association between low health

literacy and worse health outcomes, decreased use of preventive services, and poor self-reported health status (Bennett et al., 2009).

Low literacy is an unrecognized barrier to the effective self-health management (Reyes, 2010). Fransen et al. (2014) stated that inadequate health literacy is regarded as a common barrier in patient and public health education. Inadequate health literacy is associated with the inadequate understanding of written information and the poor communication with health care professionals (Davis & Wolf, 2004). Recent studies in health literacy among adolescents, link literacy rates with health behaviors and outcomes including online health information seeking, over-the-counter (OTC) medication use, and obesity (Sharif & Blank, 2010).

In comparison with individuals with adequate health literacy, those with inadequate health literacy have less knowledge of diseases and treatments, often lack the skills to negotiate health care system, exhibit suboptimal self-management, and have worse health outcomes (Gazmararian et al., 2003). Differences in health literacy levels by race and education are broadly hypothesized to contribute to health disparities (Howard, Sentell, & Gazmararian, 2006). The observed relations between health literacy and important indicators of health status have led investigators to develop the effective health interventions to improve health literacy (Sheridan et al., 2011) in the anticipation that they may be effective in improving patient health and address ethnicity-related health disparities (Waldrop-Valverde et al., 2010). Health disparities on the basis of geographic location, social economic factors, and education levels are well documented (Murimi & Harpel, 2010). Limited health literacy may also partially explain racial disparities in outcomes (Saha, 2006).

Low health literacy is recognized as a burden to the individual, thus influencing the access to health services, limiting the understanding of health information, and impacting the quality of health-related decisions (Baker et al., 2007). Low health literacy has been associated with inappropriate use of emergency services, higher rates of hospitalization, and increased health care costs (Koskan, Friedman, & Messias, 2010). Individuals with limited health literacy have overall poorer physical function, less knowledge about managing their chronic health conditions, and participate less in the health care decision-making process (DeWalt, Boone, & Pignone, 2007).

Patients with limited health literacy are reported to have less interest in shared health decision making (Levinson, Kao, Kuby, & Thisted, 2005) which has implications for treatment adherence and health outcomes (Eckman et al., 2012). Health care providers have difficulty detecting patients with limited health literacy (Wittich, Mangan, Grad, Wang, & Gerald, 2007). Patients with limited health literacy are less likely to ask questions (Katz, Jacobson, Veledar, & Kripalani, 2007), seek information from print resources (Koo, Krass, & Aslani, 2006), remember the verbally communicated medication instructions (McCarthy et al., 2012), toward contributing to patients' inabilities to effectively utilize information. Speaking and listening skills are considered more important than reading and numeracy in patient self-advocacy within the health care system (Martin et al., 2011). Verbal exchange skills are key to patient understanding and use of health information that impact health outcomes (Finan, 2002). Swavely et al. (2014) indicated that low health literacy is more prevalent in persons with limited education, members of ethnic minorities, and those who speak English as a second language, and is associated with multiple adverse diabetes-related health outcomes.

Beyond having poorer health outcomes than their adequate health literacy counterpart (Bostock & Steptoe, 2012), patients with suboptimal health literacy show poorer ability to understand medical instructions and medication labels, and to properly take their medications (Berkman et al., 2011). Patients with low health literacy contribute to the increase in health care expenditure through the less frequent

use of preventive health services, the poorly managed chronic illness, and the greater use of emergency department services (Larsen & Lubkin, 2009).

Patients with limited health literacy may have difficulty locating providers and services, understanding written medical information, communicating with health care providers, and implementing self-care instructions (Green et al., 2014) and tend to ask the fewer questions of clinicians because of fear and embarrassment associated with this condition (Aboumatar, Carson, Beach, Roter, & Cooper, 2013). This translates into an array of adverse outcomes, including increased hospitalizations (Baker, Parker, Williams, & Clark, 1998), decreased preventive health care (White, Chen, & Atchison, 2008), poorer overall health status (Cho, Lee, Arozullah, & Crittenden, 2008), and higher mortality rates (Baker, Wolf, Feinglass, & Thompson, 2008).

Health literacy has established the links between literacy skills and health outcomes and is considered as an important strategy for improving the health of disadvantaged populations and addressing social inequality (Flecha, García, & Rudd, 2011). Low health literacy negatively affects a woman's health knowledge, preventive behavior, ability to navigate the health care system, and ability to care for her children (Shieh & Halstead, 2009). In pregnancy, woman's health status and her understanding of health information may directly affect the maternal-fetal health (Lupattelli, Picinardi, Einarson, & Nordeng, 2014). Previous research among pregnant subjects with pregestational diabetes has shown that low health literacy is positively associated with unplanned pregnancies, no use of folic acid prior or during pregnancy, and later presentation for prenatal care (Endres, Sharp, Haney, & Dooley, 2004).

FUTURE RESEARCH DIRECTIONS

The classification of the extensive literature in the domains of health literacy will provide the potential opportunities for future research. Patient safety issues are the avoidable errors in health care that can cause harm to patients. Harm in this context means injury, suffering, disability or death. The effective communities of practice (CoPs) facilitate the social interactions and encourage the members' willingness to share knowledge and ideas in the workplace (Kasemsap, 2016b). Social media tools are open to anyone, whereas reaching the traditional media often requires a lot of money and a good network of media industry contacts (Kasemsap, 2016c). Total quality management (TQM) practices in quality performance has the potential to improve organizational performance (Kasemsap, 2015). Encouraging both health literacy and patient safety improvement through CoPs, social media, and TQM practices in modern health care will be the essential issue for future research direction.

CONCLUSION

This chapter highlighted the overview of health literacy; the characteristics of functional health literacy, interactive health literacy, and critical health literacy; and the significance of health literacy in global health care. Health literacy is about how patients understand health information about health and health care, and how they apply that health information to their daily lives, utilize it to make health-related decisions, and act on it. Health literacy is important because it affects an individual's ability to manage personal health: to navigate the health care system, share health history with health care providers, engage in self-care and manage chronic disease, and understand concepts, such as probability and risk.

Being able to understand health information and make sound health decisions from that information is vital to patients' well-being in health care settings.

Health literacy can help patients prevent their health problems and protect their health, as well as better manage those problems and unexpected situations that happen. Patients with good health literacy make effective health decisions because they can find, understand, and evaluate the health information in global health care. Low health literacy is linked to higher rates of hospitalization and use of emergency services, and less frequent use of preventive services in health care settings, and is linked to health disparities regarding population-specific differences in the presence of disease, health outcomes, or access to health care.

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KEY TERMS AND DEFINITIONS

Communication: The two-way process of reaching mutual understanding, in which participant not only exchange information, news, ideas, and feelings, but also create and share meaning.

Health Care: The act of taking the preventative or necessary medical procedures to improve a person's well-being.

Information: The data that is organized for a specific purpose and presented within a context that gives it meaning and relevance.

Knowledge: The understanding of a circumstance gained through experience.

Literacy: The ability to read and write.

Patient: A person who is receiving medical care, or who is cared for by a particular doctor or dentist when necessary.

Skill: The ability acquired through the deliberate, systematic, and sustained effort to smoothly and adaptively execute the complex activities.

Understanding: The knowledge about a situation or about how something works.

Chapter 31
The Applicability of Currently Available Adults ADHD Treatment Tools

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ABSTRACT

E-mental health services are able to provide tools and services to facilities treatment for many various mental disorders, such as Attentions Deficit Hyperactivity Disorder. ADHD is a neurodevelopmental disorder that affect approximately 5% of adults. This paper presents the findings of 12 interviews with psychologist who are specialized in treating adults with ADHD. The interviews emphasis on the use of Information Technology (IT) by psychologists in their treatment of ADHD. The analysis shows that using IT is beneficial for psychologists and patients. However, there are some issues emerged from the findings that could limit the usability of IT.

INTRODUCTION

E-health is the most important revolution in healthcare industry since discovery the of modern medicine and vaccines (Sibler, 2003). Within e-health the area of e-mental health (eMH) that is still new and emerging (Binhadyan, Troshani, & Wickramasinghe, 2014; Christensen, Griffiths, & Korten, 2002). Although eMH remains in its early stages, it has great potential to facilitate current mental health services by providing improved early interventions and treatments for different people with different mental issues (Christensen, Griffiths, & Evans, 2002; Lal & Adair, 2014; Musiat & Tarrier, 2014), such as Attention Deficit Hyperactivity Disorder (ADHD).

ADHD is a neurodevelopmental condition, which is characterized by inappropriate levels of inattention, hyperactivity and impulsivity (Barkley & Benton, 2010), which affects approximately 5% of Australian adults (The Royal Australian College of Physicians, 2009). ADHD also causes deficits in

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the executive functions in the brain of an individual with ADHD (Barkley & Benton, 2010). Although the literature shows that there appears to be great potential for eMH in the context of young adults with mental disorders (Burns, Davenport, Durkin, Luscombe, & Hickie, 2010; Webb, Burns, & Collin, 2008), the majority of eMH programs are mostly targeting mental disorders, such as depression, anxiety and suicidal thoughts (Australian Government, 2012).

This research explores how psychologists see the applicability of IT tools currently available to treatment of ADHD in adults. The research question is "How do psychologists perceive the applicability of current available IT tools to treat ADHD in adult?"

The next section outlines the use of IT in healthcare in general, followed by a definition of e-health and the use of technology in mental health services in general, ADHD in particular. The last part of this section introduces the relevance of ADHD in adults and what current treatments are used.

BACKGROUND

E-health services have abilities that can support countries in meeting challenges currently existing in their health services (Wickramasinghe, Geisler, & Schaffer, 2005). This can be done by providing better access to information and services, managing changes in population health patterns and increasing satisfaction and safety of stakeholders. E-health services cover a wide range of services which includes eMH (Binhadyan et al., 2014; Christensen, Griffiths, & Korten, 2002). eMH is relatively new, and there are exciting outcomes in using technologies among different age groups, for different mental disorders' preventions, treatments, and interventions (Whittaker et al., 2012).

In addition, eMH services can provide solutions to reduce issues that are preventing people from accessing mental health services or barriers to treatment. Issues arise due to this includes location, time of the services and/or patient, financial matters (Booth et al., 2004) and stigma incurred by seeing a therapist (Burns et al., 2010; Christensen & Hickie, 2010).

Reynolds, Griffiths, and Christensen (2011) claim that eMH services programs can be classified in to two categories:

1. Information, support and assessment web sites: this includes informative website, diagnostics tools and screening methods.
2. Symptom prevention and management programs: these programs are designed to treat or manage specific mental illness such as depression and anxiety.

A review of the list of the online or telephone services that were provided in the eMH Strategy for Australia documents (Australian Government, 2012), the majority of eMH programs are targeting depression, anxiety and suicidal thoughts. Even though roughly one every ten adult Australians suffer from ADHD (The Royal Australian College of Physicians, 2009). This commitment to adoption of technology in Australia makes the country a potentially rich site in which to consider possibilities.

ADHD

ADHD is one of the most common childhood behavioral disorders and can continue through adolescence and adulthood (Fischer, Barkley, Edelbrock, & Smallish, 1990), with between 5% and 10% of the child-

hood population having ADHD (The Royal Australian College of Physicians, 2009). Barkley and Benton (2010) argue that the symptoms of children with ADHD are usually impulsiveness, hyperactivity, and inattention and these symptoms will vary from one person to another.

ADHD in adults causes attention difficulties, and emotional instability which affects their life outcomes and results in underachievement (Wallace, Winsler, & NeSmith, 1999). They are in greater risk of developing anxiety, depression (Heiligenstein & Keeling, 1995), learning disabilities (Wender, Wolf, & Wasserstein, 2001) and deficits in executive functions (Brown, 2006).

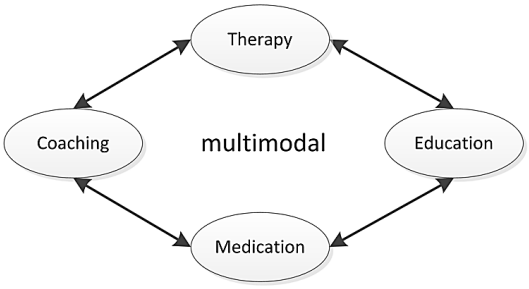
Executive Functions (EF) are described as a set of cognitive processes that connect, prioritize, and integrate cognitive functions that includes Working Memory (WM), planning, task flexibility, inhabitation, organization, and attention (Brown, 2006; Brown, 2008; Oosterman, Derksen, van Wijck, Kessels, & Veldhuijzen, 2012; Pennington & Ozonoff, 1996; Ramsay & Rostain, 2007). This disorder often co-occurs with learning disabilities (LD) such as difficulty in organizing time, poor reading, writing, spelling skills, or completing tasks abilities (Mayes, Calhoun, & Crowell, 2000; McGillivray & Baker, 2009; Ryan, 2007).

To effectively treat ADHD, the multimodal framework (Figure 1) is recommended which includes four components (Department of Human Services Victoria, n. d.): medication, therapy, coaching, and education. Medication is believed to be an important element to treat ADHD in adults, and there are two groups of medication. This include stimulant and non-stimulant medication. Stimulant medications are usually considered as the first-line medication of treatment; however, up to 30% of individual with ADHD do not respond it or cannot tolerate stimulant treatment (Banaschewski, Roessner, Dittmann, Janardhanan Santosh, & Rothenberger, 2004). Non-stimulant is perceived to be effective and well tolerated in managing core symptoms of ADHD (Biederman & Spencer, 2000).

Therapies (also known as psychotherapy) have been seen as useful for treating ADHD in adults. There are a number of Therapies including Cognitive Behavioral Therapy (CBT) (Ramsay, 2012) and Neurofeedback Therapy (Gevensleben et al., 2009). CBT refers to "the pragmatic combination of concepts and techniques from cognitive and behavior therapies common in clinical practice." (Kaltenthaler et al., 2006, p. vii).

Neurofeedback Therapy appears to be a promising alternative or additional treatment without reported adverse effects (Arns, Gunkelman, Breteler, & Spronk, 2008; Gevensleben et al., 2009). Neurofeedback therapy involves the self-regulation of ongoing neuronal oscillations which is recorded by Electroencephalography (EEG), in one or more frequency bands by visual or auditory feedback, aimed

Figure 1. Multimodal framework
Department of Human Services Victoria, n.d.



at normalizing and/or self-regulating brain activity (Lansbergen, van Dongen-Boomsma, Buitelaar, & Slaats-Willemse, 2011).

Education involves educating patients or their career about their disorder. This includes information on intervention related to educational accommodations, support, and school management (Wilens et al., 2008). Coaching is a life coaching technique that assists ADHD adults to improve their skills, for example, time management, studies, and social skills at university (Swartz, Prevatt, & Proctor, 2005).

IT Tools in ADHD Treatment

There are various IT tools that are used in different stage of ADHD and in each one of the multimodal framework: therapy, education, and coaching. The study is designed to explore and to investigate the use of technology in the delivery of the treatment of ADHD. The Multimodal framework is adapted to see where IT is used or where it can be introduced. Some findings in the literature are presented in Table 1. Furthermore, there are IT tools are used in the diagnosing process of ADHD, such as Test of Variables of Attention (TOVA) (Avior et al., 2004); Continuous Performance Test (CPT) (Epstein et al., 2003), Single-photon emission computed tomography (SPECT) and Positron Emission Tomography (PET) scans (Stormezand, 2014), EEG.

Research Method

This research paper attempts to answer the following research question,

How do psychologists perceive the applicability of current available IT tools to treat ADHD in adults?

To answer this question, data was collected from twelve psychologists who are specialized in treating adults with ADHD. These are early findings from a continuing and larger research project.

To find out how psychologists perceive the applicability of currently available IT tools, this research has gathered data from psychologists using qualitative semi-structured interviews. During each interview psychologists were asked these question:

1. How do you diagnose the disorder and do you use any technology devices to help you with the diagnoses, if yes- what? Please explain and if no- why not?
2. What is/are principle ADHD treatment/s that you use?

Table 1. Tools used in the multimodal framework

Treatment	Tool	References
Therapy	• Neurofeedback Therapy • CBT	• (Arns, de Ridder, Strehl, Breteler, & Coenen, 2009) • (Klingberg et al., 2005; Wilens et al., 1999)
Education	Informative Website and Social media	(Canadian Attention Deficit Hyperactivity Disorder Resource Alliance (CADDRA), 2011)
Coaching	• Smartphone; SMS reminder • Alarm; computerized reminders • Email coaching; Time management	(Prevatt, Lampropoulos, Bowles, & Garrett, 2011)

3. Have you advised patients to use any IT tools (such as online calendar, SMS, email alarm), please explain?
4. What impact do you think online software/programs would have in treating or managing ADHD?
5. Can you suggest any special features that such software should have?

During each interview, the researcher asked other questions to gain more information about their use of IT in their treatment of ADHD in adults. These questions included tools they do not use. This provided deeper insight what the psychologist's perspective on what is the applicability of using IT in their current treatment of ADHD.

The psychologists were selected based on four dimensions: educational level, years of experience, specialized in ADHD and offering internet technology as a treatment tool:

- She/he is specialized in treating adults with ADHD,
- She/he has a minimum with minimum of 10 years of experience,
- Offering at least one of IS/IT tools to deliver his/her services. Eg. Skype, Email, SMS.

The psychologists were reached via email, or mail requesting participation in the research. In addition, a brief introduction of the purpose of the research as well as its scope and objectives was enclosed. They were identified with the assistance of Australian Psychological Society (APS) website (http://www.psychology.org.au). In addition, ethics approval granted for audio recording of each interview then it was transcribed into text and transferred into a qualitative software tool (NVivo10®). This tool assists in the coding process of the development of the themes in each transcribed interview. The lens of analysis used in this research is grounded theory (Glaser & Strauss, 2009), which provide a process to analyze data and develop a set of themes.

FINDINGS

The themes that resulted from the analysis of interviews and supporting statements made by psychologists are outlined. The analysis of the interviews has highlighted a number of benefits and challenges on how IT is used in/for the treatment of ADHD in adults. There are other themes that have emerged in the research but they will not be included in this paper.

Integrating Information Technology with Psychology

The following set of concepts outlines the integration of IT in psychology. They describe the use of IT tools and how they are implemented and used in treatment of ADHD in adults by psychologists. These concepts also present how IT tools can fit the requirements of adults with ADHD. Psychologists use technology IT tools as methods to gather extra data in their diagnosis for ADHD. Assistive Technology (AT) tools that are used by adults with ADHD have the ability to improve issues related to ADHD. These tools include smartphone, the Internet, and cloud-based applications. Integrating IT with treatment of ADHD in general is reported as beneficial by most participants. The following are an example of this.

I think technology is very, very good for people with ADHD.

Yeah. IT can be maybe helpful in teaching people some basically positive thinking tool.

Oh very much yeah, very much. Whatever can order the brain is better.

However, there are not generic technology tools that will suit all the ADHD individuals.

The gaming industry's taking this EEG biofeedback thing quite seriously. … how there are different causes for the same problem; ADHD's not one thing.

AT tools that provide multiple options to either deliver or store information are found to be useful for adults with ADHD. These options include audio, visual, or text format output or input. AT tools that have the facility to be socially connected and have performance progression records feature are more likely to be used by the adults with ADHD. However, this use could be effected by different factors, such as cost, lacking evidence-based research, or their technology literacy. The concepts that form part of this them include:

- The use of AT by psychologists,
- AT tools for patients,
- Usability Issues of AT tools.

The Use of AT by Psychologists

The findings show the available AT tools that use brain scan or wave are not sufficient to diagnose individuals with ADHD. These tools include; TOVA; CPT, SPECT, PET scans, and EEG.

TOVA is used to measure the core symptoms of ADHD such as impulsivity and attention issues. However, a number of psychologists reported these tools are not not fully diagnostic but are used as tool to gather more data in the diagnostic process.

Now, we also use a test of variables of attention (TOVA)….and very often we find that these tests do not give us a pattern that is generally considered as being present in attention deficit disorder, but you still see that the person has ADHD symptoms.

CPT is used as a measurement technology tool in the diagnostic process as seen by psychologists. This AT tool is used as an assessment to add extra data to the diagnostic process; however, there is a minimum age limit for this tool to be used.

I also use the Continuous Performance Test, number two So, we use that from, basically, seven years old upwards as a standard, sort of, assessment tool in the battery.

SPECT/ PET scans, and EEG are methods used in the process of diagnosing ADHD. Psychologists report that these tools are able to show difference in the brain but cannot be employed as diagnostic tools that can point out the ADHD symptoms. They are able to show differences in the brain. All the methods were present in the data; the following is an example of this.

I believe that there are some doctors who are talking up SPECT scans and that these are a diagnostic tool. I know for a fact that they're not. They show differences in the brain, but they don't pinpoint ADHD.

AT Tools for Patients

AT tools, such as smartphone, the Internet, and cloud-based applications are used to enhance treatments of ADHD. Psychologists believe that they are beneficial. They have the ability to improve issues with working memory. Psychologists report that using alarms can help to improve the multitasking skills and shifting between tasks.

You increase the size of working memory by having IT.

Sometimes we put on timers for forty-five minutes, so then we have a forty-five-fifteen kind of work aspect, and then they use timers for forty-five minutes…., so there's this ability to shift between tasks.

Other AT tools such as To-Do-Lists improve commitment; however, the psychologists believe that these tools has to be more exciting, animated, and engaging for them to work with patients with ADHD. Finding locations, as a feature, is used to improve the adults with ADHD's time management skills and their commitment ability

Then there's apps, like, to-do lists, which-- and there's ones that have avatars …and you get points for kind of doing the things that you need to do.

There are excellent task lists. I encourage them to use their smart phones really smartly to use reminders attached to locations.

Using smartphones features such as reminder are found useful to mobile apps with multiple alarms are used to assist the commitment of adults with ADHD. Timer and cloud storage services are helpful in improving the management and organization. All smart phone features were present in the data, the following are an example of this.

So I suppose there's just a simple reminder, or an app, or there's a trigger to remember to do the thing. So that's the key concern is remembering to remember.

I talk to people about how to get their world into a more, kind of—like I said, they're all over the darn place—so we scan stuff and we put it up to a cloud.

AT tools that have multiple methods to present or store contents can increase the potential of successful use of technology in the treatment of ADHD. This includes text, or visual, and other multimedia methods can enhance the intervention outcomes. The tools that have the ability to be socially connected are more effective in the treatment of ADHD.

Modular, but very small modules, and ideally with different ways of accessing content, … everything's all blocks of text, or we're going to do five minute videos, or we're going to present information with choice.

If you could make it socially connected, that would even be more awesome because I'd reckon there'd be that sort of thing of like, they're excited to do it.

Usability Issues of AT Tools

The findings show that there are a number of issues that can limit the use of AT tools by psychologists and for patients. This include, professional supervision, cost, efficiency, age and technology literacy, all of these issues were presented in the data, and the followings are an example of this.

It can be done, but I think that this thing's expensive and unnecessary.

I don't know much about that technology so I can't tell people about it. I think, you know, I'd have to refer them to my kids.

They use gamification, right-- works really well for that 18-22 zone

Psychologists believed that using videoconference tools, such as Skype®, can be effected by technology literacy of patients or cost. Medicare, which is an Australian public healthcare scheme, does not cover therapy using Skype® as seen by psychologists.

The trouble is that Medicare will not pay for consultations over Skype. With Medicare to do that, if we can change Medicare on that issue that would be great.

She's not that in much into IT so I'm having to educate her on what is available and making sure she's not scared of it.

The cost of using AT tools in the delivery of ADHD treatment is high comparing to other traditional treatment methods. Psychologists based their assumption of the cost of on the numbers of years of traditional treatment and therefore not justifiable in the absence of evidence of effectiveness.

Oh there's dozens, so there's people. EEG's, ECG's, CAT scans, PET scans…. they could spend that five thousand dollars that would cost for a scan, well that's years of therapy if they needed it, years of medication if they needed it, so it's -- the cost benefit ration, there's huge cost with minimal benefit.

Some ethical concerns emerged from the data in using AT tools in their treatment of ADHD. Some of these concerns are breach of privacy between psychologists and patients, and using AT tools with no research evidence of its effectiveness to treat the disorder.

SMS that is used as reminders or communication is seen by one psychologist as breach of privacy; therefore email is the preferable option. IT industry as seen by a participant are developing solutions for the sake of quick cash which may have the potential for misuse.

Assuming they've got a smart phone, absolutely. I don't use SMSes with my clients because I'm handing out my own phone number, but I do use email.

Industry wants to roll out something and have, you know, millions of people buy it and millions of people use it, and then they make money. And their ethics are a bit of a worry…. so there's just the question of, for me, the ethics of putting a tool in people's hands that has a potential for significant misuse.

FUTURE RESEARCH DIRECTIONS

Future studies will include deeper analysis of the current use of IT in the treatment of adults with ADHD. This will help to get more insight and provide more information of how IT can be used to enhance the treatment of ADHD. This might provide a theory that may enhance the use of IT in the treatment of ADHD.

CONCLUSION

This research paper aimed to investigate how psychologists perceive the applicability of current available IT tools to treat ADHD in adults. It outlined aspects that positively or negatively impact the use of IT tools by these professionals in their routine treatment. The outcomes will contribute to Australian eMH strategy and programs.

This research intended to examine the potentials for integrating IT into the treatment of adults with ADHD. The findings show that technology is currently integrated with the treatment of ADHD in adults. It is used by psychologists to assist them in gathering more data in the diagnosis or treatment process. AT tools that are provided by psychologists to their patients are reported to be useful. These tools include smartphone, the Internet, and cloud-based applications. It is believed that certain characteristics of AT tools need to be available for successful use. Issues raised regarding factors such as cost, lacking evidence-based research, or technology literacy might affect the integration of IT with psychology. Finally, this research provides outcomes that will facilitate the use of IT in the treatment of ADHD in adults. It also contributes to both eMH practice in Australia as well as serving to extend theory regarding e-mental health.

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KEY TERMS AND DEFINITIONS

Assistive Technology: Technological support tools that are used to improve issues related to ADHD.

Continuous Performance Test: A set of test tools that used to measure attention.

Executive Functions: A centralized primary cognitive process which control, manage, supervise, connect and functions a set of cognitive processes.

Neurofeedback: A tool that is employs real-times brain activities to assist in self-regulation in brain functions.

Positron Emission Tomography: An imaging test to assist to show how tissues and organs are functioning of people.

Psychotherapy: A psychological mental disorder's treatment.

Test of Variables of Attention: A neuropsychological tool to measure an individual's level of attention.

Chapter 32
Health Policy Implementation:
Moving Beyond Its Barriers in United States

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ABSTRACT

This research describes policy implementation components of a health system and explains how they affect outcomes. It argues that implemented policies affect various components of a health system in terms of service delivery, workforce, information, financing, medical products, technologies, leadership and governance. Using health system as framework of analysis, the paper explains that the outcome of health policy implementation determines the availability, quality and equitability of program service delivery. The paper goes on to argue that policy implementation barriers, such as demand-and supply-side barriers, market, insufficient resources, cultural barriers, imperfect communication, information, education, coordination, leadership and governance affect the poor and vulnerable groups in developed and developing countries from benefitting from public spending on public health policies and programs.

INTRODUCTION

An important factor in socio-economic development of any nation is the extent to which that country in involved in healthcare delivery system. Good health is a vital factor of quality of life as well as a pre-requisite for achieving socially and economically productive lives of a nation. No government can function effectively without an appropriate health care system (Gholipour & Rouzbehani, 2016). Health care system is one of the basic institutions that are universal in nature and without which a society cannot survive. The World Health Organization Report (2000) defines health system as comprising all the organizations, institutions and resources that are devoted to producing health actions. Health action in this context entails any effort, whether in personal healthcare, public health services or through intersectional initiatives (Weimer, 2011), whose primary purpose is to improve health. Healthcare institutions consist of formal and informal organizations where preventive, social and clinical services are rendered to the members of the society. Each of the institutions has specific aims and objectives even though

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they all exist to promote health, to prevent the occurrence of diseases, to bring about a peaceful end for those suffering from terminal disease, and to treat human illness. Most health care institutions form an arm of the government. Their social structure, therefore, follows the same pattern as other government institutions.

The purpose of this paper, therefore, is to examine policy implementation by institutions of health care delivery and barriers to effective outcomes. Specifically, the paper attempts to investigate how health polices support program activities of health institutions, such as; elimination of healthcare inequities; access to healthcare facilities, products and services; availability of finance infrastructures and other resources; provision of information and education to individuals and communities to medical products, facilities and services.

Consequent upon this, the paper is structured into five parts. Part one examines the introduction, purpose, clarification of concepts and underpinning theories of health policy implementation. Part two examines the inputs required in a healthcare system, such as; finance, structures and power relationships equipment, personal and clients. Part three discusses the processes or series of activities that transform resources (inputs) into a desired product, service or output. Part four examines the outputs – direct result of the interaction between inputs and processes in the system, the types and quantities of goods and services produced by an activity, program or project. Finally, part five identifies the barriers to effective health policy implementation and its implications.

CONCEPTUAL CLARIFICATIONS

Health System

Health system comprises all organizations, institutions and resources that are devoted to producing health actions. Health actions in this context refers to any efforts, whether in personal healthcare, public health services or through intersectional initiatives whose primary purpose is to improve health. It is an open system with three components of input, processes and outputs. Inputs required in a healthcare system include; finance, physical structure, equipment personnel and clients. The process refers to a series of activities that transform inputs (resources) into a desired product, service or output. The term output is used to describe the direct result of the interaction of inputs and processes in the system, the types of and quantities of goods and services produced by any activity, program or project. On the other hand, the term outcome refers to the result of the outputs, the effects or impacts.

Health Policy

Health policy means more than a national law or intervention. Operational policies are the rules regulations, guidelines and administrative norms that governments use to translate national laws and police into programs and services. Health policy can be defined as the decisions plans and actions that are undertaken to achieve specific healthcare goals in a society. Health policy can also support program activities, such as elimination of inequities in healthcare delivery services or mobilization of community health workers.

Policy Implementation

Implementation refers to the stage of the policy process immediately after the passage of a law. Implementation, viewed broadly, means administration of law in which various actors, organization, states, local authorities, procedures and techniques work together to put adopted polices into effect in an effort to attain policy or program goals(Dunn,2012). For our purpose, implementation can be conceptualized as a process, outputs (series of activities) and outcome. As a process, it is viewed as a series of decisions and actions directed toward putting a prior authoritative federal legislative decision into effect by the state or local authorities or organizations. As an output, implementation can be defined in terms of the extent to which programmatic goals are supported, such as the level of expenditures committed to a program or the number of violations issued for failure to comply with the implementation directive. Policy implementation can be conceptualized as some measureable change in the large problem that was addressed by the program, public law, or judicial decisions (outcomes).

THEORETICAL UNDERPINNINGS

There are three major theoretical models of policy implementation, namely top-down approach, bottom-up approach and Principal Agent theory.

Top-Down Approach

This approach sees policy as formation and policy execution as distinct activities. Polices are set at higher levels in a political process and are then communicated to subordinate levels which are then to subordinate levels which are then to subordinate levels which are then charged with the technical, managerial and administrative tasks of putting policy into practice. In this approach, certain conditions are necessary for policy implementation to be effective:

- Clear and logically consistent objectives,
- An implementation process structured to enhance compliance by implementers,
- Committed, skilful implementing officials,
- Support from interest groups and legislature,
- No changes in socio-economic conditions that undermine political support,
- Adequate time and sufficient resources available,
- Good coordination and communication.

BOTTOM-UP APPROACH

This approach recognizes that individuals at subordinate levels are likely to play an active part in implementation and may have some discretion to reshape objectives of the policy and charge the way it is implemented. The bottom-up approach sees policy implementation as an interactive process involving policy makers, implementers from various levels of government and other actors.

PRINCIPAL-AGENCY THEORY

In each situation, there will be a relationship between principals (those who define policy) and agents (those who implement policy), which may include contacts or agreements that enable the principal to specify what is provided and check that this has been accomplished. The amount of discretion given to the agents and the complexity of the principal – agents relationship is affected by the nature of the policy problem – including scale of change required, size of affected group; circumstances surrounding the problem (political, economic climate, technological change); and the organization of the machinery required to implement the policy (number of formal and informal agencies, amount of skills and resources required) the three theories. Whether policies are implemented from the top-down, bottom –up or according to the principal agent theory, policy implementation involves three activities (Anderson and Sotir, 2006):

- **Interpretation:** Translation of the policy into administrative directives.
- **Organization:** Establishment of administrative units and methods necessary to put a program into effect.
- **Application:** Routine administering of the service.

Interpretation of policy directives requires the translation of knowledge on interventions into the particular local context. According to Jenkin et al (2006), factors to take account when interpreting health policy include:

- Local resources, including human resources and infrastructure;
- Specific characteristics of the population;
- Baseline incidence of the health problem;
- The latency period before an effect of the intervention will be observed;
- A balance between achieving targets that reflect process change and those that reflect risk factor change;
- Local variations in the likely effectiveness of particular interventions.

Implementing health policy, therefore involves the rearrangement and restructuring of institutions at the national and subnational levels. It entails determining the power structure and inter-institutional dynamics. Some operational policies may pertain to subnational levels, thus resulting in a more decentralized system.

CONCEPTUAL FRAMEWORK

This paper adopts health system as our conceptual framework of analysis. WHO (2000) defines health system as comprising all organizations, institutions and resources that are devoted to producing health actions. Health actions in this context refers to any efforts, whether in personal healthcare, public health services or through intersectional initiatives whose primary purpose is to improve health. Health system is an open system with three components of input, processes and outputs.

Inputs required in a healthcare system include; finance, physical structure, equipment, health information, technology, material resources, personnel, health policies and clients. The process refers to a series of actions or activities that transform inputs or resources into a desired product, service or outcome. The series of activities in the process include treatment, client education, community empowerment, official meetings and other health interventions. The term output is used to describe the direct result of the interaction of inputs and processes in the system, the types of and quantities of goods and services produced by an activity, program or project. It includes treated patient, efficient services, improved health status, community empowerment, trained staff, good quality of life and sanitation. On the other hand, the term outcome refers to the result of a process, including output, effects or impacts (Quality Assurance Project, TASC 2 Eritrea, 2003). All this depends on how efficiently the system is administered and how the resources within the operating environment. The enabling environment comprises the government, State, Local authorities, health institutions, socio-cultural and economic factors, regulatory quality control by government, rule of law, civil society, community, individuals, political stability and support, accountability and so on.

This conceptual framework is adopted because the analysis is not intended to identify causal pathway. The health system, which is an open system, is one of the basic institutions that are universal in nature and without which a society cannot survive. According to the WHO (2000), all health systems carry out the functions of providing or delivering personal and non-personal health services; generating the necessary human and physical resources to the that possible; raising and pooling the revenue used to purchase services and acting as the overall steward of the resources, powers and expectations entrusted to them. The health system is, therefore, justified as our conceptual framework of analysis for this paper since large number of people and institutions are involved at different levels.

METHOD OF ANALYSIS

The paper adopts qualitative research technique. The purpose is to select information that would help us describe and explain health policy implementation and barriers to its effectiveness. Data were collected from secondary sources. They include textbooks, journals, newspapers, internet and records. Data from these sources were analyzed using documentary data analysis, thematic analysis and content analysis techniques to elicit key concepts or themes. The concepts were coded and categorized into units of analyses: policy implementation of resources or inputs; policy implementation intervention process or series of activities; and policy implementation of outputs/outcomes (efficient services or improved health status).

HEALTH POLICY IMPLEMENTATION (RESOURCES)

Formal organizations such as health institutions are made up of people and they are set up to achieve specific goals and objectives. The attainment of these goals depends on the availability of resources in the right kind, quantity and mix. Ultimately, the attainment of the goals depends on proper utilization of resources. Resources are those inputs that help, support and/or have positive impact upon the achievement of organizational goals (Peretomode and Peretomode, 2005). According to them, resources can be categorized into human and non-human resources. Non-human resources can be further categorized into

financial and non-financial resources. Non-financial resources include: facilities, structures, equipment, time, technology, land, transportation, organizational climate, geography, information, policies and so on. The provision of health care services, consequently, involves putting together a considerable number of resource inputs to deliver an extraordinary array of different service outputs. Finance is an important asset in healthcare delivery services. The performance of the health system depends ultimately on the knowledge, skills, and motivation of the people responsible for delivering services.

GOVERNMENT INTERVENTIONS IN HEALTH POLICY IMPLEMENTATION PROCESS

Perhaps the most pervasive impact of government on the delivery of healthcare services in most nations is through regulation. There are many kinds of health-care regulations, namely: facilities, costs, quality and pharmaceuticals. Governments attempt to influence health-care delivery indirectly by providing financial support for certain activities, and directly attempt to move resources around in the health industry. One such attempt is through the regulation of "healthcare facilities and more comprehensive planning for the health needs of communities" (Peter, 1988:258). Another regulatory device is the control of costs in terms of making majority of expenses paid by a third party, such as "Blue Cross or Medicare or Medicaid" in America health care system (Peter, 1988: 258). For example, the regulation of health-care quality is another area of intervention by USA government in health policy implementation. The major public instruments used for regulating the quality of medical care are the Professional Standards Review Organizations (PSROs). These organizations are designed in part to monitor costs of services provided to Medicare Patients but they necessarily become involved in the issue of appropriate some PSROs have gone as far as to establish standard profiles of treatment for certain rather common conditions and then to question physicians whose treatment differs significantly from those patterns.

Furthermore, the US government and other nations are deeply involved in the regulation of pharmaceutical industry and in the control of substances in food and water that are potentially harmful to health. The Food and Drug Administration (FDA) in USA and National Agency for Food and Drug Administration and Control (NAFDAC) in Nigeria are responsible for most of the drug regulation. The safety and effectiveness of a drug must be demonstrated by clinical trials. Associated with drug regulation in the Food and Drug Administration (FDA) has been food regulation, especially the prohibition of carcinogenic substances in food, especially the substances that induce cancer in human beings or animals.

Another issues related to the regulation of pharmaceuticals is the regulation of tobacco, especially cigarettes. It has been observed that smoking cigarettes is harmful to health. It requires warning labels on to be placed on packages and forbid advertising on electronic media. Cigarettes and their regulations figure prominently in financing of health care, especially increased tax on cigarettes. Moreover, competitive mechanisms using market forces to produce desired changes in the health-service industry have been on the increase in recent times. So, government should develop institutional capacities to ensure that appropriate uptake and integration of policies into existing activities. That is, integration of policy into private sector and community programs, such as: public-private partnership and community-based distribution network. These health policies can also support other program activities, in fact.

HEALTH POLICY IMPLENTATION (OUTPUTS/OUTCOMES)

Outcomes of these activities help increase accountability and identify implementation barriers. There have been reported cases of fraud in America's healthcare system. Home-health fraud, such as charging for non-existent visits to giving insulin injections- got- so bad that the "Medicare and Medicaid Centres" (CMS), which run the programs called a moratorium on enrolling new providers in several large cities in 2013. Since tighter screening was introduced under "Obama care", the CMS has stripped 17,000 providers of their licenses to bill "Medicare"- services meant for the elderly recipients. Thousands of suppliers also quit after being acquired to seek accreditation and to post surety bonds of $50,000. It was reported that health-care fraud in America amounted to about $272 billion in 2013.Thus; the outcome of health policy implementation is improved health status for individuals and community. According to WHO (2000), the main objective of health action or series of health activities, whether in personal health care, public health services or through inter-sectoral initiatives is to improve health. Health policy implementation outcomes, therefore, can be summarized as: efficient services, improved health status, treated patients, community empowerment, trained staff, good sanitation and good quality of life.

ENABLING ENVIRONMENT IN HEALTH SYSTEM

For efficient services to emerge from health policy implementation, accountability and transparent mechanisms should be well established, so that civil society can monitor the implementation process, in terms of service coverage and quality, population coverage and equity, healthy behaviors by increased number of people.

BARRIERS TO EFFECTIVE HEALTH POLICY IMPLEMENTATION

1. **Economics:** The most commonly cited barrier to access to healthcare is economics. For example, in USA, majority of medical care is still paid for privately. Those who lack the income or insurance to pay for medical care may not have that medical care. Many who are poor but not sufficiently poor to qualify are not eligible to receive Medicaid benefits. Many people do not have health insurance. The elderly poor who have access to Medicare as a result of their age must still pay for parts of their insurance, at a rate that may deter some taking full advantage of healthcare program. Even having insurance as well as not having it can present troubles. The principal problem is that it can minimize mobility in the economy.
2. **Demand and Supply Barrier:** On the demand side, the economic literature is dominated by adaptations of Grossman model that analyze individual investment and consumption decisions to improve health and utilize healthcare (Grossman, 2000). Demand is influenced by factors that determine whether an individual identifies illness and is willing and able to seek appropriate healthcare. The model levels to a demand for healthcare of a given quality that is determined by individual and community factors as well as the price of medical care and other similar goods. Individual (and household) factors include age, sex, income. Demand barriers to utilization of healthcare include:
    a. **Information on Health Care Choices:** This provides lack of knowledge of the providers.

b. **Education:** Low ability to assimilate health choices and negotiate access to appropriate providers. Education and knowledge about the characteristics of and need for medical treatment. Information and education are related to failures, either in the form of knowledge of healthcare choices or in the ability to utilize this information in an effective way.
c. Indirect Consumer Costs Barriers:
   i. Distance cost,
   ii. Opportunity cost.
d. **Household Preferences:** A symmetric control over household resources.
e. **Community and Cultural Preferences, Attitudes, and Norms:** Reluctance to seek healthcare for women outside home; community resistance to using modern medical care to assist pregnancy. For example, cultural barriers such as cultural norms, such as purdah restrictions can prevent women from seeking healthcare outside the home for themselves and their children (Rashid et al. 2001). The barrier is often raised still further when men provide services and has often offered as one reason why Asian women living in Western countries often make little use of health services (Whiteford and SZelag, 2000). Such restrictions may also interact with other barriers. Community factors may include cultural and religious influences and other social factors that affect individual preferences.
f. **Input Prices and Input Availability:** Substitute products and services patients seek treatment through providers that are inappropriate for their condition such as drug sellers (Ensor and Cooper, 2004). Price is a complex variable and includes direct price and distance cost, opportunity (time) cost of treatment-since treatment can be time consuming and any informal payments made to the facility for commodities or to staff. Quality of staff may be absent because of the price of the wages and staff not attracted to the area.
g. **Knowledge of Technology of Treatments:** Inability to treat disease with given technology
h. **Management Efficiency:** Poor quality of management training, lack of management systems.

The determinants of demand may generate barriers to utilization of healthcare services. Education and information assist to assimilate health messages and are important in determining demand. Finally, barriers may also interact with other demand barriers and act as important determinant of the willingness to travel long distances to obtain treatment. Therefore, increasing demand is far more complex than simply the provision of health education advice or information but is also strongly related to the relative position and educations are family members. Demand barriers present in low and middle-income countries and even richer countries among vulnerable groups.

SUPPLY BARRIER

The provision of healthcare is, in many ways, a monopoly or cartel. Entry into the marketplace for potential suppliers is limited by licensing requirements and further controlled by the professions themselves, which limits the number of places available in medical schools. Thus, unlike other industries, the healthcare field makes it difficult for competition to develop among suppliers. One possible means for promoting competition is to break down the monopoly held by the medical profession by giving nurse practitioners and other para-professionals a greater opportunity to practice. The medical profession rather vigorously resists such changes. Hospitals do compete increasingly for patients, however, and with that competition

has come some greater attention to the quality of care. Moreover, price and quality of drugs and other consumables and weak cold chain may cause scarcity of supplies. Thus, supply barriers affect patients in obtaining treatments, especially for the poor and other vulnerable groups.

3. **High Medical Care Costs Barrier:** Medical-care costs are problem for government as well as for private citizens. Half the total medical care bill is paid by government. A number of factors have been identified as causing at least part of the increase in medical care costs. For hospitals, one factor has been a rapid increase in the cost of supplies and equipment. This has been true of large capital investments such as CAT Scanners, as well as more mundane items, such as dressings and surgical gloves. In addition, labor costs for hospitals have been increasing rapidly, as many professional and unprofessional employees unionize to bargain for higher wages (Aaron, 1991:8-37). Besides, physician costs also have been rising, not as rapidly as hospital costs. In addition to general pressures of inflation in the economy as a whole, increases in equipment and supply costs, increased insurance paperwork, the increasing cost of medical malpractice insurance and the practice of "defensive medicine" to protect against malpractice suits by ordering every possible diagnostic procedure have all produced increases in doctors' fees (Aaron, 1991: 45-47) Finally, the method of payment increases the cost of medical care. Over 76 percent of the hospital costs and approximately 60 percent of all medical expenses are paid by third party payers (Health Insurance Association, 1993)
4. **Quality Barrier:** In USA for example, both citizens and government must be concerned with the quality of medical care being provided. Citizens' obvious expressions of concern about quality have been the increased number of malpractices suits and complaints against physicians and hospitals. State Medical Associations and their Review Boards and other professional organizations that are supposed to discipline their fellow professionals and friends, find it difficult to do so. Government concern about quality extends from the general social responsibility for regulating the safety and effectiveness of medicines and medical devices on the market to the quality of care provided to Medicare and Medicaid patients to perhaps a more philosophical concern with the efficacy of modern medical care as a remedy for the health problems of American citizens.
5. **Unequal Access Barrier:** Medical care is mal-distributed, that is, the areas and persons with the greatest needs for healthcare are not the areas and persons with the greatest access to care. For example, in USA, Hospitals, nursing homes, clinics, doctors, dentists and other healthcare professionals are disproportionately located in well-to-do urban and sub-urban areas, as the highest fees can be generated there. The residents of these areas have better access to care than do the poor and residents of rural areas. This phenomenon is particularly true for access to specialized institutions and personnel, but it is also true to a lesser extent, for general practitioners and basic care institution. Medical care is distributed on the basis of ability to pay rather than on need. The limited access pattern contributes to the poor health and shorter life expectancy of those who are poor or live in rural communities. Black infant and maternal mortality rates are nearly twice those of whites and comparable to many countries in the Third world. The average life expectancy for blacks is six years lower than that for whites (Cochran et al, 1986). Unequal access is significant barrier to healthcare. Gaining equality in medical care is often difficult to the poor. Geography distantly plays a significant dual role in defining access to medical care. Aside from this, medical services would be even more pronounced if the areas of specialization of physicians and the standards and equipment of the hospital are considered. In some parts of USA, for example, high quality medical

care may not be available even for someone who can afford it, without a substantial investment in travel. Thus, the relatively high rate of infant mortality in most low-and-middle-income countries is often taken as an indicator of poor access to medical care.

6. **Overspecialization of Healthcare:** Over specialization contributes to high cost of medical care as specialists charge more and use hospitals more than do general practitioners. For example, in USA as well as other developing countries, primary healthcare physicians, - family doctors and general practitioners constitute a small proportion of American physicians. Cardiologists Pediatricians, Urologists and other specialists are the dominant figures in the medical profession. Serious consequence from the predominance of specialists may help to account for the rather poor performance on measures of infant mortality and life expectancy relative to those of other developed nations, as these measures are more sensitive to high quality routine care than to sophisticated, exceptional procedures.
7. **Financial Inequities or Barriers:** Another problem to healthcare is the financial burden imposed on many individuals and families by its high cost. The gaps in public and private health insurance are wide enough to let millions fall into financial disaster. In America, five to eight percent of the population has no health insurance, public or private. Fifty to sixty million persons have no major medical coverage. The result is that nearly ten percent of all families every year have out-of-pocket medical-gross income. Most of these families are poor, so that even $1,000 out-of-pocket is a catastrophic expense. Almost half of all personal bankruptcies each year involve medical debts. Moreover, unintended consequences are major concern, as health education policy contributes to the over-specialization of physicians and recent changes in that policy have not yet shown an effect. Public policy, again particularly Medicare and Medicaid, in American health system contributes substantially to the cost of escalation in healthcare. As health care policy reduces the financial burden on specific individual, it increases on specific individuals, and increases on the society as a whole. Thus, the most important problem in healthcare, shared by many nations is its soaring cost to society. There are substantial problems with America healthcare policy. Many differences in quality and access to care still remain among various groups. Medicare and Medicaid have contributed to health care is inflated costs and have not challenged structural problems in its delivery. And neither regulatory policies nor Professional Standards Review Organizations (PSROs); Health Safety Agencies (HSAs); Health Maintenance Organizations (HMOs) have had the success hoped for in introducing rational coordination and cost control into the system. So, developing countries face financial barriers in health policy implementation.

CONCLUSION

Within the fundamental obligations of governments at federal, state and local authorities. The National Healthcare system should be developed to support in a coordinated manner a three-tier system of healthcare. Essential features of the system should be its comprehensive nature, multi-sectoral inputs, community involvement and collaboration with non-governmental providers of healthcare. The goal of health policy should be based on primary healthcare that is promotion-based, protective, preventive, restorative and rehabilitative to every citizen of the country within the available resources, so that individuals and communities are assured of productivity, social wellbeing and improvement of living standard.

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KEY TERMS AND DEFINITIONS

Health Policy: Health policy broadly describes the actions taken by governments—national, state, and local—to advance the public's health. It is not a single action but requires a range of legislative and regulatory efforts ranging from ensuring air and water quality to supporting cancer research. Health care policy is that piece of health policy that deals with the organization, financing and delivery of health care services. This includes training of health professionals, overseeing the safety of drugs and medical devices, administering public programs like Medicare and regulating private health insurance.

Health System: It's the organization of people, institutions, and resources that deliver healthcare services to meet the health needs of target populations.

Implementation: Public policy implementation consists of organized activities by government directed toward the-achievement of goals and objectives articulated in authorized policy statements.

Inputs: Resources such as people, raw materials, energy, information, or finance that are put into a system (such as an economy, manufacturing plant, computer system) to obtain a desired output. Inputs are classified under costs in accounting.

Policy Outcomes: The outcome of what is implemented.

Chapter 33
Patient Privacy and Security in E-Health

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ABSTRACT

In the digital era, undoubtedly, e-health is a major contributor for decision support, education, research and management activities in healthcare. It provides tremendous benefits by easy store and access to data. This easiness brings a big problem together with the benefits. Users have easy access to vast amount of sensitive health data about patients. This may give way to misuse and abuse. That is why the concepts of privacy and security becomes very popular and point of major concern. This chapter is a descriptive study aimed to give principles of these concepts and invoke awareness about.

INTRODUCTION

Electronic health, E-Health, is in the intersection of medical informatics, public health and business, can be defined as the use of information and communication technologies to improve health care (Eysenbach, 2001). E-Health has grown and developed rapidly. From primary care institutions to big healthcare centers, every healthcare organization uses an information system and records every piece of patient data electronically. As the amount of data increases, using it helps improve not only the quality of services given in healthcare, but also healthcare education, research etc. Easy access to huge amounts of healthcare data brings some problems and dangers together with the benefits. One of the biggest dangers is the violation of Patient Privacy and Security. Patient Privacy and Security is becoming a popular issue as the e-health continues to improve. With the electronic storage and access of patient health data, staff has the opportunity to access huge amounts of data that they would never have when they are in paper forms. The electronic patient data also lures many organizations, who are big actors in healthcare business such as drug companies, medical device companies, insurance companies etc. Many people are in a competition to use this huge amount of patient data for legal or illegal purposes with legal and illegal access.

Patient Privacy and Security is a challenge for every e-health application and healthcare organization using e-health technologies. E-health has many advantages and benefits to both patients and caregivers,

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healthcare managements take advantage of these benefits, but the possibility of misuse and abuse of patient health data emerges.

This chapter is a descriptive study that examines the concepts and issues related to Patient Privacy and Security and techniques used to protect it. The purpose of the study is to take attention to the importance of the Patient Privacy and Security and invoke awareness of the students, academics, researches having studies and works related to healthcare and patient data.

The chapter is organized as follows: In Background section, the definition and description of patient Privacy and Security will be given. The main part is in the heading of "Patient Privacy and Security" comprising the seriousness of the situation, Patients' Rights and Healthcare Providers' Responsibilities, Privacy and security trends that affect healthcare, Laws and Regulations on Patient Privacy and Security, Security and Privacy Auditing in E-health. In the end are the future research directions and conclusion parts interpreting the chapter.

BACKGROUND

Health data is the most private data of a person. It is so sensitive that it can make a person ashamed and upset. There may be some details even the person himself wants to forget. Because of these assets of patient health data, the notion of Patient Privacy and Security has arisen.

Although privacy and security are two different things, they are used together as a repetition for patient data. In healthcare, these two terms are used together as a concept, in which one refers to what is going to be protected, privacy, and the other refers to how it will be protected, security. In this section, to avoid misusage and confusion, brief descriptions about what is intended with patient privacy and security, will be examined. Exact description of health information is going to be given to clarify what to protect.

Health Insurance Portability and Accountability Act (HIPAA, 1996) defines health information as "whether oral or recorded in any form or medium, that

- Is created or received by a health care provider, health plan, public health authority, employer, life insurer, school or university, or health care clearinghouse; and
- Relates to the past, present, or future physical or mental health or condition of any individual, the provision of health care to an individual, or the past, present, or future payment for the provision of health care to an individual."

HIPAA (1996) defines i*ndividually identifiable health information as "*a subset of health information, including demographic information collected from an individual, and:

- Is created or received by a health care provider, health plan, employer, or health care clearinghouse; and
- Relates to the past, present, or future physical or mental health or condition of an individual; the provision of health care to an individual; or the past, present, or future payment for the provision of health care to an individual; and
    - That identifies the individual; or
    - With respect to which there is a reasonable basis to believe the information can be used to identify the individual."

HIPAA (1996) defines *Protected Health Information* (PHI) as "individually identifiable health information that is:

- Transmitted by electronic media;
- Maintained in electronic media; or
- Transmitted or maintained in any other form or medium."

PHI that is electronically collected, stored, used and sent is called as Electronically Protected Health Information (EPHI).

In this chapter, the scope is limited to privacy and security of EPHI.

Patient privacy deals with any medical data (medical condition, test result, payment info etc.) at any from (paper, electronic etc.) that belongs to a patient, meaning what is protected and who will be permitted to use this information (Upstate Medical University, 2011). It is the term used for notion of the confidentiality and access restrictions of patients' PHI, which contains sensitive and personal information (Sun, Zhu, Zhang, & Fang, 2012).

Security means protecting the valuable resources against malicious attempts. Patient Security is safeguarding the patient privacy, in another words, states how the information will be protected (Upstate Medical University, 2011).

Privacy and security concerns of EPHI fall into two general categories (Electronic Health Record Vendors Association (EHRVA), 2008):

- Inappropriate release from authorized users of provider organizations, or from non-authorized users who intrude into an organization's information system with malicious intent.
- The flow of PHI between providers, payers and secondary users, with consent or with "implied consent" to conduct treatment, payment and healthcare operations.

PATIENT PRIVACY AND SECURITY

How Serious?

The numbers in the report of Health Research Institute at PricewaterhouseCoopers (PwC) in 2011 are striking and frightening, which can support the seriousness of these concepts. PwC report is composed of survey of 600 executives from U.S. hospitals and physician organizations, health insurers and pharmaceutical and life sciences companies. Findings can be summarized as (Clinical Innovation + Technology, 2011);

- Sixty-six percent of the reported health data breaches over the past two years up to 2011 are theft. Also, medical identity theft is rising. Thirty-six percent of healthcare provider organizations stated that they had patients seeking services, using somebody else's name and identification.
- Fifty-five percent of health organizations do not have privacy and security policies associated with the use of mobile devices.
- Fifty-four percent of health organizations have at least one issue with information privacy and security over the past two years.

- Improper use of PHI by an internal party is the most reported privacy and security violation. Over the past two years up to 2011, 40 percent of providers reported an incident of improper internal use of PHI. Because of the lack of awareness or training, breaches can occur with greater probability from mishandling of paper documents, people talking in the elevator, or comments made via social media.
- Among health insurers and pharmaceutical and life science companies, the most frequently reported issue was the improper transfer of PHI to unauthorized parties. Over the past two years up to 2011, 21 percent pharmaceutical and life sciences companies and 25 percent of health insurers improperly transferred files containing protected health information.
- Healthcare organizations; more than half allow access to social media while at work; less than half have a policy for the use of social media outside of work.
- Thirty-seven percent of the health organizations have the issue of use of mobile devices and social media, in their company privacy training.
- Forty-one percent of health insurers and 58 percent of providers include the appropriate use of EHRs as in their employee privacy training.

Patients' Rights and Healthcare Providers' Responsibilities

Patients have a right to (Cooper & Collman, 2005):

- Disclosure of how PHI is used and protected from providers and health plans,
- Given copies of their healthcare records,
- Request justification of their healthcare records,
- An explanation of disclosures made for purposes other than treatment, payment and healthcare operations.

Additionally, patients can (Xiong, 2012);

- Request restriction of the usage and disclosure of his PHI
- File a complaint if he believes privacy rights were violated
- Request notification of privacy practices used in the organization such as:
  - How medical information is used and disclosed,
  - How to access and obtain a copy of their medical record,
  - How to file a complaint.

Health care organizations should devise policies for PHI access such as (Oracle, 2011):

- Need-to-know and context. Is the access essential to perform the user's job related activities? As an example a receptionist or database administrator has no need to see PHI. A lab technician may need a part of medical information to perform his task.
- Privilege/authorization. Right to copy and/or modify PHI, or simply read.
- What applications have access to PHI?
- Who requires access to those applications? In what context and what functions/capabilities of the application the user is authorized to use?

Healthcare organizations can also (Australian Department of Health, 2013):

- Ensure that they comply with all security and technical requirements defined by the laws.
- Ensure their policies and procedures are up to date and the staff are well informed of.
- Ensure they have mechanisms to audit the System Operator individuals who have accessed or uploaded information.
- Ensure the information system infrastructure is clean of viruses and appropriately protected.
- Ensure the staff are well informed and educated about the Healthcare information system (HCIS), especially in privacy and security features.
- The staff's awareness is increased by reinforcing the importance of protecting and not sharing access credentials.

Privacy and Security Trends that Affect Healthcare

Experts of idexperts, a service provider for data breach care, forecast 12 top trends in data breach, privacy and security. In this section, the forecasts of idexperts about the trends that affect healthcare are going to be given. The trends that may affect healthcare are (idexperts, 2013):

- **Global Criminals:** Criminals became globally connected and they are part of organized crime. They are in an attempt to intrude into databases and capture PHI illegally.
- **Advanced Persistent Threat (APT):** APT is a huge threat to every type of organization, hackers gain access to the system somehow and standby for a long period of time to capture the PHI and they cannot be detected for a long time.
- **Malicious Attackers:** Intruders of the systems. They may have commercial purposes such as capturing and selling the data, or can hack the system to damage the reputation of the organization.
- **Data Breaches:** Breaches affect all kinds of organizations and give way to intruders.
- **Infinitely Distribution Possibility of Electronic Data:** PHI can be stolen from anywhere in the world, distributed to infinite number of locations for an infinite period of time and can cause limitless damage.
- **Increased Enforcement Risk:** Regulators increasingly aggressive in investigating security breaches and obtaining substantial monetary settlements or penalties from responsible organizations.
- **Identity Theft:** Authentication mechanisms employ identity verification to do many things in the systems. Theft of identity is a big risk, because the capturing person causes big damages by pretending to be the person of the stolen identity.
- **Ubiquity of Digital and Mobile Devices:** The systems use a wide range of digital and mobile devices, and they are increasing in number as the technology improves, to collect and digitize PHI. This both provides more opportunities for governments to resell consumer data, forcing consumers to demand better privacy protections and read/approve/decline company privacy statements, and give a road to malicious intruders.
- **Long-Term Monitoring:** Data captured by hacking, theft or unauthorized access, can't be used immediately always. Organizations should develop plans for persistent, long-term monitoring, for the possibility of lag time that may occur between the time of the breach and the fraudulent use of consumer information.

- **Mistaken Dependency on Technology:** Organizations believe that data security and cyber privacy is an outsourced product that can be purchased. It is for sure, but it is not enough by itself, it's the humans using this product (in the case of most breaches, it is not). Organizations should focus on training the staff and invoke awareness of them about the valuable data.

LAWS AND REGULATIONS ON PATIENT PRIVACY AND SECURITY

There are many non-governmental organizations releases standards and measures to provide Patient Privacy and Security beside the governmental organizations that arrange this issue by means of laws. Health Insurance Portability and Accountability Act (HIPPA), Healthcare Information Systems Management Society (HIMSS), Healthcare Information Technology Standards Panel (HITSP) are some examples. In this section HIPAA Privacy Rule and Security Rule, Health Information Technology for Economic and Clinical Health (HITECH) Act, Healthcare Information Systems Management Society (HIMSS) privacy and security toolkit, and European Regulations on Privacy and Security is going to be examined.

HIPAA Privacy Rule and Security Rule

The Office for Civil Rights department of the United States in Department of Health and Human Services (HHS) enacted the Health Insurance Portability and Accountability Act (HIPAA) in 1996 and it is updated regularly. The last update is made in 2013. It has four basic rules:

- Privacy rule,
- Security rule,
- Breach Notification rule,
- Enforcement Rule.

This chapter will examine the privacy and security rule of HIPAA. HIPAA privacy rule applies to all forms of patients' PHI, whether electronic, written, or oral whereas HIPAA security rule is applied to EPHI only (Center of Medicare & Medicaid Services, 2007).

There are three safeguards for security in HIPAA security rule (Webb-Morgan, 2013):

- **Administrative Safeguards**: Comprehensive staff training, limited access to electronic health records, contingency plans in case of emergencies.
- **Physical Safeguards:** Computer monitor privacy filters, locks to prevent equipment theft, limited access to areas that host data.
- **Technical Safeguards:** Limited access to EPHI:
  - Access Controls,
  - Audit Controls,
  - Integrity,
  - Person or Entity Authentication,
  - Transmission Security:
    - Integrity Controls,
    - Encryption.

Healthcare administrations should take cautions to comply with both security and privacy of health data. The security rule assigns duties in the heading of "Administrative safeguards" to the healthcare managements. Especially invoking awareness of the healthcare staff is an important issue that healthcare managements deal with. Most of the staff either is not aware of privacy and security issues or they do not take even simple precautions because of negligence. Employee negligence is a major source of data breach in the healthcare institutions (Wallace, 2015).

Health Information Technology for Economic and Clinical Health Act (HITECH)

Health Information Technology for Economic and Clinical Health (HITECH) Act is the part of the American Recovery and Reinvestment Act of 2009. It has four basic goals (Blumenthal, 2010):

- Define meaningful use,
- Encourage and support the attainment of meaningful use through incentives and grant programs,
- Bolster public trust in electronic information systems by ensuring their privacy and security, and
- Foster continued Healthcare Information Technologies (HIT) innovation.

HITECH strengthened HIPAA's privacy and security guidelines by imposing new privacy obligations, expanding and clarifying business associates requirements; adding provisions related to EHR, health information exchange (HIE), and personal health records (PHR), increasing enforcement and monetary civil penalties (Hiller, McMullen, Chumney, & Baumer, 2011).

HITECH extends HIPAA's Privacy and Security Rules, by addressing the privacy and security issues related to the electronic transmission of PHI (Kobus, 2012).

HITECH, enforces the healthcare organizations to report immediately breaches that affect 500 or more people mandatorily, to both HHS Secretary and the media and notify affected individuals, breaches affecting less than 500 individuals are supposed to be reported to the HHS Secretary on an annual basis (HHS, 2009).

Managing Information Privacy and Security in Healthcare by HIMSS

Healthcare Information Systems Management Society (HIMSS) defines itself as "…a global, cause-based, not-for-profit organization focused on better health through information technology (IT). HIMSS leads efforts to optimize health engagements and care outcomes using information technology" (HIMSS, 2014). HIMSS has a toolkit for privacy and security, which is the improved and moved to a dashboard format version of "CPRI Security Toolkit", created by Computer based Patient Record Institute's (CPRI) charter Work Group on Confidentiality, Privacy, and Security, in response to HIPAA (Collman & Demster 2013).

HIMSS privacy and security toolkit is a free resource to educate the healthcare industry on privacy and security, the dashboard includes 11 major categories (Collman & Demster 2013):

- **Introduction/Concepts:** Basic Foundation Knowledge,
- **Laws/Regulations:** Local, state, federal, and international,
- **Best Practices:** Industry produced guidelines,
- **Case Studies, Use Cases, Forms and Formats:** Real world experiences,
- **Personal Health Records:** P&S issues unique to PHR,

- **Policies and Procedures:** Requirements and Samples,
- **Privacy:** All privacy related content,
- **Executive Information:** C-Suite considerations,
- **Security:** All security related content,
- **Business Associates and Health Information Exchanges:** Issues unique to BAs and HIEs,
- **Specialty Segments:** LTC, HHA, Physician Practices, Medical Devices among others.

European Regulations on Privacy and Security of PHI

The Organization for Economic Cooperation and Development (OECD) declared Guidelines on the Protection of Privacy and Transborder Flows of Personal Data (OECD Privacy Guidelines) in 1980 which contain (Hiller, McMullen, Chumney, & Baumer, 2011),

- Limitation of data collected,
- Maintenance of data quality,
- Specification of the collection purpose,
- Limitation of data use to that specified purpose,
- Adequate security,
- Transparency,
- Individual access to and control of data collected, and
- Accountability.

These guidelines are updated when required.

In addition to OECD guidelines, there are two directives that privacy and security is based on: 1995 directive (95/46/EC), from which Article 29 Board is created, related to the protection of individuals with regard to the processing of personal data, and 2002 directive (2002/58/EC), related to the processing of personal data and the protection of privacy in the electronic communications sector (Hiller, McMullen, Chumney, & Baumer, 2011).

1995 directive is designed to protect the privacy and security of all personal data (not only health data) collected for or about EU citizens (Mirkovic, Skipenes, Christiansen, & Bryhni, 2015).

2002 directive, on privacy and electronic communication complements, regulates the protection of privacy when processing personal data using new telecommunication technologies (Mirkovic, Skipenes, Christiansen, & Bryhni, 2015).

Article 29 Board declared the "Working Document on the Processing of Personal Data Relating to Health in Electronic Health Records" in 2007, which provides an interpretation of the application of privacy principles to electronic health records, and recommends adoption of eleven specific legal protections to protect individual health privacy (Hiller, McMullen, Chumney, & Baumer, 2011). The requisites of the report can be summarized as (Hiller, McMullen, Chumney, & Baumer, 2011);

- **Explicit Consent:** An entity may collect and process PHI only if the owner of the PHI (patient) grants explicit consent. This consent must be given as specific, voluntary, informed, and not forced in any way.

- **Vital Interests:** The consent can be given on behalf of patient when he is "physically or legally incapable of giving his consent". This exception can only be applied to a "small number of cases."
- **Health Professionals:** For health professionals to process PHI, the requisites are:
  - Processing must be required for the purpose of "preventive medicine, medical diagnosis"
  - For the "provision of care or treatment or the management of health-care services," and
  - The health professional processing the PHI have to comply with the professional secrecy.
- **Public Interest:** PHI can be used for Public interest purposes if the requisites below are met;
  - There must be a special legal basis for the need,
  - PHI processed under the system must be necessary and proportional to the need, and
  - Specific and suitable safeguards for fundamental privacy have to be employed.

The latest regulation in EU about the patient privacy and security was performed in Prague, on the 19th of October, 2009, by the attendance of European Union Health Ministers to the conference, "eHealth for Individuals, Society and Economy" (Hiller, McMullen, Chumney, & Baumer, 2011). In this conference the official "Prague Declaration" was announced. The declaration stated paying close attention to legal and ethical issues including data protection and privacy issues (Hiller, McMullen, Chumney, & Baumer, 2011).

SECURITY AND PRIVACY AUDITING IN E-HEALTH

Audit mechanisms are employed by all sectors in information systems. The purpose is to trail the electronic records accessed and store the issues committed in these accesses. The information in the audit logs should contain the data accessed, the user who accessed that data, time of access, type of access, type of action done (read, update, delete, print), the hardware information of the access (the computer name or IP, the printer if a print is done etc.).

Recording all the audit data is not enough of course. They must be analyzed and the violations have to be spotted in time. To be capable of doing this, normal and abnormal access conditions should be clearly defined. Data mining mechanisms can be employed to detect the anomalies and outliers.

Instead of recording every action in the HCIS, some events can be selected to store in audit trails. The recommendations of the NEMA/COCIR/JIRA Security and Privacy Committee (SPC) (2001) are;

- PHI-Related Events:
  - Create Events:
    - Creation of records that contain PHI,
    - Import of records that contain PHI.
  - Modify Events:
    - Editing of data (e.g. appending, merging, modifying),
    - Re-association of data,
    - De-identifying of PHI.
  - View Events:
    - Access to PHI by any user,
    - Export of PHI to digital media or network,
    - Print or FAX of PHI.

    - Delete Events:
        - User command to delete PHI,
        - User command to delete PHI before the correct transmission of PHI was confirmed by the receiver,
        - Automated command to delete PHI.
- Non-PHI Events:
    - General:
        - Machine startup and shutdown,
        - Successful login and logout of users,
        - Changes to user accounts (creation, modification, deletion),
        - Automatic logout of a user after exceeding a locally-defined time of inactivity,
        - Switching to another user's access or privileges after logging in with one's own identification,
        - Software or hardware modification,
        - Update of virus signatures.
    - Operational Events:
        - Login attempts with failed identification or authentication, also known as failed login attempts,
        - Changes of the time or date of the system,
        - Emergency mode operation,
        - Detection of a virus,
        - Detectable hardware errors,
        - Changes to log files (creation, deletion, configuration)
    - Communication Events:
        - Network link failures,
        - Device connection failure due to device identification or authentication failure (also known as a failed connection attempt),
        - Network and device connections dropped,
        - Data integrity verification failure for information transmitted over a network,
        - Message authentication failure for information transmitted over a network,
        - Evocation of a network abnormality alarm,
        - IP addresses of successful and unsuccessful connections,
        - Changes to network security configuration (e.g., firewalls if part of a medical IT system).

SOLUTIONS AND RECOMMENDATIONS

Patient privacy and security is a very important issue. There can be great and unbearable outcomes when violated. To avoid violations and assure protection of patient rights, the institutions dealing with patient data should be beware of threats first. They have to know and inform their staff that there are many people and organizations chasing after the patient data, and motivated to capture it legally or illegally. Second, they have to know there are regulations to abide by. These regulations should be studied and related measures have to be taken.

Staff training is an important issue. With very simple measures, most of the breach risks can be eliminated. There are institutions giving this training.

The last but not the least, patients have to be well informed about their rights. In most of the cases, the patients do not know the rights. They either do not give importance to that issue, or exaggerate their rights and request more than they deserve. In this case, this is the duty of public authorities to inform the patients by drawing attention. The healthcare institutions also may employ patient's rights departments to both handle the disputes and inform the patients. Staff training is also a solution to avoid disputes, by enabling the staff to inform the patient first about their rights and then start giving healthcare.

FUTURE RESEARCH DIRECTIONS

As seen, privacy and security of the EPHI is very critical, violations have both legal and moral consequences. Protection of patient privacy and security is major concern for every healthcare organization and bodies that deal with PHI.

Securing technologies will be the major future work item, in both technical and managerial concern, for both electronic and manual ways. Security is the challenge of all information technologies not only in healthcare but in all sectors. It is improving in an ongoing way. E-health will take advantage of the general improvements, as well as the healthcare specific works and researches.

Literature tells, most of the breaches occur as a result of insider related activities, mostly by negligence of the users. Security professionals think the risks posed by negligent insiders (65%) is the biggest security concern (SANS, 2013). Intruders and malicious attacks have less shares in the security breaches than the insider negligence. Employee negligence is a major source of data breach in the healthcare institutions (Wallace, 2015). Development of strategies for invoking the awareness of the staff and ensuring that they take the tiny measures for protecting the patient privacy is another future work candidate. It is not possible to secure the EPHI, without being sure that the staff does not take part in the violations whether intentionally or mistakenly.

Protection of patient privacy and security in mobility is another future work item. Mobility is the miracle of the era. There is a large number of mobile applications in healthcare and they are growing in a tremendous way. The ubiquity of the mobile devices whets the application developers and health investors' appetite. As a result of this appetite, mobility becomes a huge application area. There should be great concern and work about the patient privacy and security in mobility. Especially unexperienced users about mobile device security can give breaches to malicious people and applications, by not employing necessary security measures.

CONCLUSION

The privacy and security of patient data is a research and application area in e-health and healthcare. There are conferences dedicated to this subject, certification programs are available.

It has been found that electronic data breaches occur three times as many as paper based breaches and affect 25 times more people (Torrieri, 2011). E-health has many advantages, there is no need to mention or list them here again. What we should know and be aware is, it has challenges and problems together with the benefits.

Most electronic breaches are caused by are insider theft or human errors other than hacking. Especially when the subject is healthcare, because of the dynamics of it, security and privacy will be its weakness. The staff does not like the security issues and sees it as an obstacle to doing his work properly. This issue must be gently and seriously handled by the managements.

I want to end the chapter with the saying of Peter Harries, principal and co-leader, Health Information Privacy and Security Practice, PwC. "To protect patient trust and their own brand reputation, organizations need to go beyond minimum regulatory requirements and adopt an integrated approach that combines privacy, security and compliance within a culture where all employees see themselves as champions of confidentiality and where privacy is part of the patient experience" (Techtw, 2011).

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KEY TERMS AND DEFINITIONS

Data Breach: An incident in which sensitive, protected or confidential data has been viewed, stolen or used by an unauthorized body.

E-Health: E-health is the use of information and communication technologies to improve health care.

HIMSS: HIMSS is a global, cause-based, non-profit organization, focused on better health through information technology.

HIPAA: HIPAA is the federal Health Insurance Portability and Accountability Act of 1996.

HITECH: The HITECH Act is an incentive program that urges healthcare organizations to use a certified Healthcare Information System for everyday practice and use.

Privacy: The state of being free from being observed or disturbed by other people.

Protected Health Information (PHI): PHI is the individually identifiable health information of a patient.

Chapter 34
Accountable Care and Evidence-Based Decision Making

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ABSTRACT

In today's cost challenged healthcare environment accountable care and evidence-based decision making have become important considerations. Contemporaneous to this is the fact that the superior management of diabetes has become a global priority especially given the exponential increase in the number of diabetes patients as well as the financial implications of treating this silent epidemic. Thus, this research focuses on trying to address these respective yet critical issues by examining the possibility of using a mobile web-based reporting system that taps into existing widely available resources to monitor and manage gestational diabetes. To test this solution, we adopted a randomized control trial with two-arm cross over applied to a not-for profit hospital in Victoria, Australia. From the perspective of practice, we have uncovered far reaching implications for hospital management's cost vs. quality care to patients. In particular, it appears that the adoption of smartphones to support many aspects of care and patient-clinician interactions is prudent.

INTRODUCTION

Diabetes is one of the leading chronic diseases affecting Australians with approximately 1 million Australians currently diagnosed with diabetes (Baker IDI, 2013). This alarming phenomenon triggers this research. In particular, we examine the aspects of accountable care and evidence-based decision making in the context of gestational diabetes management. Traditionally, healthcare delivery has been designed to treat patients at the point of care with less focus on being proactive in supporting preventative measures

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that keep people healthy and away from the hospital. This could be due to several reasons including the lack of suitable healthcare information systems to support the ideology of Accountable care.

Accountable care aims to improve quality and lower healthcare costs by proactively keeping people healthy and away from the hospital (Morse, 2013). This view of healthcare is one of the most popular discussions relating to US health reform and has supported the launch of pilot projects to test the concept, examine its sustainability, and explore how the model might look and be assessed for its potential (McClellan, et al. 2010). However, this concept is challenging especially when applied into solo and small-group practices primarily due to the cost of the required IT (information technology) investment and quality improvement training for staff (Shields, et al., 2011). In view of this critical challenge, this study examines the possibility of using a mobile web-based reporting system that taps into existing widely available resources (e.g. smartphones and cloud systems) and thus requires minimal IT cost and user training. Thus, we set out a unique research initiative that focuses on a specific issue to address a current dilemma, namely the support of gestational diabetes through improved accountable patient care.

Hence, the primary objective is to examine "how smartphones might keep Australian mums healthy" by preventing and/or reducing the impact of gestational diabetes (GDM). Specifically, the research question under consideration is "can using a smartphone solution to facilitate monitoring and management of Gestational Diabetes (GDM) support the accountable care paradigm?"

BACKGROUND AND LITERATURE REVIEW

The relevant key bodies of literature include management of gestational diabetes and the accountable care system and are presented in turn below.

Management of Gestational Diabetes

Managing diabetes using information technologies is a relatively recent priority within the healthcare domain as diabetes has become one of the most prevalent and exponentially increasing diseases around the world. Further, the cost of managing patients with diabetes is also considerable. In Australia, it costs over $14.6 billion to treat a diabetes patient with complications running up to $9,645 per year (Diabetes Australia, 2013). Therefore, an effective management system for diabetes is an imperative.

As diabetes is a chronic disease there is by definition no cure. This makes the adoption of various management strategies paramount in the successful care of diabetic patients (Britt, 2007, AIHW, 2007, AIHW, 2008, Diabetes Australia, 2008). Moreover, the prudent adoption of these strategies can dramatically affect the cost of care without significantly impacting the quality of care. Typically, the management of diabetes is based on a mixture of self-management protocols linked with the support of a dedicated medical care team (Victorian Government, 2007). An essential element of self-management relies on regular testing of blood glucose, using a glucometer or blood glucose monitor.

Gestational Diabetes Mellitus (GDM) requires tight control of Blood Sugar levels, with a preferred range of readings between 4-6 mmol/L (Hoffman, et al, 1998; Siri and Thomas, 1999). The management of GDM is conducted over a short period of time (that of the pregnancy) and thus a tighter management of sugar levels is required while the impact for both mother and baby of poor control can be far reaching and unpleasant. The need for such control draws into question the information that a diabetic may need when self-managing their condition.

Accountable Care System

An Accountable care system (ACS) refers to an entity that implements organized processes to improve and control the quality of care and cost, more importantly the providers will be held accountable for the results (Shortell and Casalino, 2008). Specifically, the term system refers to the care that must be established and delivered by healthcare providers (e.g. physicians, clinicians, nurses) and settings (e.g. hospital and nursing homes) over time with accountability to ensure quality care with reduction of cost (Shortell and Casalino, 2008; McClellan et al., 2010; Shields, et al. 2011).

An examination of the literature suggests that many studies look into the importance (Shortell and Casalino, 2008), application (Shields, et al., 2011), execution of the accountable care system (McClellan et al., 2010; Lewis et al., 2013) and its quality performance standard (Berwick, 2011). However, issues such as how quality of care is being defined and measured remain vast and unclear (Dentzer, 2013). More importantly, it is unsettling to be reminded that doctors' decisions are not always evidence-based and in fact only 55% adhere to evidence based care (Asch, et al. 2006).

The pressure to provide evidence-based care has significantly impacted the medical sector over the past decade (Wickramasinghe and Schaffer, 2010). Since then much research was done to understand what it is, how it will impact medical practices, what its challenges are and how it could benefit people, organizations and society (Pfeffer and Sutton, 2006). Traditionally, evidence-based management is complimented with online services and technology (Jadad, et al., 2000). For that, very often quality of care and cost was being compromised. In this study, to overcome such an issue in achieving affordable care, we need a bridge between evidence-based care and technology that can then support the paradigm of accountable care.

In this study, after assessing the characteristics of accountable care across levels (McClellan, et al. 2010), comparison of prospective attribution and performance to stimulate accountable care (Lewis, et al., 2013); we found that the most reasonable framework that can serve as the foundation for our research in bringing out the core characteristics of accountability to ensure quality care (through Evidence-based management) with reduction of cost (use of smartphone) is the accountable care paradigm proposed by Muhlestein, et al, (2013).

The accountable care paradigm proposed by Muhlestein, et al (2013) defines the movement of terms of structural requirements, core processes and expected outcomes but it was lacking of emphasis on quality of care. To improve this accountable care paradigm, we believe that quality of care should include:

1. Quality of life,
2. Evidence-based management, and
3. Affordable care.

The 1st level of the accountable care paradigm is about accountable care outcome measurements (Muhlestein, et al, 2013). It comprises of three criteria; they are:

1. Improving the individual experience of care,
2. Improving the population health,
3. Reducing the cost of health care for populations (Muhlestein, et al, 2013).

With these criteria we believe that the improvement of quality of life can be further achieved if customers were to be provided with more emphasis on maximizing outcomes and control costs. Usually patients have little or no control over the cost of the care they consume and almost no information available to them regarding the cost or quality of care delivered by the providers or care giver (Bozic, 2013). For this reason, we believe that for some health issues, the ability to measure accountable care outcomes, requires the care providers and giver to avail patients with a few treatment options that are based on service receive and cost involved. This provides patients with options as to how they can live a quality life.

1. **Process Level Care Management:** The 2nd level of the accountable care paradigm (Muhlestein, et al, 2013). This level consists of three criteria, which are:
   a. Overseeing the provision of clinical care,
   b. Adopting an administrative infrastructure to coordinate the provision of care across the continuum of health services,
   c. Investing in and learning to use appropriate information technology to manage population health.

To enhance the quality process level of care management, we suggest including the concept of evidence-based management. Especially with the empowerment from technologies, today many physicians are able to capitalize on the rich online information with internet connections to build experts communities for knowledge, best-quality evidence, and information sharing with care givers and patience directly. To better amalgamate evidence-based management into process level care management we incorporated Rousseau's (2013) suggestion of the importance of managing user's expectation, providing models of evidence-based practice, promote active use of evidence, building collaboration among all users. In this study, all users include physicians, nurses, and pregnant mothers.

The last level of accountable care paradigm is about *aligning financial structures* (Muhlestein, et al, 2013). It entails two criteria;

1. Bearing financial risk for the measured health of a population,
2. Aligning financial and professional incentives to encourage the production of high quality health outcomes.

However, what is more important is to incorporate affordable care by providing choices in finding plans that are cost-effective and appropriate to consumer needs. For example, the use of a smartphone approach may be a cheap option for patients who require regular health monitoring to record and communicate with health practitioners. This may become evident if compared to other more dedicated or sophisticated technology that usually comes at a higher cost.

METHODOLOGY

As part of our ongoing effort to understand changes occurring within the Australian healthcare system, we have been identifying and tracking healthcare organizations that appear to practice at least some aspects of accountable care from the Australian perspective. In our efforts of searching, we identified

XYZ hospital as we believe that they showed unique characteristics of accountable care. In fact, many aspects of this concept were initiated and appreciated by their medical staff.

On selecting the specific hospital to evaluate we adopted a user-centred design approach to develop a unique mobile solution to support self-management of GDM. Specifically, we adapted the web-based mobile solution developed over several years by INET Intl. Inc (Goldberg, 2002, Wickramasinghe and Goldberg, 2007, 2008; Wickramasinghe, Troshani and Goldberg, 2010). In particular, the solution works as follows: after the patient has taken their blood sugar reading using a glucometer, they enter the reading into a web-based form design for mobile phones. The submitted reading is then accessible to the designated clinician who can then review the readings in conjunction with all other relevant medical data and then provide immediate feedback and recommendation to the patient. The patient readings that are accessible to the clinician can be depicted in a chart. Specifically, the chart displays the 4 readings normally taken for GDM patients for example before breakfast, 2 hours after breakfast, 2 hours after lunch and 2 hours after dinner. The mobile interface also allows patients to write messages about their food and exercise consumption and the clinician can review this information and provide additional feedback to the patient. All of this communication is managed through the mobile solution and provides a health model that can provides immediate support to patients remotely located from the hospital setting.

The solution was then trialed after all necessary ethics clearances were obtained using a two period cross-over clinical trial strategy (Rigby, 2003; Senn, 2002) over a 10-week duration. Initial results are promising. Not only has proof of concept been established but we also demonstrated the benefits of a real time smart phone solution to facilitate the self-management and monitoring of GDM patients. Most notably all patients preferred the technology solution to the standard care and those patients who start with the technology solution found the change to the standard care disappointing. In addition, the clinical care team (obstetricians, diabetic educator and endocrinologist) preferred the technology solution over the standard care approach.

INITIAL FINDINGS

Based on the research method used, we mapped the collected results with the affordable care paradigm. We find that the smartphone solution supports the affordable care paradigm at multiple levels including;

1. At level 1 of the accountable care outcome measurements - since the solution enables improved individual experience of care; and improved population (all sufferers of GDM in this context) health and reductions in the cost of healthcare delivery (which were apparent from the data generated) and
2. At the process level care management - since the solution supports:
    a. Overseeing the provision of clinical care, and
    b. Facilitating the adoption of an administrative infrastructure to better co-ordinate care.

Finally, we note that given smartphones are a pervasive technology, there is essentially no learning curve so the solution is particularly beneficial and cost effective as no or minimal training and infrastructure costs are required.

From the perspective of measured outcomes of accountable care, it appears that the use of the smartphone as a health monitoring and communication channel, not only improved the patient experi-

ence of care but potentially provided a better quality of life to patients. That is, patients with pertinent information will be able to receive timely medical feedback, understand the result and take appropriate actions in controlling their blood sugar level. As a result, it improves the population health in a way that supports prevention and reduces the impact of the mother passing high levels of glucose to the baby inutero. Further, with such control there is evidence of a direct potential of smartphones to reduce health care costs at many levels.

FUTURE RESEARCH DIRECTIONS

This small study has identified several impotent research streams that we intend to pursue. First we plan to develop further understanding of the key benefits and impacts technologies such as smartphones have on effecting accountable care delivery and supporting evidence based decision making in healthcare. In addition, we will continue to examine various aspects of the role of smartphones in providing superior management and monitoring for patients with GDM as well as type 1 or type 2 diabetes. Finally, we will investigate the role of Smartphones for providing superior care delivery in various other contexts concerning chronic disease management.

CONCLUSION

Our initial research serves to contribute to theory and practice in several ways. This study strongly suggests that the use of smartphones to support GDM self-management not only facilitates superior monitoring and management Gestational Diabetes from an affordable way but it also supports the accountable care paradigm. Moreover, patients suffering from GDM can benefit by having a better quality of care and enjoying better health for themselves and their babies. From a theoretical stand point, we unpacked McCleallan, et al's (2010) study with our conceptual framework that consists of providers for information (evidence based management) and technology (smartphone) who are jointly held accountable for a defined patient population in achieving measurable healthcare quality improvements with reductions of healthcare spending. Further, we have enhanced Muhlestein's (Muhlestein et al, 2013) accountable care paradigm with the three concepts:

1. Quality of life,
2. Evidence-based management, and
3. Affordable care.

Finally, in terms of managerial contributions, the study uncovers far reaching implications for hospital management as they currently wrestle with the orthogonal dilemmas of controlling costs and providing high quality and value to patients. In particular, it would appear that they should investigate the possibility of adopting smartphones to support many aspects of care and patient-clinician interactions.

In closing, we note that this was a small pilot study to investigate the potential of smartphones to support the affordable care paradigm in the context of management and monitoring GDM. Clearly more confirmatory research is required to generate statistically significant results and we plan to do such follow up studies.

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KEY TERMS AND DEFINITIONS

Accountable Care: The policies in healthcare delivery that ensure that any intervention is justified and someone is held responsible for making the key decisions.

Chronic Disease: Disease that has no foreseeable cure and thus the patient must live with the disease for the rest of their life.

Evidence Based Decision Making: A practice of making decisions in clinical contexts based on used medical cases.

Gestational Diabetes Mellitus (GDM): A type of diabetes, problem with sugar in the blood that is experienced by women who are pregnant only.

Information Communication Technologies (ICTs): Computers and mobile devices such as iPads and mobile phones that support electronic data and communication exchanges.

Smartphones: Mobile devices that enable the use of many applications.

Section 6

Theoretical Considerations

Chapter 35
Readiness as a Novel Construct of Readiness Acceptance Model (RAM) for the Wireless Handheld Technology

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ABSTRACT

In this conceptual chapter we have reviewed prominent theories or models in relation to the adoption of technology for wired devices. We have identified shortcomings in these leading models in predicting adoption behaviour associated with the wireless technology. The shortcomings are particularly acute in wireless handheld technology by comparison with desk top technology in which the adoption models have been extensively studied. Here we propose "Readiness Acceptance Model" (RAM) as new conceptual model for the adoption of ICT in conjunction with wireless handheld technology. Readiness is defined as user's ability to perceived readiness of the business in the context of organizational, technological, perceptional, behavioural, and environmental attributes for the acceptance of wireless handheld devices. In formulating the conceptual framework for RAM we incorporated variable characteristics from the nine prominent models reviewed here. We believe these considerations would allow RAM to be useful in wireless handheld technology ICT domains.

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INTRODUCTION

Scientists in the area of information systems and information technology (IT) have preoccupied in the recent decades on explaining and understanding the phenomena of adoption behaviour. One of the common objectives among all the theories and models is to understand behavior of use or intention-to-use information technology (IT). None of these theories has the ability to explain technology adoption phenomena in its own right. However, they could provide a sound background for developing a framework to explain adoption phenomena for wireless handheld technology in the globalized economy. In keeping this in mind we have reviewed nine prominent adoption models or theories (namely TRA, TPB, IDT, TAM, MM, C-TAM, SCT, and MPCU, and UTUAT).

The nine predominant theories are: Theory of reasoned action (TRA); Theory of planned behavior (TPB); Social cognitive theory (SCT); Innovation Diffusion theory (IDT); Technology acceptance model (TAM); Motivational model (MM); PC utilisation model (MPCU); Combined TAM (C-TAM) and TPB; and Unified theory of technology acceptance (UTUAT). These theories have dealt with a platform where users go to the computers. However, the emerging paradigm is the data going to users, especially facilitated by mobile devices and this domain appears to be radically different to the 'wired' domain for the following reasons:

1. The data stream in the mobile device environment is based on small devices such as the PDAs that have limited processing capabilities;
2. The data are in small sets rather than huge databases;
3. The main purpose is to facilitate data access from anywhere and thus the concept of connectivity assumes utmost significance;
4. Users know how to access the data and hence training issues assume lees significance in generic applications; and
5. Affordable access cost.

For these reasons it is imperative that we revisit the theories with a view to assess their applicability to wireless handheld devices. Review of the 9 major theories may help us identify shortcomings of the theories in explaining the adoption phenomena in information system domain. These in turn may allow us to formulate new conceptual models for the adoption of wireless handheld technology in information system domain.

Review of Current Models

TRA, TPB, IDT and TAM share some similarities. These theories suggest that beliefs lead to attitude, attitude toward the technology and, as a result, lead to behavioural intentions (willingness to use the technology) which reflect in usage of Information Systems / Information Technology (IS/IT). For example, one of the major constructs of Technology Acceptance Model (TAM) is Perceived Usefulness PU, and this is quite similar (individual perceived benefits can be achieved through the use of technology) to the philosophy of relative advantage mentioned in Innovation Diffusion Theory (IDT). The situation is not much different (in terms of complicity associated with the use of technology) with Perceived Ease of Use PEU and Complexity in TAM and IDT respectively. In TRA and TAM, it is assumed that individu-

als are free from any constraint and will act whenever they have an intention to do so. TPB assumes that user beliefs are specific to the context and environment. For example, the availability of resources and technical expertise can have an effect on the user's beliefs, attitudes and actual usage. For example, in the context of wireless handheld devices in a healthcare environment this could be crucial. Bagozzi et al. (1992, 1992a) found that variables such as age, time, environment and ability can influence individual behaviour of intention and actual usage.

Other studies have tested a range of adoption theories to explain the phenomena of adoption in different contexts. However, many of these started by varying the original concepts relating to adoption theories (Adams et al., 1992; Igbaria et al., 1997; Liker & Sindi, 1997, Lin & Lu, 2000; Szajna, 1996; Tan & Teo, 2000). Even though these adoption theories have been used widely in the domain of information systems there is little evidence in the literature on the use of these theories in the domain of wireless handheld devices in an environment such as healthcare setting. Taken together we reasoned that IDT (Rogers, 1983b) and TPB (Ajzen, 1991b) could provide necessary theoretical basis for the development of the framework for this study.

In Table 1, we have summarized characteristics, attributes and shortcomings of the nine major models. The theories highlighted above mainly focus on individual behaviours and then generalise the outcomes to organisational settings. A major weakness of these theories, with an exception of the unified theory, is that they ignore organisational factors. Considering the attributes provided in the Table 1, most of the theories and models of adoption fall into three categories; namely; characteristics-based, intention-based, and cognitive. Briefly, Rogers' IDT model (Roger, 1983) is characteristics-based, and focuses on the user's perceptions and the characteristics of the innovation itself; these affect the adoption/usage phenomena (Moore & Benbasat, 1991; Plouffe et al., 2001; Rogers, 1995a). Examples of Intention-based theories are TAM and TPB, which demonstrates that adoption, is a complex issue involving personal beliefs and attitudes towards the innovation (Davis, 1989b; Davis et al., 1989b; Venkatesh & Brown, 2001; Venkatesh & Davis, 1996, 2000). Finally, cognitive theories such as SCT relate to the social foundation of thoughts and actions (Compeau et al., 1999, Compeau & Higgins, 1991).

As mentioned above, acceptance of technology has been researched extensively resulting in various competing theories and models, each with its own different set of determinants. According to Bagozzi et al. (1992b) and Taylor and Todd (1995b) the best model is the one, which is the most parsimonious. However, Venkatesh et al. (2003b) argued that the best model is the one that facilitates understanding of the adoption phenomena. With the exception of UTAUT the rest of the nine models of adoption incorporated only 17% to 53% of the variance in users' intention-to-use IT. For the same data, the UTAUT model was able to incorporate 69% of the variance. Even though UTAUT is better than others, further validation is necessary (Venkatesh et al., 2003b). The two main constructs of the UTAUT model, Performance expectancy (PE) and Effort expectancy (EE) are similar to the TAM constructs namely, PU and PEOU respectively. Li and Kishore (2006) studied the UTAUT model with undergraduate students who belonged to online-user community and found that key constructs of UTAUT have invariant true scores in some cases. UTAUT model has also been applied successfully for explaining the acceptance of IS/IT at an organizational level (Carlsson et al., 2006; Cody-Allen & Kishore, 2006; Lubrin et al., 2006; Robinson, 2006).

In contrast to earlier studies showing applicability of TAM and UTAUT at the organizational level, this study focuses on the adoption of wireless handheld devices at an individual level. Clearly, for example the healthcare setting is very different from that of the mobile device services described above (Carlsson

Table 1. Brief summary of major adoption theories/models

	Model Name	Authors	Brief Analysis	Applicability and Descriptions	Problems of the Model
1	The Theory of Reasoned Action (TRA) Def: Assumes that humans make rational decisions and that there is a casual relationship linking beliefs, attitudes and intentions and that attitudes and subjective norms determine behavioural intentions	(Fishbein and Ajzen, 1975, Ajzen and Fishbein, 1980) (Ajzen and Fishbein, 1980, Farhoomand et al., 1990, Fredricks and Dossett, 1983, Tan and Teo, 2000).	Origin of the theory/model relates to psychology in attitudes; TRA tries to explain individual's behaviour through intention to perform a particular behaviour. This theory defines intention as a function of attitude towards a particular behaviour and subjective norms.	Concentrated on the behaviour of adoption in general domain and beliefs behaviour results from attitude and intentions. The two main constructs are attitude towards behaviour, and subjective norms.	Irrational decisions, habitual actions and other unintentional behaviours are not explained by the theory. TRA is also limited by its reliance on self reported information to determine the subject's attitude and the data reported may be subjective in nature
2	The Theory of Planned Behaviour (TPB) Def: Developed as an extension of TRA to overcome some of the limitation associated with TRA, specifically those limitations relating to behaviours of adopters that occur without volitional control. This model has been used in a number of contexts to explain adoption behaviour	(Ajzen, 1985, Ajzen, 1991a, Ajzen and Madden, 1986) (Ajzen and Driver, 1992, Cheung et al., 1999, Madden et al., 1992, Randall and Gibson, 1991).	Extends the TRA theory to include the perception of individual behaviour towards ease or difficulty.	Like TRA this theory also explain the adoption in general. The constructs of this theory are Attitude towards behaviour, Subjective norms, and perceived behaviour control.	The model is still limited in that it describes the attributes of adoption at the individual unit of analysis rather than at the organizational level. This precludes its use when dealing with an adoption based on primarily, organizational units.
3	Technology Acceptance Model (TAM). Def: Model which essentially uses perceived usefulness and ease of use as it main determinants of acceptance of technology	(Davis, 1989a, Davis et al., 1989c) (Burton-Jones and Hubona, 2005, Darsono, 2005, Legris et al., 2003, Riemenschneider et al., 2003, Venkatesh and Brown, 2001, Venkatesh et al., 2003b) (Hu et al., 2002, Hu et al., 1999).	This theory/model attempts to provide a hybrid model by combining the "Perceived usefulness" construct from TAM with the three constructs of TPB (Attitude toward behaviour, Subjective norm, and Perceived behavioural control).	This model mostly tries to explain the adoption phenomena in the domain of technology, and IT/IS. The main constructs of TAM are perceived usefulness and perceived ease of use.	Examination of the model validity is with students and administrative workforce as population, who have limited computing exposure, administrative and clerical staff who do not use all ICT functions found in software applications, applicability of TAM to specific disciplines such as medicine is not yet full established
4	Unified Theory of Acceptance and Use of Technology (UTAUT) Def: UTAUT presents various constructs (Perform ace Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions) to be direct determinants of user acceptance and usage behaviour.	(Venkatesh et al., 2003b) Li and Kishore (2006) (Carlsson et al., 2006, Cody-Allen and Kishore, 2006, Lubrin et al., 2006, Robinson, 2006)	The UTAUT model tries to combine all the prominent models of adoption into a unified approach. UTAUT states that in addition to variables such as performance expectancy, effort expectancy, social influence, and facilitating conditions, there are adoption/use processes that are also influenced by moderating factors such as age, gender, experience and voluntariness of use.	UTAUT theory/model reviewed the prominent models of adoption and found direct determinants of adoption are performance expectancy, effort expectancy, social influence, and facilitating conditions.	The need to establish invariance of the UTAUT scales across different subpopulations as well as to develop and test new scales that may exhibit characteristics of invariance across a wide range of user populations. Three additional reported indirect determinants such as self-efficacy, anxiety and attitude towards using technology need further study
5	The Diffusion of Innovation (DOI) Def: Model indicates how barriers can render implementation of new technology unsuccessful. Represents the rate of adoption and the stages through which one passes before adopting innovation.	(Moseley, 2000) (Baskerville and Pries-Heje, 2001). Rogers (1983, 1995, 2003) (Vuarin and Rodriguez, 1994). Rogers (1995) (Hamblin et al., 1973) (Mahajan and Peterson, 1985). Van de Ven et al., 1989) Wejnert (2002)	This theory/model tries to establish that adoption is a sequence of events or processes, which include learning about the innovation, being persuaded about the merits of the innovation, making decisions about the innovation, implementing the innovation, and confirming the decision to adopt the innovation.	Explains the adoption phenomena in general. It explains the characteristics of the innovation adoption through factors such as, relative advantage, compatibility, complexity, trialability, and observability.	Model is limited and may not always hold true due to its linearity. It is unstructured, emergent phenomenon and complex to be expressed in a step-like model. Diffusion processes focused on describing observed diffusion patterns in terms of pre-specified trend or distribution functions. And no references to technical, organisational or social context. The need for an understanding of the adoption triggers within an industry sector. Process is not uniform.

continued on following page

Table 1. Continued

	Model Name	Authors	Brief Analysis	Applicability and Descriptions	Problems of the Model
6	Motivation Model Def: The Motivational model combines some of the previous findings and explains that perceived enjoyment, usefulness and social pressures could motivate the usage of microcomputers. Skills, also, play a crucial role (Igbaria et al., 1996).	(Igbaria et al., 1996)	This model for the acceptance of individual behaviour for usage/acceptance of information technology is based on the general motivation theories to explain this particular behaviour.	In the information systems domain "Motivation Model" has been used to understand the usage and adoption of information technology (Davis et al., 1992; Venkatesh, 1999; Venkatesh et al., 2003b).	Microcomputer usage is influenced by effects on perceived usefulness and it is proposed that perceived usefulness, perceived fun/ enjoyment, and social pressure would motivate increased use of microcomputers by professionals and managers. However there is great deal of difference between the desktop technology and the wireless handheld technology. For example how the data is accessed and provided.
7	Model of PC utilization Def: This model presents a computing perspective proposed by TRA and TPB	(Thompson et al., 1991)	Has its basis on the theory of human behaviour and tries to explain the actual use of the innovation rather than the intention of the individuals to use the innovation.	Helps to predict computer usage at an individual level, and explains individuals' behaviour in terms of their habits, social norms and perceived beliefs.	Relates to individual characteristics such as genetic factors, personality, habits, attitudes, behavioural intentions and behaviour, all of which help to predict usage of computers. Individual environmental characteristics such as culture, social situation, social norms, facilitating conditions etc. also help to predict individual behaviour for computer usage (Moez et al., 2004; Triandis, 1980).
8	Combined TAM and TPB (C-TAM-TPB) Def: This theory helps to predict user behavioural intention.	Taylor and Todd (1995)	Taylor and Todd (1995a) provided a hybrid model by combining the Perceived usefulness construct from TAM with the three constructs of TPB (Attitude toward behaviour, Subjective norm, and Perceived behavioural control).	TAM does not incorporate the effects of social and control factors on the behaviour of users' intention to use the technology; rather, it is established on the premise that these factors influence the actual behaviour of users in using IT (Ajzen, 1991b; Moore & Benbasat, 1991; Taylor & Todd, 1995a).	It was hypothesized that a user's prior experience of using a particular IT system would expose different strengths for Combined TAM and TPB (C-TAM/TPB) constructs. However as mentioned above individually both TAM and TPB do not provide sufficient ground to explain the acceptance of wireless handheld devices due to the unique nature of wireless technology.
9	Social cognitive theory Def: According to SCT, human behaviour is defined as an interaction of personal factors, behaviour and environment (Bandura, 1977)	(Bandura, 1977) (Bandura, 1986)	Focuses on changing human behaviour and explains human behaviour as interactions of personal factors. SCT helps the understanding of individual and group behaviour and tries to explain which behaviours can be changed.	Indicates that a person's behaviour is uniquely determined by personal, behavioural, and environmental factors, and that the environment influences the person's thoughts and actions. The dependent constructs are Learning and Change in behaviour, and the independent constructs are Personal factors, Behaviour, and Environment.	Has been used to study morals and internalisations in children and how children are socialised to accept standards and values of society. Whereas technology, especially wireless technology and the healthcare environment, are very different; here we are dealing with the interactions of adults, not children (Bandura, 1977; Bandura & Jourden, 1991; Johnston et al., 1994).

et al., 2005, Carlsson et al., 2006). Further, Carlsson and his colleagues warned that the applicability of the UTAUT model was expressly related to the acceptance of mobile devices and services, and the model may not support all situations (Carlsson et al., 2006). Burley and colleagues also stated that UTAUT is better suited to study organizational environment and may not be as useable as a diffusion of innovation model for the mobile devices in a healthcare environment (Burley et al., 2005).

A Brief Comparative Account of Core Constructs Used in the Models

The core constructs of TRA are drawn from social psychology "Attitude Towards Behaviour" and "Subjective Norm". TPB extended the TRA by an additional construct of "Perceived Behavioural Control" as an additional determinant of attention and behaviour. TAM helps to understand the usage and acceptance of information technology, its core constructs are "Perceived Usefulness" and Perceived Ease of Use". TRA/TPB Subjective Norm was missing from TAM, and TAM was extended to TAM2 to include the "Subjective Norm". Motivational Model (MM) is derived from motivation theories to explain the acceptance and usage behaviour and its main constructs are "Extrinsic Motivation" and Intrinsic Motivation" C-TAM_TPB this model of acceptance combine the constructs of TAM and TPB to provide the hybrid model. MPCU is derived from the theory of human behaviour in conjunction with TRA and TPB to predict the PC utilization. This theory helps to understand individual acceptance and use of information technologies. The core constructs of MPCU are Job-Fit, Complexity, Long-Term Consequences, Affect Towards Use, Social Factors, and Facilitating Conditions. IDT is used to understand the adoption and usage of variety of innovations. Main constructs of IDT are Relative Advantage, Ease of Use, Image, Visibility, Compatibility, Results Demonstrability, and Voluntariness of Use. SCT predicts human behaviour of acceptance and usage of computer technology. The main constructs are Outcome Expectations-Performance, Outcome Expectations-personal, Self-Efficacy, Affects, and Anxiety (Venkatesh et al., 2003b). Common to these theories is that they all explore the phenomena of acceptance and usage of technology in organizations. These theories differ in the context of theoretical structure, determinants, constructs and their relationship.

According to theory of reasoned action, a person's intention is a function of two basic determinants, one "personal" in nature and the other reflecting "social influence". The personal factor is the individual's positive or negative evaluation of performing the behaviour, which is called "attitude toward the behaviour" and refers to attitudinal factors. The second determinant intention is the person's perception of the social pressure put on him/her to perform or not perform the behaviour in question. This factor is termed "subjective norm" – which deals with perceived prescriptions and relates to the normative considerations (Ajzen & Fishbein 1980). The relative weight of the two determinants of intention is the solution for the situation of conflict between attitude toward behaviour and subjective norm. As a result, it is possible to predict and gain some understanding of a person's intention by measuring his/her attitude toward performing the behaviour, his/her subjective norm, and the relative weights.

Over the last three decades, various studies have provided theoretical frameworks for research in the adoption and acceptance of information technology and information systems (Ajzen, 1985, 1991; Davis, 1989; Davis et al., 1989; Mathieson, 1991; Moore, 1987; Taylor & Todd, 1995). Among these, TAM is considered to be the most vigorous model explaining adoption behaviour of IT/IS (Davis, 1989; Davis et al., 1989; Igbaria et al., 1995; Mathieson, 1991). TAM specifically focused on explaining computer usage behaviour and uses. TRA, as a theoretical basis for specifying the causal linkages between Perceived usefulness and Perceived ease of use, produced determinants of user attitude, intention and actual adoption of technology. TAM's approach to identify behaviour is less general than TRA's.

Developments in ICT and the emergence of the concept of mobility, availability and accessibility of resources and information have generated substantial enthusiasm among practitioners and academics. The booming publicity and need for mobility, such as m-communication, m-commerce, and m-collaboration, have generated much speculation about the endless potential of wireless technology. Due to the lack of clear solutions and the evolving nature of wireless technology, manufacturers are producing devices based

only on their understanding about what the user might value and desire. What is missing is a clear understanding of the motivations of prospective users, the circumstances in which the wireless devices may be used, and the processes of adoption of these devices. To achieve the full potential of wireless handheld devices, it is critical that these technologies and their applications be widely acceptable. Consequently, there is a clear need to understand how and why users adopt such wireless handheld devices. There are well-established theories and models to explain consumer adoption phenomena in general terms (Sarker & Wells, 2003). However, some models of adoption rely on a wide range of miscellaneous theories and try to explain the concept of adoption through a wider generic view. Thus, they have focused only on the adoption of products and technology (Pagani, 2004). For example, innovation diffusion theory relies on individual perceptions about using an innovation and on adoption behaviour (Agarwal & Prasad, 1999; Moor & Banbasat, 1991; Rogers, 1995b). Other theoretical models try to explain adoption behaviour through user beliefs, attitudes, intentions and actual system use (Ajzen, 1991a; Davis et al., 1989a; Davis, 1989a; Pagani, 2004).

Studies in information systems have shown considerable interest in theories and models that predict variables to determine acceptance of computer systems. The successful use of any system depends on the acceptability of the system to its users. A developer's ability to understand these factors and to address them as early as possible in the design and implementation process is crucial to ensuring acceptance. The process of understanding why people accept or reject a particular computer technology is becoming more popular in the field of information systems research. The impact of user beliefs and attitudes and how these internal factors are influenced by external factors in order to understand acceptance have been studied extensively (DeSanctis 1983; Fuerst & Cheney 1982; Ginzberg 1981; Ives, Olson & Baroudi 1983; Lucas 1975; Robey 1979; Schultz & Slevin 1975; Srinivasan 1985; Swanson 1974, 1987). Intention models from social psychology, such as the TRA are well researched and have proven successful in describing user behaviour (Davis et al., 1989a).

There are many validation studies on the adoption theories with some variation in regard to wide range of products and technology (Holak and Lehman, 1990, Labay and Kinnear, 1981, Ostund, 1973, Rogers, 1995b, Beatty et al., 2001, Pagani, 2004). However, there is no single model which have the ability to explore and explain the phenomena of ICT specific to wireless handheld technology adoption. The above reviewed adoption models cannot be directly transposed to the adoption of wireless handheld technology because of its unique features such as individual differences, physical features, complexity, operating environment, social influences, security and trust, convenience, localization, personalization, workflow systems, privacy and security issues as opposed to the desk top computing (Lu et al., 2005).

TOWARDS DEVELOPMENT OF CONCEPTUAL FRAMEWORK

The 21st century ICT developments in the context of wireless technology have the following characteristics.

1. New ICT environment is very time sensitive.
2. ICT infrastructure is the backbone of the new business and globalization.
3. Flow of information is very sensitive.
4. Delay/distortion of information on micro level can make the difference between survival and bankruptcy.
5. ICT user characteristics are integral part of the adoption process for the use of ICT.

6. ICT user workflow and surrounding characteristics as an input to the process.
7. Wireless technology/applications have unique characteristics in the ICT environment.
8. Possibility/Probability using wireless/ICT as necessity.

For better understanding of the ICT environment and users' characteristics with respect to adoptability of wireless handheld technology, it would be beneficial to develop a framework for the adoption of the technology that incorporates traditional variables and explore the user perception towards wireless handheld technology. Such a framework will help in identifying adoption factors in sensitive environments and provide researchers in their domain a road map for implementation and uses of wireless handheld technology in a complex environment. The outcome of this research can also help managers/administrators to develop training workflow plans for target population. By investigating the factors underlying adoption of wireless handheld technology/applications, we hope to provide insights into those factors that need to be given priority in wireless handheld technology/applications for data collection purposes as well.

We realized that it would be highly beneficial to develop a framework for the adoption of wireless handheld technology. Such a framework would not only help to identify adoption factors in a sensitive environment but also provide the researcher with a road map for the implementation and use of such wireless handheld technology. It was also expected that the outcome of the study would enhance the data collection procedures, realizing significant cost and time savings. The overreaching aim of the study was to explore and identify the internal and external drivers and inhibitors of adoption of wireless handheld technology. Table 2 provides a list of all the variables associated with the previous adoption models. These variables can be categorized into 5 groups, each of which describes a specific readiness attribute. These are:

1. Behavior,
2. Perceived,
3. Organizational,
4. Technical,
5. Environmental readiness.

Readiness is defined as individual's perceptions or views how well the business is ready to motivate its user to adopt the wireless handheld technology in question. Thus we propose a new conceptual model called "Readiness Acceptance Model" (RAM). The influence of the user's age, experience and qualification on the five readiness attribute groups is integral to the RAM as shown in the Figure 1. RAM provide comprehensive conceptual model for the wireless handheld technology adoption in the information system domain, which incorporate various constructs from the previous models and readiness of the organization and individual perceptions in the context of wireless handheld technology adoption.

In the above table there are five main themes emerged for the qualitative data analysis. Researcher name these five constructs in the research as, Behavioural Readiness (BR), Perceived readiness (PR), Organizational Readiness (OR), Technical Readiness (TR), and Environmental Readiness (ER). Section below provides the brief definition of these constructs which considered helping predict Intention to Use (ITU). These constructs can be defined as follows.

1. **Behavioural Readiness:** Behavioural readiness (BR) is also directly borrowed from the original TAM. Attitude can be defined as an individual's behaviour towards using the technology. An

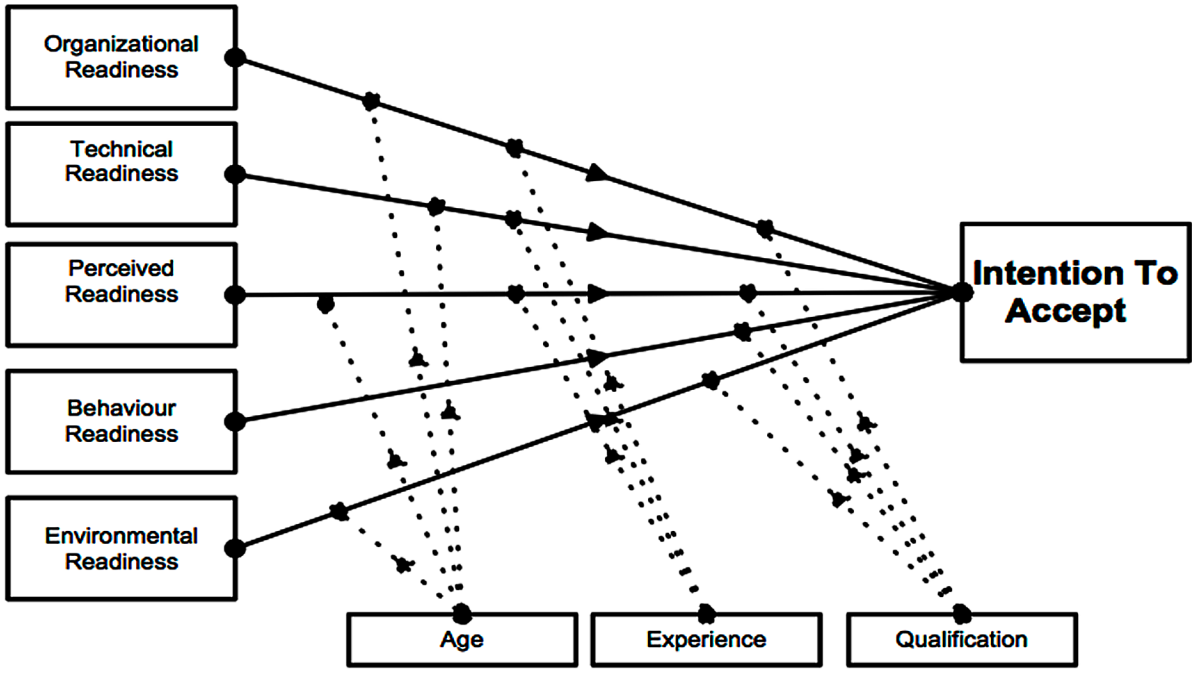
Table 2. Summary of all the constructs from the 9 adoption models in the IS domain

Constructs from 9 Adoptions Models	Variables	Variable Categories
• Attitude Toward Behaviour • Subjective Norms • Perceive Behaviour • Usefulness • Social Pressure • Perceived Usefulness, Behaviour, • Subjective Norm, • Attitude towards using technology • Perceived Behavioural Control • Normative Beliefs • Attitude towards using Technology • Subjective norm • Perceived Behavioural Control • Habits, • Personality • Social norms, • Attitude • Job Fit • Complexity • Long term consequences • Affect towards use • Facilitating conditions • Behaviour • Environmental Factors • Personal Factors • Outcome expectations • Self Efficacy • Affect • Anxiety • Perceived Usefulness • Perceived Ease of Use • Attitude • Subjective Norms • Compatibility of Technology, • Complexity of Technology, • Relative Advantage • Ease of Use • Result Demonstrability • Trailability • Visibility • Image • Voluntariness • Performance Expectancy • Effort Expectancy • Social Influence • Facilitating Conditions	• Attitude Toward Behaviour • Attitude • Behaviour • Perceived Usefulness, Behaviour • Perceived Behavioural Control • Personal Factors • Perceive Behaviour • Personality • Attitude towards using technology • Habits, • Affect towards use • Voluntariness • Anxiety	Behaviour Readiness
	• Performance Expectancy • Perceived Usefulness • Perceived Ease of Use • Effort Expectancy • Usefulness • Outcome expectations • Relative Advantage • Ease of Use Self Efficacy	Perceived Readiness
	• Job Fit • Visibility • Long term consequences • Affect • Result Demonstrability • Image • Subjective Norms	Organizational Readiness
	• Compatibility of Technology, • Complexity of Technology, • Complexity • Trailability	Technical Readiness
	• Environmental Factors • Facilitating Conditions • Social Influence • Social norms • Social Pressure • Normative Beliefs	Environmental Readiness

individual's behaviour can be either positive or negative towards a wireless handheld technology. Behaviour attitude can also be aligned with the previous adoption models such as TRA and TPA in the context of intrinsic motivation (Davis et al., 1992) and affect towards use (Thompson et al., 1991, Venkatesh et al., 2003).

2. **Perceived Readiness:** Perceived readiness (PR) can encapsulate the perceptions of users about wireless handheld technology. It also contains perceptions about usability, and the readiness of their organization to adopt the use of wireless handheld technology. Examples include perceptions

Figure 1. Readiness acceptance model for the ICT adoption



about the availability of electronic records, the ability to retrieve and store information electronically, available knowledge, and existing work place practices. Earlier researchers in the domain of adoption and innovation diffusion theories provided a solid background of evidence that adopter decisions and intentions to use new technology depend on their perceived belief about the innovation itself (Ajzen & Fishbein, 1975; Davis, 1989; Davis et al., 1989; Rogers, 1995). Such beliefs are influenced by the idea of complexity, which is defined as "the degree to which an innovation is perceived as difficult" (Rogers 1995, p. 16). Thus complexity measures how difficult an innovation is to understand, learn, and use. This research will test this construct for wireless handheld technology in the healthcare environment and education domain. Consequently, this construct is included under the label of Perceived Readiness (PR).

3. **Organizational Readiness:** Organizational Readiness (OR) in the context of wireless handheld technology is the level of ICT sophistication that exists in the facility1, the ability to provide financial and non-financial resources, the availability of knowledge, training, policies and procedures, and the degree of integration of business processes. Increased levels of leadership and commitment from management can lead to organizational readiness toward the adoption of wireless handheld devices. Encouragement and level of strategic planning are also part of organizational readiness. Earlier studies have identified the importance of organizational factors that influence adoption phenomena (Kwon & Zmud, 1987; Tormatzky & Fleischer, 1990). For example, in the healthcare environment, the use of technology is a common feature, as healthcare professionals already use a range of sophisticated medical equipment. Thus, individual perceptions and available infrastructure

can influence an intention to use the technology. For example, healthcare professionals are conversant with handling pagers, communication devices, X-ray machines, and desktop computers. In this study, work practice, social context, and compatibility of existing technology can play vital roles in the adoption of, or intention to use, the wireless handheld technology. Therefore, this research will study the impact of these variables on adoption or intention-to-use in the context of a wireless handheld technology.

4. **Technical Readiness:** Technical readiness (TR) refers to an organization's technical ability to install and provide the support required for the use of wireless handheld technology. It refers to having adequate technical knowledge, awareness and interconnectivity, and reliability of the infrastructure available with respect to technical issues. Another variable, trialability, is "the degree to which an innovation may be experimented with on a limited basis" (Rogers 1995; p. 16). It describes how easy an innovation is to try out or test. This variable will also be tested in the healthcare environment and this construct is included under the label of Technical readiness (TR).
5. **Environmental Readiness:** The environmental readiness (ER) of the business environment can affect the use of wireless handheld technology. For example, the extent to which wireless handheld technology in a particular environment or setting is perceived to be socially acceptable would influence its adoption. For example, how patients and healthcare professionals perceive this technology depend on factors such as their particular organizational culture or political environment, and this can have an effect on the potential use of wireless handheld technology in any setting.

This research study proposes the above frame work for the acceptance of wireless handheld technology and it is hypothesised that RAM will help to predict the intention of the user to accept the wireless handheld technology. In this research study the construct intention to use2 wireless handheld technology is related to the level of the user's purposefulness or determination to use the wireless handheld technology in a given setting.

CONCLUSION

This research paper provided a review of the existing adoption theories and models in the domain of information systems. Prominent adoption models/theories were identified and analyzed with a view to utilizing their constructs for the adoption of wireless handheld devices in a setting. We have incorporated traditional theories with the readiness and perception of the users to explain the phenomena of adoption of ICT in wireless mobile domain.

In order to validate the conceptual framework, we are in the process of collecting data for all the variable categories identified in the RAM. We will be able to test the model in the two different domains, such as healthcare, and education to prove how generalized and reliable is the model in explaining the phenomena for acceptance of wireless handheld technology. The incorporation of "readiness" as additional parameters is a novel idea and refines the theory for use in mobile ICT. Furthermore, testing of RAM in education and healthcare domain will help us to further refine RAM adoption model for wireless handheld technology.

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ENDNOTES

[1] This definition is developed specifically for this study.

[2] In this research study only intention to use the wireless handheld devices, such as PDA's, was tested. There was no attempt to measure the actual use of wireless handheld devices.

Chapter 36
A Taxonomy for mHealth

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ABSTRACT

Recently, we are witnessing an exponential growth in remote monitoring and mobile applications for healthcare. These solutions are all designed to ultimately enable the consumer to enjoy better healthcare delivery and /or wellness. In order to understand this growing area, we believe it is necessary to develop a framework to analyse and evaluate these solutions. The purpose of this chapter then is to offer a suitable taxonomy to systematically analyse and evaluate the existing solutions based on number of dimensions including technological, clinical, social, and economic.

INTRODUCTION

Within consumer health informatics, one of the key driving technology enablers has been mobile solutions. These mobile solutions, whether smartphones or other sensor devices, promised to empower consumers to be better able to monitor their own health and wellbeing and thereby be better placed to engage in more meaningful and in-depth discussions with their respective clinicians. It is clear that such mobile solutions are only in their infancy in health care, and the whole area of mobile health (mHealth) care is growing exponentially. Given this, it believes us to understand the whole domain of mobile health including remote monitoring and mobile apps, and thus, this chapter, offer an appropriate taxonomy to assist us in developing a better understanding

mHealth

The area of ubiquitous and pervasive computing as it relates to health monitoring underscores the need to be continuous and support anywhere-and-anytime monitoring, preferably in a seamless and unobtrusive fashion.

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As a result, with the prevalence of smartphones, mHealth emerged in the past decade. mHealth is viewed as driving force in transforming health-care delivery, making some elements of health care faster, better, more accessible, and cheaper (Levy 2012).

While a standard or a definition for mHealth is absent, the definition for "mHealth applications" provided in the American Health Information Management Association (AHIMA) guide was adopted and given below:

… the use of devices such as smartphones or tablets in the practice of medicine, and the downloading of health-related applications or 'apps'…[to] help with the flow of information over a mobile network and…improve communication, specifically between individuals and clinicians. (AHIMA Guide 2013, p. 1)

While the AHIMA guide offers a reasonable definition for mHealth applications, it is argued that the above definition lacks comprehension in the following two elements:

1. The definition does not include a holistic view on the communication technology aspects of the mHealth applications. This chapter argues that the mHealth information flow does not necessarily occur over a mobile network. Depending on the application and the adopted technology, a single mobile or networking communication technology (mobile/wireless) or hybrid communication method could be used for global connectivity in the system.
2. As Malvery and Slovensky (2014) argue, it does not include key elements of clinical purpose. The definition focuses on communication with a physician or other clinician and fails to acknowledge the important role mHealth applications play in self-care and self-management of health issues and the resulting information that is not intended to be reported to the individual's physician.

Istepanian et al. (2006) argue that mHealth redefines the original concept of tele-medicine as "medicine practiced at a distance" to include the new mobility and "invisible communication technologies" to reshape the future structure of global health-care systems. Further, the definition of mHealth by Istepanian et al. (2006) is "emerging mobile communicates and network technologies for healthcare," which gives a more holistic focus to the communication aspect. They further state that convergence of future wireless communication, wireless sensor networks, and ubiquitous computing technologies will enable the proliferation of such technologies around health-care services with cost-effective, flexible, and efficient ways. Supportively, Free et al. (2010) identify mHealth as "the use of mobile computing and communication technologies in health care and public health".

TAXONOMY

As the vision of pervasive computing, to be connected anywhere, anytime, on any device was accomplished, an exponential growth in mHealth systems and applications also appeared over the past decade. For example, in 2013, it was estimated that more than 40,000 mHealth apps were in use (Silow-Carroll and Smith 2013).

Similarly, an exponential growth of mHealth can be expected in the future. The market for mHealth app services is predicted to reach US$ 26 billion worldwide by 2017, according to a March 2013 report by research2guidance, a Berlin-based consulting company (in Malvery and Slovensky 2014, p. 65).

With the high growth of mobile health solutions, it is vital to introduce a taxonomy to keep track of these solutions. The purpose of the taxonomy is to present a checklist of criteria for comparison of mHealth applications. The potential users of the taxonomy are the researchers, developers, funding agencies, and users who want to compare one mHealth application with another.

This chapter presents a multidimensional taxonomy for mHealth applications and systems in a socio-technical context. The four dimensions used in the taxonomy include technological, clinical, social, and economic, and these are dicussed briefly in turn.

Technology Dimension

The "technology" dimension focuses on any system/applications that is/are developed for remote monitoring of a health condition. With the rapid advancement of pervasive computing and the vision to achieve anywhere anytime connectivity on any device, a smart personal device like a smartphone with health applications, so-called mHealth applications, are becoming an essential element in day-to-day life. The mHealth applications are classified based on the mode of sensing as follows.

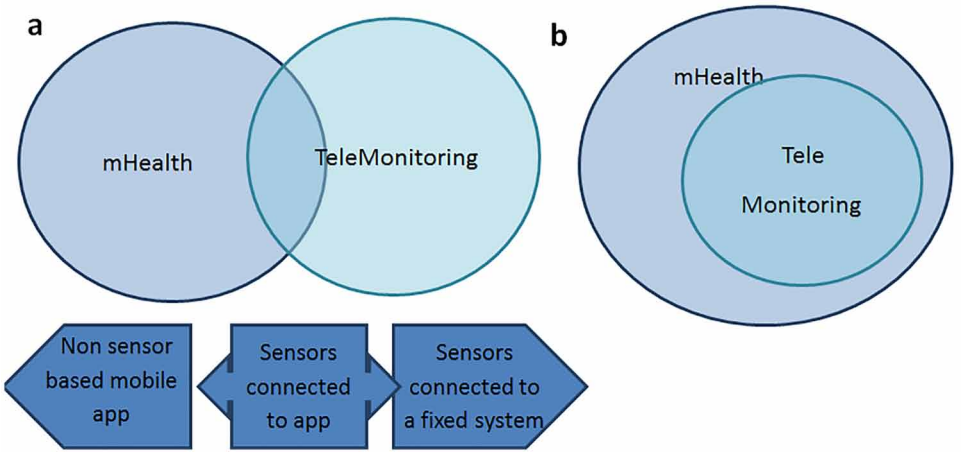
Clusters of Remote Monitoring (Telemonitoring) and mHealth

From the mHealth and telemonitoring points of view, the ubiquitous sensors used in the health-care industry can be of two basic types. The two clusters are the sensors inbuilt in the mobile device or the external sensors. For example, as Stanley and Osgood (2011) argue, the typical smartphones have inbuilt location (global positioning system (GPS)), activity (accelerometer), and sound (microphone) sensors. The mHealth applications developed on the smartphone to use such sensors can be visualised as telemonitoring embedded in mHealth. This is illustrated in Figure. 1b. Situations where external sensors and mHealth applications jointly form a comprehensive system with or without the many other features of mHealth and telemonitoring are represented in Figure. 1a. These systems could have external sensors wirelessly connecting to the smartphone and or other device, with or without a mHealth application. For example, the intersection of the two sets represents a mHealth app which uses external sensors. These external sensors could be of many forms such as wearables, patches, clothing, implanted, or even a tablet that can be swallowed (see Figure 1).

There is a tremendous number of consumer mobile apps developed in the healthcare sector. It was estimated in 2013 that more than 40,000 mHealth apps were in use (Silow-Carrol and Smith 2013). The types of apps in descending order of popularity include:

1. Exercise, fitness, pedometer, or heart rate (HR) monitor;
2. Diet, food, and calorie counter;
3. Weight;
4. Menstrual or period cycles;
5. Blood pressure (BP);
6. WebMD;
7. Pregnancy;
8. Blood sugar or diabetes;
9. Medication management (tracking/alerts);
10. Mood;

Figure 1. Illustration of the two clusters of sensors



11. Sleep; and
12. Other (Malvey and Slovensky 2014, p. 5).

The technology dimension of the taxonomy is composed of a sub-dimension including:

1. Context parameters sensed,
2. Communication aspects,
3. Scope of access and information flow, and
4. Technology evaluation.

Context Parameters Captured

In ubiquitous computing paradigm, context is defined as any information that can be used to characterise the situation of an entity (Dey 2001). Health-care systems measure various context parameters including patient behaviours and social and environmental parameters.

- **Physiological Parameters:** Physiological health can be monitored in patients with chronic diseases such as hypertension and diabetes. General health monitoring for wellbeing and fitness purposes is also doable. The parameters such as BP and blood glucose levels, HR, oxygenation, electrocardiogram (ECG), oxygen saturation, and respiration are measured. In addition, environmental measurements such as temperature, humidity, and visible light in the living environment are also monitored in health assessments.
- **Movement-Related Parameter:** Location information is measured to estimate motion pattern and activity recognition of elderly or physically and mentally disabled people.
- **Other Parameters:** Activities, social parameters such as access to grocery stores or fast food restaurants, proximity of individual to each other are also considered in mHealth applications.
- **Parameters Inferred:** These include any parameters inferred from the captured parameters above. Examples are arrhythmias and ventricular fibrillation (VF).

Architecture

The components of the system architecture include hardware (sensors and other hardware), software (operating system and processing algorithm), and the communication method(s). The communication methods are linked with the geographical boundaries and also with the clinical purpose; hence, are discussed it in detail below.

Communication Method

The sensors that measure various physiological parameters, environmental conditions, and other activities can form various communication mechanisms according to the needs such as range of communication, power consumption, and availability of the technology.

The communication aspects of a given system also depend on the capabilities of the devices in use. For example, the smartphones today have Bluetooth and Wi-Fi built in as the short-range communication method in addition to cellular communication. There are cost implications as well as available data rate and frequency of update on selection of the communication technology or the mix of technologies. A holistic and generalised system, which is composed of multiple technologies is considered.

- **Body Area Network (BAN):** The physiological sensors attached to the body and the other external sensors will be connecting to form a network of sensors using Zigbee (IEEE 802.15.4 standard) or Bluetooth. This addresses the solutions to low-power and short-range communication challenges. This sensor network data is fed to the smartphone using Bluetooth connection.
- **Local Area Network (LAN):** The smartphone then connects to the home computer or home server via Wi-Fi (IEEE 802.11 standard). In case of the absence of a smartphone, the sensor network master can directly connect to a Wi-Fi-enabled laptop/computer to transmit data.
- **Global System for Mobile Communication (GSM):** The data is transmitted through the cellular network typical in the form of short message system (SMS).
- **Internet Protocol (IP):** The home computer connects to the cloud via Internet, and the data is transmitted to the external world.
- **Alternative Connectivity Technologies:** Include infrared (IR) for indoor communication and localisation and GPS for outdoor localisation.

Scope of Access and Information Flow

- **BAN:** This basic unit of information flow enables self-education or self-awareness for the patient. They empower patients with self-care. Ultimate benefits include saving money and time and enhancing patient satisfaction.
- **LAN:** This local information flow has dual purpose. One is to create a link with the external world through IP. Second is to execute complex processing of the sensor collected sensor data such as signal and trend analysis and pattern recognition.
- **Cloud:** This enables sending patient monitoring information and information pertaining to treatment response to health-care providers, physicians, and other clinicians as well as hospitals. Above and beyond, this related information can be fed to the health system.

Communication method and scope of access and information flow sub-dimensions discussed above are illustrated in Figure 2.

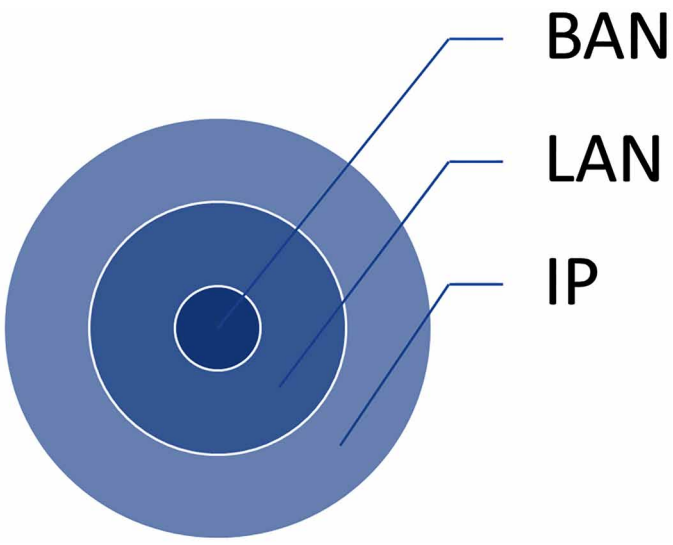
Technology Evaluation

Once the system is implemented, it is equally important to evaluate it technically as well as clinically. This technical evaluation might include quantitative system evaluation to benchmark the criteria such as error, reporting load on patients' richness of data, and qualitative user evaluation. A similar study (Berke et al. 2011) evaluates the devices that are easy to use and comfortable to wear based on a questionnaire.

Criteria to Use in Technology Evaluation

- **Timely Information:** Health domain is inherently characterised to be a time-critical domain for decision-making. The timeliness of monitored health conditions is vital. Hence, real-time monitoring should have very little tolerance for obsolete data.
- **Accuracy of System:** The system should do what it intends to do with a very small error. In some critical situations such as telecardiology applications or tele-operation applications, no error is tolerable.
- **Power Management**: The commercially available sensor units are generally battery powered. Hence, the limited battery life of the sensors is a limitation in any application. Energy-harvesting sensors, which are currently in the research stage, are hoped to solve this issue in the near future.
- **Security:** Security is a major concern when sensitive health information traverses on any network, particularity on the web. Malvery and Slovensky (2014) and Lim et al. (2010) discuss in detail the mHealth regulations and legislation and cybersecurity aspects related to mHealth.
- **Privacy:** The ability to protect the privacy of patients' health information is also vital as discussed by Malin et al. (2012).

Figure 2. Communication and information hierarchy



- **Integration with Other Systems:** As there are a number of health systems in place, for example, the systems used by general practitioners, specialists, and hospitals, the ability of any proposed system to integrate with other systems is vital. Hence, the interoperability or compliance with Medical Information System (MIS) is an important criterion in evaluating its usefulness.
- **Effectiveness (Fit for Purpose):** It is necessary to evaluate the ability of the system to satisfy user needs. Thorough investigation and user requirement analysis prior to the implementation will result in a greater effectiveness of any mHealth system.

Clinical Dimension

The clinical aspect of the mHealth application or system is considered under clinical dimension. Clinical dimension covers three sub-dimensions:

1. Clinical focus,
2. Clinical purpose, and
3. Clinical evaluations.

These are further discussed below.

Clinical Focus

The clinical focus dimension represents whether the proposed solution is developed to focus on physical coordination or psychological coordination. The solution might be targeting both of the key segments of the health-care industry, which are primary care and chronic care management; however, regardless of the segment, the clinical focus of the system is critical for classification.

Clinical Purpose

Clinical purpose is the primary purpose of the system. Clinical purpose includes:

1. Clinical diagnosis,
2. Prevention,
3. Providing information or monitoring,
4. Self-care and awareness,
5. Clinical decision support,
6. Treatment and management of a medical condition, and
7. General wellbeing.

End users such as patients, health-care professionals, and caregivers use the system for various purposes. For example, patients use the system for the purpose of self-care and awareness. Health-care professionals such as doctors and nurses use for the purposes such as clinical diagnosis, prevention, treatment, and management of a medical condition. These user groups are further discussed in the section “Social Dimension” below.

Clinical Consumer Group

Despite the clinical purpose, a particular application can be developed for a target consumer group. The following are example consumer groups:

- **Elderly:** Providing home-assistive and other support services for elderly people living in their own home reduces the need for hospitalisation, decreases the cost of care, and improves the patients' quality of life (Norris et al. 2008).
- **Disabled:** Various assistive, support, and guiding services for the disabled relieve the burden on the caregivers and also improve the patients' quality of life.
- **Cognitive and Mental Disorders:** Mobile phones offer the opportunities for accessing heath information, monitoring progress, receiving personalised prompts and support, and using self-management (Judith Proudfoot 2013).
- **Patients with Chronic Diseases:** Self-monitoring and self-management of chronic diseases such as diabetes and high BP using an automated technological solution could relieve a major burden they impose on the medical systems.

Clinical Evaluations

Clinical evaluations capture whether the proposed solution has conducted clinical trials to evaluate the effectiveness of the system by monitoring the effects of health outcomes on a relative sufficient number of users. This assures that the system reliably works in a clinical setting. Clinical evaluations can be done by conducting clinical trials. Clinical trials are defined as follows.

A clinical trial is defined as a prospective research study of human subjects that is designed to answer specific questions about biomedical or behavioural interventions (vaccines; drugs; treatments; devices; or new ways of using known drugs, treatments, or devices). Clinical trials are used to determine whether new biomedical or behavioural interventions are safe, efficacious, and effective.

The spectrum of the clinical evaluations could vary from rigorous trials done to no trials. Regardless of the clinical purpose whether to prevent, detect, treat, or manage various diseases or medical conditions, the clinical evaluations verify the ability of the system to perform what it is intended to. For example, the systems developed for the purpose of treatments or management of a medical condition are required to be measured with rigorous clinical trials. However, the systems developed for the purpose of general wellbeing are unlikely to be measured using clinical trials. They are measured in other ways such as technology and usability evaluations.

Social Dimension

Social dimension in the taxonomy includes the social context where the system is used and the end user of the system.

Social Context

The social context sub-dimension investigates the degree of social elements in the system. This is evaluated to see whether the system is purely for a personal diary or it goes beyond that to the level of social media health clubs, for example, or even to the level of rapidly growing social media.

Paralleling a rapidly growing online trend toward the "quantified self" and "life-logging", some individuals may choose to share this information socially, either in person or through social media sites, much like the readings on a scale in weight loss clubs. The combination of personal retrospectives and social stigma could prove sufficient to deter a person from fast-food restaurant visits if they knew that the trip would be logged and displayed for both themselves and their peers to see (Stanley and Osgood 2011).

End User

In any technological system, the end user and the end user's needs are vital. The second social sub-element of mHealth applications is to identify the end user of the system. This could be one or more of the following stakeholders:

- Patient,
- Doctor,
- Nurse,
- Carer,
- Other.

User centered design (UCD) is a modern human–computer interaction (HCI) design philosophy and a multistage problem-solving process in which the needs, desires, and limitations of the end users of an interface are questioned and analysed and assumptions of user behaviour are transferred to prototypes and tested (LeRouge & Wickramasinghe 2013). Hence, it is vital to identify the end user of the system very clearly.

Usability Evaluation

Some estimate that the failure rate of software development projects is as high as 60% due to HCI issues of poor functionality and usability and hence low uptake (LeRouge & Wickramasinghe 2013).

For several decades, HCI research and practice have focused on designing human-centred technologies, often referred to as UCD (Ritter et al. 2014). UCD is a modern HCI design philosophy and a multistage problem-solving process, in which the needs, desires, and limitations of the end users of an interface are questioned and analysed, and assumptions of user behaviour are transferred to prototypes and tested (LeRouge and Wickramasinghe 2013).

Usability is defined as the extent to which a user can fulfil a task using a tool effectively, efficiently, and with satisfaction (Shackel 2009). The level of the usability of a tool or application can be defined only in the context of its specific users and the specific tasks that are to be accomplished. Hence, designing highly usable software applications requires an in-depth understanding of the user needs.

Usability is currently one of the primary concerns of clinicians and a key factor in their decisions about adopting health information technologies for routine use (Russ et al. 2014). In this regard, several

large vendors acknowledged that practices such as formal usability testing, UCD process, and routine involvement of cognitive and usability engineering experts are not common (Civan-Hartzler et al. 2010; Yen and Bakken 2014).

Economic Dimension

The focus of economic dimension is to identify the ultimate economic benefit of a proposed system. It also includes the ways to analyse the benefit flow in the workflow. Is the benefit mainly intended for the patient? Is it for the doctors or physicians? Is it for the health system or providers? The ultimate economic benefit might be even for the community. The benefit might even partially pass on to the various stakeholders. The sub-dimensions of the economic dimension are given below:

- **The Extent to Which the mHealth Application Has a Business Case:** The business case verifies that the economies of the application use are sustainable (as an initial investment or a subscription by the patient or the insurance company).
- **Change Management:** The extent to which the app changes the current the process/method—whether it replaces the current method or adds a new component. Change management analyses the cost-benefit of the change process.
- **The Extent to Which the App Is a Disruptive Technology:** Whether the technology transforms the way the work is done at a broader level. For example, the introduction of a blood glucose monitor for diabetes management was a disruptive technology, where the device changed the industry. The economies of benefit of the introduction of the device included the time and cost to visit the doctor for a referral for frequent blood tests.

In Figure 3, the taxonomy is presented as discussed above with the key dimensions and sub-dimensions identified.

DISCUSSION

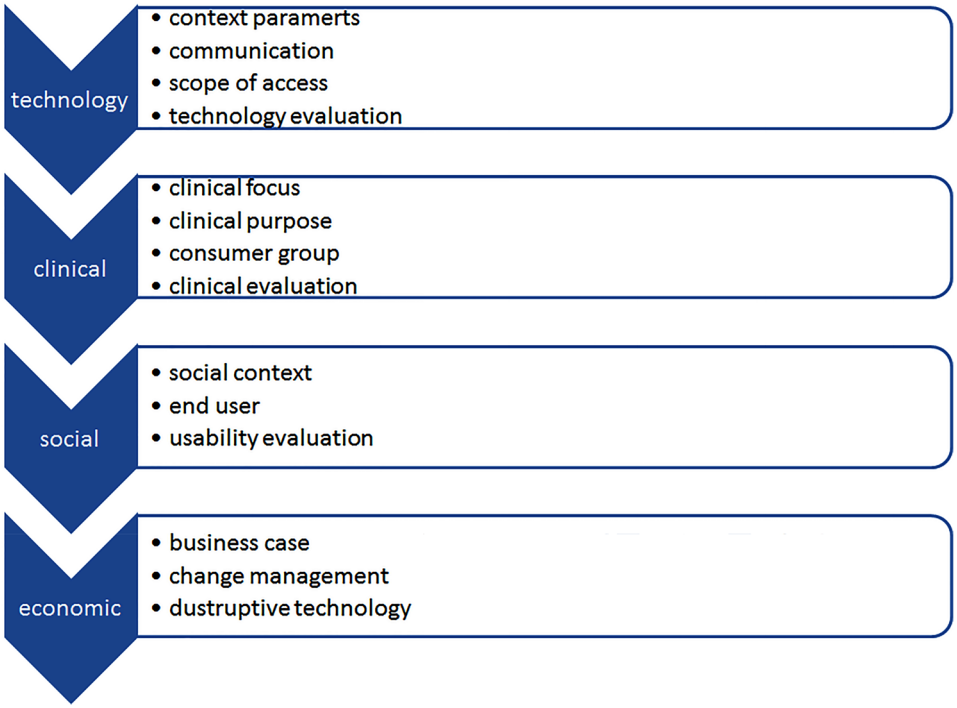
Existing Solutions

To illustrate the ideas, some existing solutions are mapped into the proposed taxonomy. A comprehensive literature review was conducted to identify most recent mHealth related work from the year 2004. Search terms such as "mHealth", "mobile Health", "remote health monitoring", "telemonitoring", "teleHealth", "personal health monitoring", and "telecare" are used in retrieving articles. The articles reviewed and are discussed below.

A tremendous number of sensor-based monitoring applications are proposed to assist the elderly in the literature (Rodrigues et al. 2014; Chan et al. 2005; Hewson et al. 2007; Scanaill et al. 2006; Suryadevara and Mukhopadhyay 2012; Yuan and Herbert 2011; Lubrin et al. 2005; Lin et al 2006 and Lv et al. 2010).

Rodrigues et al. (2014) propose a mobile health-care solution for ambient assisted living environment. Sensors attached to the body of the elderly measure ECG, BP, and temperature. The sensors forming a BAN connect to a personal computer, tablet, or smartphone through Bluetooth. The system immediately alerts both the elderly and caregivers of significant changes that might raise life-threatening situations.

Figure 3. Taxonomy for mHealth applications



The accuracy and performance of the system are investigated in controlled clinical trials with three levels of surveillance (alerting). A multisensor home monitoring system (Chan et al. 2005) monitors the activities of elderly. Ten IR sensors fitted in the ceiling of the house connected to an acquisition interface, which is wired to a PC. Accuracy of the behaviour assessment is tested. Changes in activity data and correlations between in-bed restlessness and getting up variables show trends in the behaviour of elderly people (as a predictive tool in abnormal situations). The system provides information to caregivers. The system was trialled with four participants in clinical setting. Hewson et al. (2007) propose a posture and falls-monitoring system for the elderly. The system captures images from a camera and uses advanced image-processing algorithms for fall prevention. Similarly, Scanaill et al. (2006) propose the telemonitoring of mobility trends of the elderly using accelerometer data. The data is sent to a central server through SMS via the mobile network. Suryadevara and Mukhopadhyay (2012) developed a wireless sensor network-based home monitoring system to monitor the wellbeing of the elderly. The proposed mechanism estimates the wellbeing condition based on the usage of household appliances connected through various sensing units. The normal behaviours and wellbeing are mathematically defined and tested with four elderly people. Web-based real-tie health-care monitoring was proposed by Yuan and Herbert (2011). Wireless BAN-based sensors monitor position in space, ECG, BP, and blood oxygenation. Interactive medical consultation and replay, review, and annotation of the remote consultation by the medical professional are also provided. Lubrin et al. (2005) use an existing monitoring network tool, namely, multi router traffic grapher (MRTG), to propose an infrastructure for recording environmental variables (light) as a proof of concept of a remote monitoring system. iCare is a mobile health monitoring system for the elderly (Lv et al. 2010). It is composed of wireless body sensors and smartphones to

monitor the wellbeing of the elderly. It can offer remote monitoring for the elderly anytime anywhere and provide tailored services for each person based on their personal health condition. When detecting an emergency, the smartphone automatically alerts preassigned people, who could be the old people's family and friends, and calls the ambulance of the emergency centre.

Doukas et al. (2011) review the home-assistive technology developed for the elderly and disabled and highlight the social issues about acceptance and training with the technology. Raad and Yang (2009) proposed a smart home for the elderly and disabled. Medical wearable sensors such as pulse oximeter sensor and BP sensor together with a number of environmental sensors, camera, weight sensors, and motion detectors were used to form the smart home. Web interface enables integrating physicians' reports. Lyu et al. (2014) developed a robotic walking-aid system with mobility assistance and remote monitoring of the elderly and disabled. The walking accessibility robot with embedded controller uses a laser range finder, ultrasonic radar, grip sensors, and other environmental sensors. The robot can prevent collision with a navigation and adaptation speed control, and remote monitoring.

The health-care system for the elderly with dementia (Lin et al 2006) is based on radio frequency identification, GPS, global system for mobile communications, and geographic information system (GIS) to construct a stray prevention system. A service platform was implemented for indoor and outdoor monitoring, emergency rescue, and remote monitoring. Nugent et al. (2007) proposed a system of home-based assistive technologies for people with mild dementia. User requirements captured during three workshops involving people with mild dementia as well as caregivers of an ongoing project were presented with the overview of the proposed system.

Telecardiology and monitoring through implanted devices is proposed in the literature (Boriani et al. 2008; Ricci et al. 2008). Boriani et al. (2008) studied the potential for telecardiology and remote monitoring of implanted electrical devices. Ricci et al. (2008) proposed a home monitoring technology for detection and treatment of atrial fibrillation (AF). The data collected from the implanted device through the transmitter device called CardioMessenger is forwarded to the service centre through a GSM network via SMS. Web interface is provided for nurses and physicians to analyse the received data. The data is decoded, analysed, and organised at the service centre. In a follow-up study, the system is evaluated with regard to patient acceptance of and satisfaction with the home monitoring remote control system with the implanted device (Ricci et al. 2010). After 1 year, the remote control by home monitoring (HM) was evaluated. A high level of acceptance and satisfaction was detected using a five-point scale for the system, which showed a good internal reliability.

Wearable physiological remote monitoring system was developed by Pandian et al. (2008); a washable shirt, which uses an array of sensors connected to a central processing unit with firmware for continuously monitoring physiological signals. Lee and Chung (2009) developed a wireless sensor network-based wearable smart shirt for health and activity monitoring. ECG and acceleration data is transmitted via Zigbee. Similarly, Paradiso et al. (2008) developed a health monitoring system with a wearable system. ECG, HR, oxygen saturation, impedance pneumography, and activity data is transmitted via general packet radio service (GPRS; transmission control protocol (TCP)/IP) for remote access.

Agarwal and Lau (2010) developed a remote monitoring system for chronic diseases (BP). The BP data collected via a mobile phone are sent to doctors via the Web so that doctors can manage the chronic condition by providing feedback to the patient remotely.

Other systems include medication support systems. Suzuki and Nakauchi (2014) conducted a month-long study with two elderly participants on a reminder system to keep recipient medication condition up

to date. The system is composed of an intelligent medicine storage case, wireless sensing devices, and a database server. The medicine case recognised the presence of medicine in its storage compartments by image processing to estimate the patient's present living state (i.e. current activity) on the basis of a fuzzy inference algorithm. The sensing devices are distributed throughout the houses to collect data for living state estimation. The intelligent medicine case works with wireless sensing devices to assist a recipient in maintaining good medication compliance.

A tremendous number of health-related mobile apps are currently available. Selected examples include the studies by Mowad et al. (2014), Ketabdar and Lyra (2010), and Banos et al. (2014).

An android app developed by Mowad et al. (2014) connects with the electrical appliances and services allowing them to be remotely controlled, monitored, or accessed. Even though the health focus of this solution is limited, an arduino-based system can be connected to monitor and control the electronic house equipment from anywhere.

A mobile app to remotely monitor physical activities is developed by Ketabdar and Lyra (2010). The system uses the data retrieved from the mobile phone accelerometer sensor for monitoring physical activities of users.

Banos et al. (2014) propose a wearable health monitoring system called Physio-Droid consisting of physiological sensors and a mobile app. ECG, HR, respiration, motion (acceleration), and body temperature are measured. Two use cases are considered.

Similarly, a large number of remote monitoring systems were proposed for home health care. Some examples are Chen (2011), Berke et al. (2011), and Istrate et al. (2008).

Web-based remote human pulse monitoring system for home health care is proposed by Chen (2011). The designed arterial pulsation measurement system is recommended for assessing and pre-diagnosing the health of a human being in traditional Chinese medicine clinical practice.

Berke et al. (2011) propose mobile sensing and activity monitoring to detect changes in health. The system measures physical, social, and mental indicators. Sensors include accelerometer; a microphone (to measure the presence and style of interactions); and sensors for barometric pressure, temperature, humidity, visible light, and IR light. Concurrently conducted questionnaire survey data were well correlated with mobile sensing of sociability and activity in the study of 400 participants.

Istrate et al. (2008) propose real-time sound analysis for medical remote monitoring. The study uses everyday life sounds and distress expressions in order to participate in an alarm decision for the elderly. The speech/sound segmentation module recognised a real-time test with 9% accuracy.

CLASSIFICATION OF EXISTING SOLUTIONS

The above-discussed solutions were classified using the taxonomy proposed above. Technology and clinical and social dimensions were considered. However, none of the articles/proposed solutions discussed the economic impact of the proposed solution. Hence, the economic dimension was excluded in the classification. The sub-dimensions of technology dimension context parameters, communication, scope of access, and technology evaluation; clinical dimension-clinical focus, clinical purpose, consumer group, and clinical evaluation; and social dimension–social context, end user, and usability are considered. Table 1 summarises the classification of the existing solutions.

Issues Challenges and Road Ahead

The benefits of mHealth applications and systems come at a risk of their limitations and challenges. Based on our literature analysis, it is found that the three key areas of limitations are:

1. Technology limitations,
2. Technology adoption and user needs,
3. Security.

Each key area is briefly outlined below.

- **Technology Limitations:** Technology limitations include the choice of the right device(s) for the right application. For example, as Boulos et al. (2011) noted, a smartphone with portability but limited internal storage, processing power, and screen size compared to a tablet or a laptop. However, the use of external cloud computing resources may prevent the needs for inbuilt processing speeds and memory requirements in the future (Kailas et al 2010). Device-related technology limitations also include the accuracy, reliability, and power supply of the sensors.
- **Technology Adoption and User Needs:** It is vital to understand that the mHealth system and application users have goals and expectations around the technology, and studies should focus on clarifying those goals and exploring how technology could address these goals prior to developing the systems. For example, Dawe (2006) argues that technology adoption, particularly assistive technologies for cognitive disability, must be studied as a process, consisting of multiple stages and involving a variety of caregiver stakeholders who jointly form a caregiver network. Supportively, Spinsante (2012) studied the usability of three different systems and found that the need of a clear and intuitive graphical user interface (GUI) is expressed by the users and highlighted the need of a specific technological design suitable for the elderly or disabled, by taking into account their requirements, either physical or cognitive ones.
- **Security:** Security has been discussed as a major challenge in mHealth application in the past (Poon et al 2006; Thilakanathan, et al. 2014). Poon et al. (2006) argue that is it essential to protect the BAN in order to ensure the security of the overall system. They also highlight the need to secure the sensitive medical information from unauthorised access, which could be hazardous to a user's life (e.g. alteration of system settings, drug dosages, or treatment procedures). They proposed a biometrics method to secure the BAN as a solution. Other issues such as loss or theft of devices which can impact the security of confidential digital health records or data held on mobile phones were also discussed in the past (Boulos et al. 2011).

CONCLUSION

mHealth is still only in its infancy. Scholars and practitioners alike predict that mHealth will be one if not the key driver for future health-care initiatives (gov2020). However, it is believed that the move forward will also contain several challenges connected with privacy and security issues, integrity of information, the distinction between health care and wellness, and the need to have a patient-centric focus as well as support the needs of health-care providers. The chapter does not have all the answers at this point and

Table 1. Classification of existing solutions

	Technology				Clinical				Social		
	Context Parameters	**Communication**	**Scope of Access**	**Technology Evaluation**	**Clinical Focus**	**Clinical Purpose**	**Consumer Group**	**Clinical Evaluation**	**Social Context**	**End User**	**Usability**
Rodrigues et al. (2014)	ECG, blood pressure, and temperature	Bluetooth	Data store on PDA BAN	Accuracy	Physical	Self-care and awareness	Elderly	Controlled environment	N/A	Patient and caregiver	No
Hewson et al. 2007	Motion images	Camera	N/A	No	Physical	Providing information and monitoring	Elderly	No	N/A	Caregiver	No
Chan et al. (2005)	Motion	Infrared and wired	LAN	Accuracy	Physical	Providing information and monitoring	Elderly	Yes	N/A	Caregiver	N/A
Scanaill et al. 2006	Motion	Mobile network GSM	IP	No	Physical	Providing information and monitoring	Elderly	No	No	Medical personal	No
Suryadevara and Mukhopadhyay (2012)	Appliance usage data	Zigbee	LAN	Yes	Physical	Wellbeing monitoring	Elderly	No	No	N/A	No
Yuan and Herbert (2011)	Position in space, ECG, blood pressure, and blood oxygenation	Bluetooth/ Zigbee/ Wi-Fi	BAN and IP	Performance	Physical	Monitoring and remote medical consultation	At-risk patients	No	No	Patient, caregiver, and medical consultants	No
Lubrin et al. (2005)	Light		BAN, LAN, and IP	No	Physical	Proof of concept for home monitoring	Patients need monitoring	No	No	Patients and health-care professionals	
Lin et al. 2006	Location	RFID, GSM, and GPS	GSM, satellite, IP	Performance and reliability	Physical	Chronic disease patient monitoring	Elderly with dementia	No	No	Family members and caregivers	No

believes much more careful research is required. However, it is believed that a guiding framework and taxonomy is a very necessary first step in trying to understand this space and thereby design and develop appropriate solutions, policies, protocols, and guiding principles for moving forward. Thus, the proffered taxonomy is presented as a suitable framework to serve in this regard. Our next steps will include testing this taxonomy in various contexts.

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Chapter 37
A Guideline to Use Activity Theory for Collaborative Healthcare Information Systems Design

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ABSTRACT

In healthcare, collaborative systems serve very different stakeholders: researchers, clinicians, nurses, patients, and administrators for instance. In order to design a collaborative healthcare information system that satisfies the stakeholders' needs, all individual requirements have to be mapped into the software. Traditional system design focuses at technical features and oftentimes ignores social requirements like human factors or organizational structures. Instead of integrating existing processes and working habits into a system, a technical-focused design approach tries to force new behaviors. As a result, stakeholders could refuse to use collaborative healthcare information systems. In line with Kuutti (1991), we recommend activity theory as a rich framework to study and design collaborative information systems. We believe that activity theory analysis is particularly useful for healthcare settings where diverse stakeholders pursue very different goals. This book chapter offers a structured approach to analyze collaborative activities and to design the IT-support accordingly.

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INTRODUCTION

The development of collaborative healthcare information systems is a very complex but promising undertaking. Numerous collaborative activities can be optimized by information and communication technologies. The increasing digitalization of those activities and processes results in time saving, error reduction and most important it enables the analysis, evaluation and knowledge creation of the collected data. Healthcare information systems can improve and support patient safety and avoid medical errors (Baxter & Rooksby, 2011). To date, all OECD countries recognize the opportunities of those systems especially in the light of access, quality and value facing healthcare delivery (Wickramasinghe & Schaffer, 2010).

However, system failures can lead to damages with serious consequences. A significant example is the failure of the dispatch system of the London Ambulance in 1992. Up to 30 people died because of technical problems. The system was not able to address and support the established practices of dispatch. This example shows that development approaches for collaborative systems in healthcare need to focus on both: technical aspects and work practices (Baxter & Rooksby, 2011).

In order to raise the aforementioned potentials, the major challenge is the design of such collaborative systems in healthcare due to the diverse stakeholders and complex work practices. Traditional system design approaches often target at technologically driven features. This means, instead of existing processes and work habits forming the system, the design approach tries to push new behaviors (Sawyer, 2013). It is widely acknowledged that adopting a socio-technical approach to system development leads to systems that are more acceptable to end users, delivers better value to stakeholders and overall value to the company. Despite this knowledge, there is a lack of theories and methods which consider human, social and organizational factors (Sawyer, 2013; Whitworth & Ahmad, 2014). In order to design effective systems, it is not sufficient to only understand the process in general, but it must also be clear how the various stakeholders interact and what motivates them to strive for the joint objective (Sadeghi, Andreev, Benyoucef, Momtahan, & Kuziemsky, 2014a).

One attempt to narrow the so called socio-technical gap is provided by Kuuttii (1991). He suggested to employ the concept of “activities” - originating from activity theory - as basic unit of analysis for collaborative information systems design. He argues, that the properties of the activity concept correlate well with the characteristics and social requirements of collaborative activities (Kuutti, 1991). Applying activity theory analysis helps to understand the work practices of all stakeholders involved in the activity and how these individuals interact with technological and non-technological artefacts. With creating and analysing an activity system it is possible to obtain a complete overview of an activity. This overview can not only be used to uncover contradictions between components of the activity systems (e.g. a nurse has problems to work with certain tool) but also to have deeper insights into the activity system e.g. the number of stakeholders, the objectives that are motivating the individuals to fulfil an activity, or the number and quality tools used. The results can be used for both analysing an activity and capturing requirements for collaborative healthcare information systems.

The remainder of the book chapter is structured as follows: After presenting the theoretical background of activity theory, we discuss related work on the application of activity theory in healthcare. Based on this foundation, we propose a guideline to use activity theory for the analysis and the design of collaborative healthcare information systems. The book chapter closes with concluding remarks, pointing to areas of our future research.

BACKGROUND

Activity Theory

Activity theory has been used in the field of information systems and general HCI research before with promising results (e. g., (Barki, Titah, & Boffo, 2007; Bharosa, Lee, Janssen, & Rao, 2012; Durst & Grottke, 2015; Kamaruddin, Yusop, & Ali, 2011; Riechert, Durst, & Wickramasinghe, 2016; Sadeghi et al., 2014a). The concept, evolved from Russian philosophy, is considered to be a meta-theory or a framework, rather than a predictive theory and aims at providing holistic descriptions for social systems. In this context, an activity is a goal-directed interaction of a *subject* with an *object* mediated by the use of *tools* in order to achieve a certain *outcome* (Leont'ev, 1978; Vygotsky, 1978). These tools can be external such as a scissor or internal such as concepts or heuristics (B. Nardi, 1996).

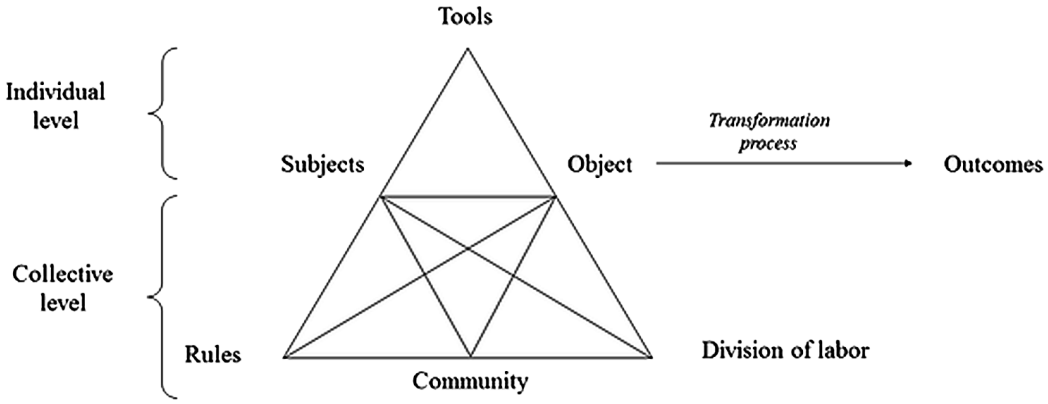
Engeström (1987) extended the original concept of activity to the case of collective activities. He added the element of *community* to the foregoing notion of subject-object interaction in order to enable a three-way interaction between subject, object, and community. Additionally, two types of mediators for each possible interaction between these three elements were defined:

1. *Rules* were introduced to mediate the subject-community interaction.
2. The community-object interaction is mediated by *division of labor* (Engeström, 2000).

The expanded activity system by Engeström can be seen in Figure 1.

According to the principles of activity theory, human activities are always directed towards their objects (Kaptelinin & Nardi, 2012a). As stated by Leont'ev (Leont'ev, 1978), an objectless activity is impossible. "Objects motivate and direct activities, around them activities are coordinated, and in them activities are crystallized when the activities are complete." (Kaptelinin & Nardi, 2012a). Taking on the perspective of a subject, this means that the subject's interactions are organized around objects to achieve an outcome. Analyzing the object of an activity helps to understand activities on an individual and collective level. When defining object, objective, and outcome of an activity it is important to consider the differences between these elements. "Objects have their "objective" meanings, determined by their relationship with other entities existing in the world (including the subject himself or herself)" (Kapteli-

Figure 1. Activity system model of Engeström (2000)



nin & Nardi, 2012a). The subjects' objectives can be very different, especially in activity systems which involve heterogeneous stakeholders. Objectives can not only be physical but also socially or culturally motivated (Kaptelinin & Nardi, 2012a). In a nutshell: Activity theory explains both the 'how' and the 'why' of human action and thus collaboration.

Activity systems are constantly evolving and by nature internally contradictory. Contradictions in activity systems exist because activities are constantly developing and even most well-planned actions involve failures, disruptions, and unexpected innovations (Kaptelinin & Nardi, 2012a). By analyzing the activity system, the underlying contradictions that lead to these failures, disruptions, or innovations may be recognized and offer possibilities for expansive design adjustments (Engeström, Miettinen, & Punamäki, 1999). In activity theory four types or levels of contradictions can be identified (Kaptelinin & Nardi, 2012a).

- **First-Level Contradictions:** Deal with inner-contradictions of each activity system component: subject, object, community, tools, rules, and division of labor. For example, a physician chooses a more affordable medication over the best available medication that is more expensive (Kaptelinin & Nardi, 2012a).
- **Second-Level Contradictions:** Occur between the components of an activity system. For example, if a certain type of medical treatment is unsuitable for certain patients (Kaptelinin & Nardi, 2012a).
- **Third-Level Contradictions:** Are potential problems emerging between the existing and a more advanced form of the activity system (Kaptelinin, Nardi, & Macaulay, 1999). For example, stakeholders involved in a certain activity could refuse to adapt to new IT-supported work practices.
- **Fourth-Level Contradictions:** Occur between different activity systems that are involved in the achievement of a joint outcome. For example, a positive effect of surgery can be undermined by an improper follow-up rehabilitation (Kaptelinin & Nardi, 2012a).

Activity theory is regarded as a powerful lens for studying complex social systems. It analyzes existing relationships among different elements mediated by tools, rules and division of labor. In addition, activity theory considers different user perspectives of the subjects, too (Greenhow & Belbas, 2007). Even though it is characterized as an analytical framework, activity theory does not offer ready-made techniques and procedures for research (Rogers, 2008). It is considered as an evolving framework that only contains general guidelines and therefore must be further developed (Greenhow & Belbas, 2007).

Activity-Oriented Design Method

In literature, we identified two different methods of executing activity theory analysis: The activity-oriented design method (AODM) by Mwanza (2011) and the activity checklist by Kaptelinin and Nardi (Kaptelinin et al., 1999). The activity checklist offers important aspects for system evaluation and system design. Amongst others, it includes aspects such as "People who use the target technology" or "Criteria for success or failure of achieving target goals". However, there are no specific recommendations of how to gather the needed information (Kaptelinin et al., 1999). The AODM by Mwanza (2011) offers a series of well-structured procedures and stages in order to execute the activity theory analysis (Greenhow & Belbas, 2007). In consequence, we adopt the AODM by Mwanza (2011) for the analysis and the design of collaborative healthcare information systems.

The AODM was developed to identify contradictions in activity systems (Greenhow & Belbas, 2007). According to Engeström, contradictions are seen as means of expanding and transforming the system and developing human practices. In other words, uncovering contradictions is necessary in order to improve system design (Greenhow & Belbas, 2007). In addition, design insights for further studies and refinement can be derived (Greenhow & Belbas, 2007). The AODM offers four methodological tools to support data gathering, analysis and communication of design insights. These tools are divided into four stages (Sadeghi et al., 2014a):

Stage 1: Defining Activity System (Eight Step Model)

The eight step model of stage 1 puts theory into practice by defining and interpreting the activity system. It is a requirements capture methodology grounded in activity theory (D. Mwanza & Engeström, 2003). Table 1 shows the eight step model with the corresponding questions to ask.

Stage 2: Activity Notation

Stage 2 reduces complexity of the examined activity system by decomposing or breaking down the complex activity system into manageable sub-activities. Three rules-of-thumb, proposed by Mwanza (2011), should be considered:

1. The actor is represented by the subject or community component of the activity system;
2. Tools, rules, or division of labor function as mediators; and
3. The activity focuses on an object. As a result of this stage, a triangle for each sub-activity is created (Sadeghi et al., 2014a).

Stage 3: Research Questions

At stage 3, a research question for each sub-activity is generated. Here, either generic questions such as "What tools are used by the subjects to achieve their objects and how do they do that?" or questions

Table 1. The eight step model

Step	Identification of	Question to Ask
1	Activity of interest	What sort of activity am I interested in?
2	Objective	Why is the activity taking place?
3	Subjects	Who is involved in carrying out this activity?
4	Tools	By what means are the subjects performing this activity?
5	Rules and Regulations	Are there any cultural norms, rules or regulations governing the performance of activity?
6	Division of Labor	Who is responsible for what, when carrying out activity and how are the roles organized?
7	Community	What is the environment in which this activity is carried out?
8	Outcome	What is the desired outcome from carrying out this activity?

Mwanza-Simwami, 2011.

specific to the context such as "How do whiteboards help the clinical manager to facilitate the safe and effective transition of patients towards discharge?" (Sadeghi et al., 2014a) are asked.

Stage 4: Data Collection and Technique of Mapping Operational Processes

Based on these questions data is collected and analyzed in stage 4. Stage 4 communicates research insight by modelling inter-relations of operational processes and by modelling study findings (e.g., contradictions identified in the analysis of human practices).

The intended result of AODM is to uncover contradictions. In a next step, these contradictions serve as a starting-point to improve the system design. In order to solve the contradiction, elements of the activity system need to be adapted or changed. For instance, the division of labor is revised, new rules are introduced or tools need to be adapted. Another way of adapting the elements of an activity system is to support them with IT. Examples of IT support are the automation of routines supported by tools and providing data about the object or make the object manipulable. Linking work tasks of several people in order to create a community is another example of IT support (B. Nardi, 1996).

Applications of Activity Theory in Healthcare

Since Kaptelinin and Nardi's work "Synthesis Lectures on Human-Centered Informatics: Activity Theory in HCI: Fundamentals and Reflections" (Kaptelinin & Nardi, 2012b), activity theory analysis is widely accepted in information systems research. A plentiful amount of studies was published in the last years. Examples of these studies are "An activity-theory analysis of corporate wikis" (Hasan & Pfaff, 2012), "Using Activity Theory to Model Context Awareness" (Cassens & Kofod-Petersen, 2006), and "Demonstrations of the Activity Theory Framework for Research in IS" (Crawford & Hasan, 2006). So far, the largest field of application is education. Publications in this field are characterized by their attempt to improve education services, for example "Using activity theory and its principle of contradictions to guide research in educational technology" (Murphy & Rodriguez-manzanares, 2008).

In the context of healthcare, however, activity theory is not widely used and we identified only a couple of authors who applied the concept of activity theory. Engeström's research group (Engeström, 2000; Hasu & Engeström, 2000) belong to the first researchers that applied activity theory analysis to traditional work systems in healthcare. After the digitalization had transformed the traditional healthcare processes, Er and Kay (Er & Kay, 2005), Zao et al. (Zao et al., 2008), Bardram and Doryab (Bardram & Doryab, 2011) and (Sadeghi et al., 2014a) revisited this domain. Er and Kay (Er & Kay, 2005) studied technology issues of a mobile hospital ward system through the lens of activity theory. The authors conducted several semi-structured interviews and observed doctors while conducting their ward rounds and mapped their observations into an activity system. Activity theory was found to be a useful approach to identify additional issues. Zao et al. (Zao et al., 2008) also applied activity theory to a mobile healthcare solution. But in contrast to Er and Kay (Er & Kay, 2005) the authors used the theory to design a new application. In their article, they compared activities to features of the desired mobile solution. This approach was found to be very helpful to structure the design process of their mobile solution to support the elderly, but according to the basic idea of Engeström, activities are more than just "features". Bardram and Doryab (Bardram & Doryab, 2011) and (Sadeghi et al., 2014a) applied activity theory successfully to the newly emerging socio-technical systems and were able to provide insights for the design of work environments. While Bardram and Doryab (Bardram & Doryab, 2011) used activity theory to describe

processes of a hospital in a very detailed manner, Sadeghi et al. (Sadeghi et al., 2014a) applied the AODM to analyze the patient discharge process and identified several contradictions. Both approaches were descriptive and did not aim at deriving design recommendations based on the uncovered contradictions (Sadeghi et al., 2014a).

Riechert et al. (Riechert et al., 2016) also applied AODM to analyze the chemotherapy administration process and derived several contradictions as well as design recommendations. Building prior research and the lessons learned from the chemotherapy case, the authors modified and enhanced the initial AODM. The following section presents the derived learnings by means of a guideline to use activity theory for the analysis and design of collaborative healthcare information systems.

GUIDELINE TO USE ACTIVITY THEORY FOR COLLABORATIVE HEALTHCARE INFORMATION SYSTEM DESIGN

Based on the experiences collected during the chemotherapy case study a guideline for using activity theory analysis was developed by extending the AODM. The guideline is represented in Table 2. Literature-based recommendations are also included.

Finally, it is important to mention that both executing the chemotherapy case study and analyzing literature made obvious that the stages of the AODM cannot be applied iteratively. Insights gathered in one stage often lead to changes in another stages, mostly in the eight-step model. Therefore, the application of the proposed guideline is rather cyclic.

DISCUSSION AND CONCLUSION

The successful development of collaborative information systems in healthcare faces several challenges: The work environment in healthcare is complex and dynamic. Health professionals work with multiple technologies, paper, devices, other people, and patients. Many technologies and tools might be used at the same time. Furthermore, it still is a challenge to produce an integrated electronic record. Even though electronic records are already widely used, there are still problems such as ensuring the correct people have access to records or the information is correct and meaningful. In addition, health professionals still like to work with paper because historical information and other notes can be captured and recognized easily.

We found, that activity theory analysis is a useful lens to analyse collaborative activities in healthcare settings and to design the IT support accordingly. So far, activity theory analysis was criticized for its descriptive character without delivering predictions for future development (Nardi 1996 cited in Nathanael et al. 2002). This is true but activity theory analysis offers a high value for system analysis and offers a good starting point for system or design improvements. The chemotherapy case study proved that the uncovered contradictions of an activity system can lead to activity system recommendations by changing or adopting the activity elements.

Capturing the elements of the activity system and the sub-systems is critical for the whole analysis, influences all upcoming steps and decides on success or failure of the analysis (Greenhow & Belbas, 2007). It should be done through the lens of the overall objective of the activity system. To date, there is no clear method offered by the AODM, which helps researcher to define this scope. Existing literature

Table 2. Guideline for using activity theory analysis based on the AODM

Stage		Recommendations
Stage 0: Preparatory Stage		Collect the data that is needed for the following stages (Greenhow & Belbas, 2007) if scope requires or much data are available
Stage 1: Defining activity system – eight-step model	1.1 General	• Use information from people involved or experienced with the activity of interest rather than literature analysis because then the collected information is more significant • Consider that other people might have no knowledge about activity theory analysis • Start with capturing the subjects as this is the easiest start for someone who has little or no knowledge about activity theory analysis • Start with defining subject or outcome because these are the most obvious o Because the outcome might be defined in the strategic management or o Easier to capture in comparison to other elements of the activity system o Capturing the subjects first might be the easiest for someone who has little or no knowledge about activity theory analysis • In general, capture the more obvious elements first • Develop an activity system for each subject in order to be able to consider the different perspectives of these subjects (Greenhow & Belbas, 2007) if scope requires
	1.2 Activity of interest	• First, define the scope of the activity by selecting a specific activity or sub-activity that is further analyzed o Consider that this decision has a high influence on the complexity of the activity theory analysis o Keep in mind time, costs, and quality requirements of the project o Prefer to develop several activity systems instead of one complex one • Double check if the analyzed point of view is correct
	1.3 Object(ive)	• Differentiate between object, objective, and outcome at once • Object: material or mental and can be modified by a subject according to the activities objective (Bedny, 2014) • Objective: aim of the activity e.g. providing better healthcare. Ask "Why is the activity taking place?", is the direct target or aim of activity • Outcome: the activity's result e.g. improved health
	1.4 Subjects	• List all participants of the activity • Consider how subjects are defined in activity theory: Subjects can be individual humans, animals, teams, and organizations (Kaptelinin & Nardi, 2012b) • Capture subjects and their division of labor simultaneously in order to save time (only feasible in dialogue) • Consider that the roles of subject and object can be switched during the execution of an activity and decide for the appropriate point of view
	1.5 Tools	• For initial analysis, take all tools (electronic, paper-based, communications tools etc.) into consideration to get a rich overview • Especially for projects in information technology: all aspects of activity need to be considered e.g. not only software tools but also cognitive tools. Do not only focus on the software in order to ensure completeness. • If the scope of the activity system is adapted, it may would make sense to keep only specific tools or summarize likewise tools into groups • divide artefacts or tools into groups such as social, assignments, cognitive, and technological (Greenhow & Belbas, 2007) if scope requires
	1.6 Rules and regulations	Consider that this section can get very complex depending on the scope of activity (e.g. if code of conduct or corporate guidelines are included)
	1.7 Division of labor	• Describe responsibilities of all subjects • Capture subjects and their division of labor simultaneously in order to save time (only feasible in dialogue) • Include additional roles such as external roles if the scope requires
	1.8 Community	• Ask "Who has an influence on the object/objective/outcome?" e.g. all employees of a department in an organization because only they have access to comment ideas • If it is not clear from the beginning, take a high scope e.g. all employees and break down later
	1.9 Outcome	• Differentiate between object, objective, and outcome at once • Can be seen as overall (or strategic) goal such as increasing flexibility or reducing healthcare costs
Stage 2: Activity notation		• Consider Mwanza's three rules-of-thumb: (1) the actor is represented by the subject or community component of the activity system; (2) tools, rules, or division of labor function as mediators and (3) the activity needs to focus on an object (Daisy Mwanza, 2002) • Double check if the captured activity system is correct because there might have been confusions during the interview
Stage 3: Research questions		• First, refer all research questions to the objective of the activity in order to remain in scope • Second, add additional research questions if necessary for the specific analysis
Stage 4: Data collection and technique of mapping operational processes		• Use the research of the sub-triangles e.g. subject-tools-object to find contradictions • Use the levels of contradictions in order to capture them completely • Define the activity hierarchy in order to get a more valuable overview of the activity • Use dialogue to capture the information because this proved as most efficiently as discussions uncovered many aspects of the activity system

does not differentiate clearly between the activity system elements *object*, *objective* and *outcome*. Some even use object and objective synonymously (Greenhow & Belbas, 2007; Sadeghi, Andreev, Benyoucef, Momtahan, & Kuziemsky, 2014b). In order to find contradictions and to derive design recommendations we found, that this differentiation is very crucial. Our guideline builds on the existing AODM. We added our lessons learned while applying the AODM in terms of hints or additional questions and findings from other literature. We want to encourage researchers to take up the identified suggestions, apply and improve them in order to establish activity theory as a solid foundation for collaborative healthcare information system design.

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Chapter 38
Mathematical Programming and Heuristics for Patient Scheduling in Hospitals: A Survey

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ABSTRACT

The effective and efficient treatment of individual patients subject to scarce hospital resources is an increasingly important and challenging problem for decision makers to address. A recent study by the U.S. Bureau of Labor Statistics listed Registered Nursing among the top occupations in terms of job growth until the year 2022 (American Association of Colleges of Nursing (2015)). This growing demand can be explained in part by the large number of aging baby boomers with multi-morbid health conditions who typically require more treatments and longer length of stay in a variety of healthcare delivery settings (Vetrano et al. (2014)). Given the projected demand growth and reduced mobility of elderly patients, efficient operational research methods have to be developed and deployed for optimizing the process of scheduling the treatment of individual patients in highly resource constrained environments. We will henceforth denote this process as 'patient scheduling' and provide a problem definition and a review of current approaches in the course of this chapter.

PREVIOUS REVIEWS AND AIM OF THIS REVIEW

Over the past few decades, a significant literature has been accumulated on resource allocation problems in health care. Textbooks include, among others, Brandeau et al. (2004), Hall (2006), Hall (2011), Kaplan et al. (2015), Kolker (2012), Langabeer (2008), Ozcan (2008), Ozcan (2009), Shiver and Eitel (2010), Vissers and Beech (2005) and Yih (2011). In the review paper by Hulshof et al. (2012), the au-

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thors provide a valuable taxonomic classification of planning decisions in health care for the Operations Research and Management Science community. Focusing on hospitals, Vanberkel et al. (2010) provide a literature review on the planning of multiple hospital departments while Cardoen et al. (2010) and Guerriero and Guido (2011) offer reviews on planning the operating theater. Methodological reviews that focus on specific techniques are also available. Jun et al. (1999) provides a survey on simulation techniques applied to health care. Teixeira et al. (2015) and Cayirli and Veral (2003) focus on admission systems and admission planning. The difference between these reviews and the one we provide is twofold: From a methodological point of view, this review focuses exclusively on mathematical programming and heuristic approaches that have been successfully applied to the patient scheduling problem in hospitals. Selection criteria will be defined in order to identify journal articles which will be categorized into different health care services, resources considered, modeling and solution approaches, modeling and evaluation of uncertainty as well as patient and resource-related objectives. The second major difference as compared to previous reviews is that we provide a recent literature review that closes the gap between i) Hulshof et al. (2012)'s broad and exhaustive review on planning problems in Operations Research and the Management Science, ii) Cardoen et al. (2010)'s detailed classification of operating room (OR) planning problems, and, iii) literature that is available in the Medical Informatics/Artificial Intelligence in Medicine domain.

DEFINITION AND CHARACTERISTICS OF PATIENT SCHEDULING

A search for definitions for the term 'patient scheduling' revealed that there is lack of precision in its definition. An excellent starting point, however, is provided by Hulshof et al. (2012) who state the following: "Based on the appointment scheduling blueprint developed on the tactical level, patient scheduling comprises scheduling of an appointment in a particular time slot for a particular patient. A patient may require multiple appointments on one or more days. Therefore, we distinguish scheduling a single appointment, combination appointments and appointment series."

Below is a definition of the term 'patient scheduling', followed by some examples.

Definition 1: *Patient scheduling is the process of assigning individual patients and/or patients' activities to time and/or healthcare resources.*

- **Scheduling Individual Patients or Patients' Activities:** Individual patients can be, for example, elective patients, urgent patients, and so on. Patients' activities can be, for example, a surgery or diagnostics activity. Table 1a provides sample activities.
- **Temporal Assignment of Patients or Patients' Activities:** When assigning patients and patients' activities to time, researchers usually consider a finite planning horizon, such as one week (Conforti et al. (2011)) or one month (Gartner and Kolisch (2014)). The planning horizon can be divided into time points, for example starting time points of each hour within a day. Each patient's activity may have a time window within which it has to be scheduled. The activity's time window, which is a subset of the planning horizon, does not necessarily have to contain consecutive time points. For example, the start of a surgery for an elective patient may be scheduled between 8a.m. through 11a.m., or 1p.m. through 4p.m., but not between 11a.m. and 1p.m.

- **Assignment of Patients or Patients' Activities to Healthcare Resources:** We also include the assignment of patients' or patients' activities to healthcare resources which are typically scarce. Table 1b provides an overview of hospital resources, including their temporal availability.

The above definition of the term 'patient scheduling' can be seen both as a variant and an extension of Hulshof et al. (2012)'s, making the connection between patient and appointment. However, using the term activity rather than appointment(s) to be scheduled, where each activity is associated with individual patients, allows this definition to cover not only the assignment of patients or patients' activities to time, but also the patient-to-resource or activity-to-resource assignment, which generalizes Hulshof et al. (2012)'s temporal assignment.

The table reveals that hospital resources do not necessarily have to be available during the whole planning horizon and each resource may have a different measure of capacity, such as duration in minutes or beds for operating theaters and wards, respectively.

- **Compulsory and Optional Activities:** Sometimes, activities are compulsory for patients, while other activities may be optional. If a patient has, for example, no pre-operative treatment prior to the hospital admission, the pre-operative admission and discharge are optional. Figure 1 shows a typical patient flow for surgical patients in hospitals including this compulsory and optional phase.

As an illustrative example, the figure indicates that ambulatory patients do not necessarily have to be admitted when they are treated for surgery in an ambulatory surgical unit (ASU). However, resources

Table 1a. Activities

Activity ID	Description
1	Admission of patient 1
2	Spine CT for patient 1
3	Spinal surgery of patient 1
4	Discharge of patient 1
5	Admission of patient 2
6	Arteriography for patient 2
7	Stent implantation of patient 2
8	Discharge of patient 2

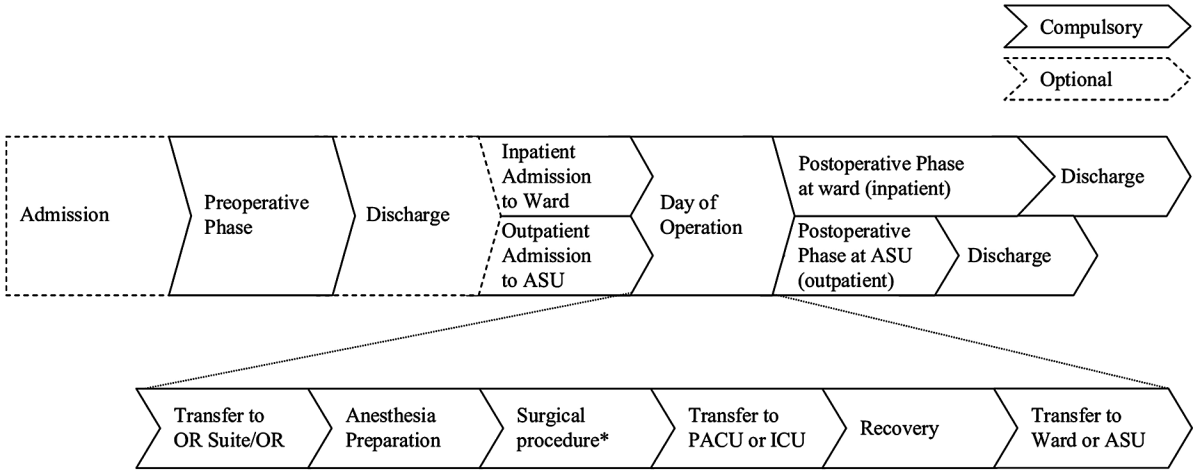
Gartner and Kolisch (2014).

Table 1b. Resources

Resource ID	Description	Capacity
1	Radiology unit	30 minutes on workdays, 0 otherwise
2	Operating theater	100 minutes on workdays, 0 otherwise
3	Surgical ward	2 beds on workdays, 1 otherwise

Gartner and Kolisch (2014).

Figure 1. Typical patient flow in hospitals
Heil (2009).

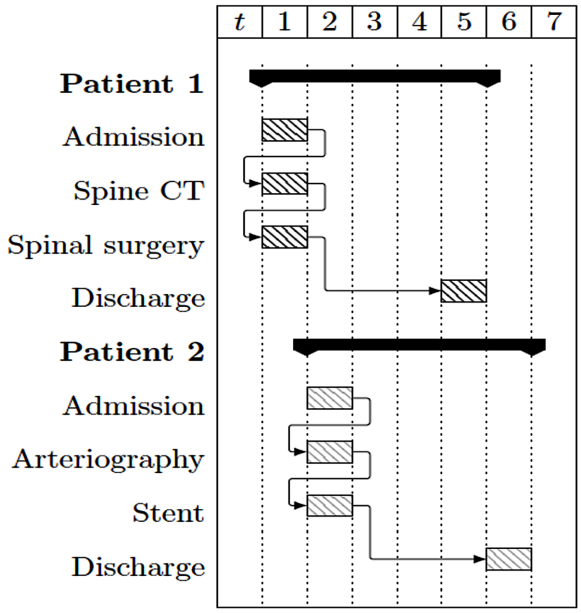


* incl. patient preparation in operating room and emergence from anesthesia

such as operating rooms (OR), post-anesthesia care unit (PACU) or intensive care unit (ICU) are compulsory. Inpatients, on the contrary, have to be admitted and stay in the hospital for at least one night and be allocated ward beds.

- **Result of Patient Scheduling:** The result of the patient scheduling process is an assignment of individual patients to time and/or resources. Figure 2 shows a sample schedule as a Gantt chart.
- **Objectives:** Patients seeking treatment in ambulatory, inpatient, surgical or residential care facilities have individual characteristics which can be distinguished on a variety of metrics. Inpatients have preferences for single, twin rooms or a ward as well as medical needs such as availability of oxygen or telemetry in a room (Demeester et al. (2009)). However, in surgical care facilities where the task of operating room planning and scheduling is crucial for an efficient process management, measures such as overutilization and overtime become predominantly important (Cardoen et al. (2010)). When focusing, however, on hospital-wide planning where inpatient and surgical care facilities' resources are required by patients, financial objectives become increasingly important (Blake and Carter (2002); Gartner (2015); Gartner et al. (in press); Schreyögg et al. (2006)).
- **Delineating Patient Scheduling from Appointment Scheduling and Other Resource Allocation Approaches:** Located on the operational offline planning level (Hans et al. (2011)), patient scheduling problems can be delineated from classical appointment scheduling (which is not the focus) in three ways: First, for patient scheduling, we can assume that arriving patient demand is given. Second, the appointments are fixed/determined on the appointment scheduling level. Finally, the resources have to be assigned to the patients. Cayirli and Veral (2003) and Gupta and Denton (2008) provide reviews of appointment scheduling research. Recent work is included in the review by Saremi et al. (2015). Hence, we exclude appointment scheduling from the current review, as well as patient-to-resource assignment problems which exclude a time slot or period assignments such as in Gartner et al. (in press), and processes such as laboratory services. Recent work in this area is covered by Azadeh et al. (2015).

Figure 2. Result of a sample patient scheduling problem
Gartner and Kolisch (2014).



STAKEHOLDERS AND OBJECTIVES

From a hospital stakeholder's or analytics researcher's perspective, (see Figure 2), this review focuses on the operational planning level (Hans et al. (2011)). On this planning level, individual patients are assigned to diverse hospital resources, so we develop and employ a classification scheme which breaks down patient scheduling problems into different categories supporting hospital stakeholders and analytics researchers to quickly obtain an overview of the increasing number of patient scheduling problems addressed in the scientific literature.

Framing this chapter into a patient flow and resource planning perspective, the aim of the literature review is threefold: First, we provide an up-to-date overview on patient scheduling problems in hospitals that captures the recent developments in an area that is rapidly evolving. Second, we structure publica-

Table 2. E-hospital framework

Stakeholder			
Decision Level	**Senior Management**	**Nursing/Operating Room Manager**	**Analytics Researchers**
Strategic	Resource planning decisions	Staffing decisions	Problem Analysis
Tactical	Identification of bottlenecks in shift or other tactical planning decisions	Shift scheduling	
Operational	Identification of which elective patients may be responsible for increasing or decreasing profit margins on a day-by-day basis	Appointment scheduling	

Gartner and Padman (2015).

tions in a way that research contributions can easily be linked to each other and compared on multiple facets such as resources required by patients. This facilitates the detection of similar problems but may use a different solution method. Third, clustering literature in a detailed manner enables the identification of issues that are currently covered/not covered sufficiently well.

SELECTION CRITERIA AND SEARCH FOR RELEVANT LITERATURE

Motivated to provide an interdisciplinary review, we searched for journal publications from the Thomson-Reuters Journal Citation Report in the subject category of Health Policy, Medical Informatics as well as Operations Research and the Management Sciences. We started the search with a structured search string to retrieve a base set of papers using the Scopus search engine until November, 2015. Based on this, we carried out a forward- and backward search as suggested by Webster and Watson (2002).

CLASSIFICATION OF LITERATURE

Employing the selection criteria, 47 papers were retrieved in total which are considered relevant for this review. The articles can be categorized according to publication year, as given in Table 3a. The table shows that this field of research is becoming increasingly popular, since the number of publications from 2008–2015 is almost 6 times higher than between 2000 and 2007. In the following subsections, a classification framework for these articles will be provided, breaking them down into health care services, resources, modeling and solution approaches, consideration of uncertainty, and objectives of each study.

Resources Considered

Table 3b provides an aggregate overview of whether the selected articles consider single or multiple resources, with the majority of papers considering multiple resources. For example, Augusto et al. (2010) consider operating room capacity as well as recovery beds and transporters.

Table 3a. Articles broken down by publication year

Interval	2000-2003	2004-2007	2008-2011	2012-2015	Total
Articles	5	2	27	13	47

Table 3b. Articles broken down by resources

Single Resources	Abdeljaouad et al. (2014), Bard et al. (2013); Braaksma et al. (2014), Ceschia and Schaerf (2011); Conforti et al. (2010, 2008); Demeester et al. (2009); Range et al. (2014); Denton et al. (2010, 2007); Griffiths et al. (2012); Lamiri et al. (2009, 2008a,b); Marcon et al. (2003); Qu et al. (2013)
Multiple Resources	Ceschia and Schaerf (in press); Gartner and Kolisch (2014); Augusto et al. (2010); Batun et al. (2011); Cardoen and Demeulemeester (2011); Cardoen et al. (2009b,a); Chaabane et al. (2008); Chow et al. (2011); Conforti et al. (2011); Denton and Gupta (2003); Fei et al. (2009a, 2008, 2010, 2009b); Guinet and Chaabane (2003); Hanne et al. (2009); Jebali et al. (2006); Marques et al. (2012); Meskens et al. (2012); Min and Yih (2010); Ogulata and Erol (2003); Ozkarahan (2000); Persson and Persson (2010); Pham and Klinkert (2008); Riise and Burke (2011); Roland et al. (2010); Schimmelpfeng et al. (2012); Shao et al. (2012); Testi and Tánfani (2009); Vijayakumar et al. (2013)

Table 4 breaks down the considered resources by care services defined in Hulshof et al. (2012).

The table reveals that articles predominantly deal with the operating room (OR) as well as its immediate upstream or downstream resources. Another observation is that the majority of the papers that consider inpatient services incorporate beds as a scarce resource. On the contrary, for ambulatory patients, beds

Table 4. Detailed overview of the resources considered

Ambulatory Care Services	
Beds	Conforti et al. (2011)
Clinical services	Bard et al. (2013); Braaksma et al. (2014); Shao et al. (2012); Conforti et al. (2011); Qu et al. (2013)
Equipment	Conforti et al. (2010, 2008)
Inpatient Care Services	
Beds	Ceschia and Schaerf (in press); Gartner and Kolisch (2014); Ceschia and Schaerf (2011); Conforti et al. (2011); Demeester et al. (2009); Range et al. (2014)
Services provided by staff	Hanne et al. (2009); Conforti et al. (2011)
Transportation resource	Hanne et al. (2009)
Surgical Care Services	
Equipment/services	Cardoen and Demeulemeester (2011); Cardoen et al. (2009b); Chaabane et al. (2008); Denton and Gupta (2003); Guinet and Chaabane (2003); Jebali et al. (2006); Meskens et al. (2012); Ozkarahan (2000)
ICU beds	Gartner and Kolisch (2014); Jebali et al. (2006); Min and Yih (2010); Ozkarahan (2000); Testi and Tánfani (2009)
OR (general)	Ceschia and Schaerf (in press); Augusto et al. (2010); Batun et al. (2011); Chaabane et al. (2008); Denton and Gupta (2003); Fei et al. (2009a, 2008, 2010, 2009b); Guinet and Chaabane (2003); Jebali et al. (2006); Marques et al. (2012); Meskens et al. (2012); Min and Yih (2010); Ogulata and Erol (2003); Persson and Persson (2010); Riise and Burke (2011); Roland et al. (2010); Testi and Tánfani (2009); Vijayakumar et al. (2013)
OR time/capacity	Abdeljaouad et al. (2014), Gartner and Kolisch (2014); Cardoen and Demeulemeester (2011); Cardoen et al. (2009b,a); Chaabane et al. (2008); Chow et al. (2011); Denton and Gupta (2003); Denton et al. (2010, 2007); Fei et al. (2009a, 2008, 2010, 2009b); Guinet and Chaabane (2003); Jebali et al. (2006); Lamiri et al. (2009, 2008a,b); Marcon et al. (2003); Marques et al. (2012); Meskens et al. (2012); Ogulata and Erol (2003); Ozkarahan (2000); Persson and Persson (2010); Riise and Burke (2011); Roland et al. (2010); Testi and Tánfani (2009); Vijayakumar et al. (2013)
Other	Pham and Klinkert (2008); Roland et al. (2010)
Recovery beds	Augusto et al. (2010); Cardoen and Demeulemeester (2011); Cardoen et al. (2009b,a); Chow et al. (2011); Fei et al. (2010); Guinet and Chaabane (2003)
Staff	
Anesthetists	Meskens et al. (2012)
Nurses	Gartner and Kolisch (2014); Meskens et al. (2012)
Surgeons	Gartner and Kolisch (2014); Batun et al. (2011); Cardoen et al. (2009b); Chaabane et al. (2008); Chow et al. (2011); Fei et al. (2009a, 2010, 2009b); Guinet and Chaabane (2003); Jebali et al. (2006); Marques et al. (2012); Ogulata and Erol (2003); Riise and Burke (2011); Roland et al. (2010); Testi and Tánfani (2009); Vijayakumar et al. (2013)
Transporters	Augusto et al. (2010)
Ward capacity	Gartner and Kolisch (2014); Chow et al. (2011); Testi and Tánfani (2009)
Residential Care Services	
Medical devices	Schimmelpfeng et al. (2012)
Therapists	Griffiths et al. (2012); Schimmelpfeng et al. (2012)
Rooms	Schimmelpfeng et al. (2012)

are considered less important which is not surprising since ambulatory patients usually leave the hospital on the day of their treatment. Moreover, when considering surgical care services, staff such as surgeons is usually considered as scarce resource while anesthetists or nurses are considered less frequently. This is surprising since, in practice, anesthetists and nurses spend more time with the patient than surgeons during surgeries. Another observation is that downstream units such as wards or ICU are considered relatively frequently in the literature. In contrast, transporters who ensure that the patient shows up at the operating room on time are covered rarely in the literature.

Modeling and Solution Approaches

In the following, we present a basic Integer Programming model for patient scheduling as formulated by Gartner and Kolisch (2014), which we modified in terms of length of stay minimization. We start with a definition of parameters and decision variables and describe the objective function and the constraints.

- **Patients, Activities and Clinical Pathways:** We consider a set of elective patients $\mathcal{P}$ who have to be treated in the hospital starting from the admission date α_p of patient $p \in \mathcal{P}$. Let $\mathcal{A}$ denote the set of all clinical activities to be performed and let ϕ_p denote a unique discharge activity of patient p. Let $\mathcal{E}$ denote the set of all minimum time lags between clinical activities. A minimum time lag $(i,j) \in \mathcal{E}$ of weight $d_{i,j}^{\min} \in \mathbb{Z}_{\geq 0}$ defines that activity j has to be scheduled at least $d_{i,j}^{\min}$ periods later than activity i; a period in this model accounts for one day. Let $\mathcal{W}_i$ denote the time window of activity i. In contrast to Gartner and Kolisch (2014), we assume that within time windows, days do not have to be consecutive. Let $\mathcal{T}$ be the set of periods (days) within the planning horizon. The last day of the planning horizon $\max \mathcal{T}$ is set to the latest period of all activities $\max \bigcup \{t \in \mathcal{W}_i \mid i \in \mathcal{A}\}$. A patient's discharge activity ϕ_p has an earliest and a latest day to be scheduled, denoted by E_{ϕ_p} and L_{ϕ_p}, respectively.
- **Hospital Resources and Capacity Demand:** Scarce hospital resources are depicted by two sets, day resources and overnight resources. The set of day resources $\mathcal{R}^d$ depicts all resources which are available during regular working days, such as computer tomography scanner (CT), magnetic resonance imaging scanner (MRI) and surgery room. Each day resource $k \in \mathcal{R}^d$ has a capacity $R_{k,t}$ in period $t \in \mathcal{T}$.

The capacity demand of activity $i \in \mathcal{A}$ on day resource $k \in \mathcal{R}^d$ is $r_{k,t}$. $R_{k,t}$ and $r_{k,t}$ are typically measured in minutes. The capacity demand $r_{k,t}$ of clinical activities ranges between several minutes and several hours, whereas the capacity of day resources is, in the case of a single shift, 8 hours. The set of overnight resources is depicted by $\mathcal{R}^n$. Overnight resources represent specialties and the capacity is measured in beds.

The number of beds available at overnight resource $k \in \mathcal{R}^n$ in period $t \in \mathcal{T}$ is $R_{k,t}$. If patient $p \in \mathcal{P}$ stays in the hospital from day t to $t+1$, he requires one bed from the overnight resource b_p in day t.

- **Decision Variables and Model Formulation:** Using the binary variables $x_{i,t} = 1$, if activity $i \in \mathcal{A}$ is scheduled at day $t \in \mathcal{W}_i$ and 0, otherwise the patient scheduling problem reads as follows:

$$\text{Minimize } z = \sum_{p \in \mathcal{P}} \sum_{t \in \mathcal{W}_{\phi_p}} t \cdot x_{\phi_p,t} \tag{1}$$

subject to

$$\sum_{t \in \mathcal{W}_j} t \cdot x_{j,t} \geq \sum_{t \in \mathcal{W}_i} t \cdot x_{i,t} + d_{i,j}^{\min} \ \forall (i,j) \in \mathcal{E} \tag{2}$$

$$\sum_{i \in \mathcal{A}: t \in \mathcal{W}_i} r_{i,k} \cdot x_{i,t} \leq R_{k,t} \ \forall k \in \mathcal{R}^d, t \in \mathcal{T} \tag{3}$$

$$\sum_{p \in \mathcal{P}: b_p = k, t \geq a_p} (1 - \sum_{\tau = E_{\phi_p}}^{\min\{t, L_{\phi_p}\}} x_{\phi_p,\tau}) \leq R_{k,t} \ \forall k \in \mathcal{R}^n, t \in \mathcal{T} \tag{4}$$

$$\sum_{t \in \mathcal{W}_i} x_{i,t} = 1 \ \forall i \in \mathcal{A} \tag{5}$$

$$x_{i,t} \in \{0,1\} \ \forall i \in \mathcal{A}, t \in \mathcal{W}_i \tag{6}$$

The objective function (1) minimizes the length of stay of all patients who have to be admitted to the hospital. Constraints (2) ensure minimum time lags between clinical activities. Note that for $d_{i,j}^{\min} = 0$ activities i and j can be performed on the same day. For example, this may be the case for two diagnostic activities. Constraints (3) depict the limited capacity of day resources. For each resource and day, the capacity demand of all activities performed on any day must not exceed resource capacity. Note that the dimension of resource capacity can be, for example, time or slots in a master surgical schedule. Constraints (4) denote the resource constraints for overnight resources. For patient p, the bed allocation starts with the fixed admission date a_p and the discharge activity ϕ_p releases the bed. Constraints (5) ensure that each activity is assigned to exactly one period of its time window. Variable definitions and their domains are provided in (6). Since this review focuses on mathematical programming, a detailed overview about the modeling and solution approaches is given in Table 5. The table reveals that mixed-integer programming (MIP) is a commonly used modeling and solution method in the field of patient scheduling. In addition, in order to incorporate uncertainty, stochastic programming is also a commonly used modeling and solution approach.

Table 5. Modeling and solution approach

Mathematical Programming	
Branch-and-bound extensions	Cardoen and Demeulemeester (2011); Ogulata and Erol (2003)
Branch-and-cut	Batun et al. (2011); Denton et al. (2010)
Branch-and-price	Cardoen and Demeulemeester (2011); Cardoen et al. (2009b); Fei et al. (2008)
Column generation (exact)	Cardoen et al. (2009b); Fei et al. (2009a, 2008, 2010); Lamiri et al. (2008a, b)
Constraint programming	Meskens et al. (2012)
Dynamic programming	Cardoen et al. (2009b); Lamiri et al. (2008b)
Goal programming	Ogulata and Erol (2003); Ozkarahan (2000)
Linear programming	Abdeljaouad et al. (2014); Conforti et al. (2010, 2011); Denton and Gupta (2003); Fei et al. (2008, 2010); Testi and Tánfani (2009)
Mixed-integer programming	Braaksma et al. (2014); Gartner and Kolisch (2014); Augusto et al. (2010); Bard et al. (2013); Batun et al. (2011); Cardoen and Demeulemeester (2011); Cardoen et al. (2009b,a); Ceschia and Schaerf (2011); Chaabane et al. (2008); Chow et al. (2011); Conforti et al. (2010, 2008, 2011); Demeester et al. (2009); Range et al. (2014); Denton and Gupta (2003); Denton et al. (2010); Fei et al. (2009a, 2008, 2010, 2009b); Griffiths et al. (2012); Guinet and Chaabane (2003); Hanne et al. (2009); Jebali et al. (2006); Marcon et al. (2003); Marques et al. (2012); Meskens et al. (2012); Persson and Persson (2010); Pham and Klinkert (2008); Riise and Burke (2011); Roland et al. (2010); Schimmelpfeng et al. (2012); Shao et al. (2012); Testi and Tánfani (2009); Vijayakumar et al. (2013)
Stochastic programming	Batun et al. (2011); Denton and Gupta (2003); Denton et al. (2010, 2007); Lamiri et al. (2009, 2008a, b); Min and Yih (2010); Qu et al. (2013)
L-shaped method	Batun et al. (2011); Denton and Gupta (2003); Denton et al. (2010, 2007)
Sampling methods	Qu et al. (2013); Min and Yih (2010); Lamiri et al. (2009, 2008a,b)
Heuristics	
2-exchange	Riise and Burke (2011)
Column-generation (heuristic)	Range et al. (2014)
First fit decreasing-based	Vijayakumar et al. (2013)
Hungarian method based	Guinet and Chaabane (2003)
Lagrangian relaxation based	Augusto et al. (2010)
Local search	
Tabu search	Ceschia and Schaerf (2011); Griffiths et al. (2012); Lamiri et al. (2009); Demeester et al. (2009)
Simulated annealing	Ceschia and Schaerf (in press, 2011); Griffiths et al. (2012)
Genetic algorithm	Fei et al. (2010); Qu et al. (2013); Roland et al. (2010)
Steepest descent	Griffiths et al. (2012); Demeester et al. (2009)
Other	Hanne et al. (2009); Lamiri et al. (2009); Shao et al. (2012)
MIP based	Bard et al. (2013); Cardoen et al. (2009a); Conforti et al. (2010); Range et al. (2014)
Other	Abdeljaouad et al. (2014); Fei et al. (2009b)

Modeling and Evaluation of Uncertainty

A challenging task in patient scheduling is the incorporation of uncertainty into the planning process. Uncertainty arises for many reasons, and examples include uncertain patient arrivals and activity durations. Table 6 provides a classification of whether or not articles incorporate uncertainty in the planning problem. Moreover, when uncertainty is incorporated, the articles can be divided into categories based

Table 6. Modeling of uncertainty

Deterministic	
Deterministic	Abdeljaouad et al. (2014); Augusto et al. (2010); Bard et al. (2013); Braaksma et al. (2014); Cardoen and Demeulemeester (2011); Cardoen et al. (2009b,a); Ceschia and Schaerf (2011); Chaabane et al. (2008); Conforti et al. (2010, 2008, 2011); Demeester et al. (2009); Range et al. (2014); Fei et al. (2009a, 2008, 2010, 2009b); Guinet and Chaabane (2003); Hanne et al. (2009); Jebali et al. (2006); Marques et al. (2012); Meskens et al. (2012); Ozkarahan (2000); Pham and Klinkert (2008); Riise and Burke (2011); Roland et al. (2010); Schimmelpfeng et al. (2012); Shao et al. (2012); Testi and Tánfani (2009); Vijayakumar et al. (2013)
Uncertainty Incorporated into the Model	
Activity durations	Batun et al. (2011); Denton and Gupta (2003); Denton et al. (2010, 2007); Min and Yih (2010); Qu et al. (2013)
Capacity requirement	Lamiri et al. (2009, 2008a,b); Min and Yih (2010); Qu et al. (2013)
Resource availability	Min and Yih (2010)
Uncertainty Evaluated in the Computational Study	
Activity/recovery durations	Ceschia and Schaerf (in press); Gartner and Kolisch (2014); Marcon et al. (2003); Ogulata and Erol (2003); Persson and Persson (2010)
Arrivals	Persson and Persson (2010)
Capacity requirement	Chow et al. (2011)
Overtime costs	Min and Yih (2010)
Priority values	Ogulata and Erol (2003)
Remaining capacity	Gartner and Kolisch (2014)

on whether uncertainty is incorporated into the model (e.g. in terms of scenarios or chance constraints) or whether uncertainty is evaluated in the computational study (e.g. using a simulation). Moreover, each category can be subdivided into which type of uncertainty is considered. The table reveals that most articles focus on the deterministic formulation and solution of the problem. However, when uncertainty is considered, activity durations and capacity requirements are the most frequently studied types of uncertainty.

Patient and Resource Related Objectives

Finally, the selected articles can be broken down by patient and resource related objectives. A patient related objective is, for example, that patients should be assigned to a preferred resource such as therapist and ward. A resource related objective is, among others, that utilization has to be maximized. Table 7 provides an overview about the patient and resource related objectives and the categorization of the papers. The table reveals that the most popular patient related objective is the minimization of patient waiting time. Among the resource related objectives, overtime minimization is one objective that is most frequently considered. Overtime is usually weighted with costs, e.g., for staff. The table also reveals that contribution margin has not yet been considered as an objective in the context of patient scheduling.

CONCLUSION

In this chapter, we reviewed manuscripts that focus on the application of mathematical programming and heuristics for patient scheduling. We developed a categorization scheme in order to classify contribu-

Table 7. Patient and resource related objectives

Patient Related	
Minimize	
Penalties	Braaksma et al. (2014); Ceschia and Schaerf (in press); Cardoen and Demeulemeester (2011); Cardoen et al. (2009b, a); Ceschia and Schaerf (2011); Demeester et al. (2009); Range et al. (2014)
Waiting time of (prioritized) patients	Cardoen and Demeulemeester (2011); Cardoen et al. (2009b, a); Chaabane et al. (2008); Hanne et al. (2009); Jebali et al. (2006); Lamiri et al. (2009, 2008a,b); Min and Yih (2010); Ogulata and Erol (2003); Qu et al. (2013); Riise and Burke (2011)
Welfare loss	Testi and Tánfani (2009)
Maximize	
Patients to be scheduled	Conforti et al. (2010, 2008, 2011); Schimmelpfeng et al. (2012)
Patient satisfaction	Hanne et al. (2009)
Resource Related	
Minimize	
Breaks	Braaksma et al. (2014);
Completion time	Abdeljaouad et al. (2014), Augusto et al. (2010); Fei et al. (2009b); Guinet and Chaabane (2003); Meskens et al. (2012); Pham and Klinkert (2008)
Costs	Bard et al. (2013); Batun et al. (2011); Denton and Gupta (2003); Denton et al. (2010, 2007); Fei et al. (2009a, 2008, 2010, 2009b); Jebali et al. (2006); Lamiri et al. (2009, 2008a, b); Min and Yih (2010); Qu et al. (2013); Roland et al. (2010); Shao et al. (2012)
Gap between demand & supply	Chaabane et al. (2008)
Maximum workload	Cardoen and Demeulemeester (2011); Cardoen et al. (2009b, a); Chow et al. (2011)
Overtime, overutilization	Cardoen and Demeulemeester (2011); Cardoen et al. (2009b, a); Chaabane et al. (2008); Fei et al. (2010, 2009b); Jebali et al. (2006); Lamiri et al. (2009, 2008a,b); Meskens et al. (2012); Min and Yih (2010); Ogulata and Erol (2003); Ozkarahan (2000); Qu et al. (2013); Riise and Burke (2011); Roland et al. (2010); Shao et al. (2012)
Penalties	Ceschia and Schaerf (in press, 2011); Demeester et al. (2009); Range et al. (2014)
Risk of no realization	Marcon et al. (2003)
Total traveling distance/time	Bard et al. (2013); Hanne et al. (2009); Shao et al. (2012)
Underutilization	Hanne et al. (2009); Qu et al. (2013)
Welfare loss	Testi and Tánfani (2009)
Maximize	
Contribution margin	Gartner and Kolisch (2014)
Preference satisfaction(s)	Ozkarahan (2000)
Staff collaboration	Meskens et al. (2012)
Utilization	Fei et al. (2010, 2009b); Marques et al. (2012); Ogulata and Erol (2003); Ozkarahan (2000); Persson and Persson (2010); Vijayakumar et al. (2013)

tions at the interface between Health Policy, Medical Informatics as well as Operations Research and the Management Sciences. Within each category, we highlighted significant trends. The result of this review is twofold: Firstly, for researchers who collaborate closely with practitioners in hospitals, the healthcare provider's problem description about his patient scheduling problem can be matched easily with the articles identified and discussed in this review. Secondly, to enhance their study trajectory, researchers

have an overview of which problems have been solved in which category and where potential research could be carried out to fill gaps, such as between solving problems heuristically and to optimality. Future work will extend this literature review towards appointment scheduling and supporting processes associated with laboratory and other ancillary services as well as the new initiatives in digital health services.

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KEY TERMS AND DEFINITIONS

Ambulatory Care Services: Provide medical interventions without overnight stay, that is, the patient arrives at the facility and leaves the facility on the same day (Hulshof et al. (2012)).

Clinical Pathway: A standardized, actionable plan, based on best practice recommendations for a health care process (Gartner and Kolisch (2014), Zhang and Padman (2015)).

Day Resources: Resources that are allocated during a day, for example, operating rooms.

Heuristics: Methods which lead to a good (but not necessarily optimal) solution. They are used to solve a problem by trial and error when an algorithmic approach is impractical (Winston (2004)).

Inpatient Care: Refers to care for a patient who is formally admitted (or 'hospitalized') for treatment and/or care and stays for a minimum of one night in the hospital (Hulshof et al. (2012)).

Mathematical Model: In Operations Research, a mathematical model involves a set of mathematical relationships (such as equations, inequalities and logical dependencies) that correspond to some more down to earth relationships in real world (Williams (2013)).

Operations Research: A scientific approach to decision making that seeks to best design and operate a system, usually under conditions requiring the allocation of scarce resources (Winston (2004)).

Overnight Resources: Resources that are allocated overnight and between two consecutive days, for example, beds.

Patient Scheduling: The process of assigning individual patients and/or patients' activities to time and/or healthcare resources.

Residential Care Services: provide supervision and assistance in activities of daily living with medical and nursing services when required. Examples are nursing homes, psychiatric hospitals, rehabilitation clinics with overnight stay, homes for the aged, and hospices (Hulshof et al. (2012)).

Surgical Care Services: Provide operative procedures (surgeries) for the correction of deformities and defects, repair of injuries, and diagnosis and cure of certain diseases. Examples of surgical care facilities are the hospital's operating theater, surgical daycare centers and anesthesia facilities (Hulshof et al. (2012)).

Chapter 39
Building an Ontological Framework for Healthcare:
The Case of the Health Cluster

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ABSTRACT

Health is a multidisciplinary domain which necessitates experts from diverse backgrounds coming together to effect optimal care delivery for patients. Such a context can benefit by being framed as a knowledge cluster. To illustrate, the case study of a health cluster research group is mapped in terms of ontology. In this way, key relationships and informational exchanges are captured and this in turn can enable more prudent use of critical knowledge assets within the cluster. This ontology is then proffered for the healthcare domain in general as the following discusses.

HEALTH CLUSTER APPROACH

The Health Cluster is a community of practice, comprising a diverse group of researchers in an Australian University. Defined by Wenger (2011), 'Communities of practice are groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly'. As a community of practice, the Health Cluster drew researchers from a range of fields including acute care, sociology and business information technology. When such a group forms, there are inevitable differences in ontological traditions. The focus of the group was developing and delivering a research strategy broadly described as the "Business of Health". The Health Cluster focused on a diversity of

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work, including health informatics, mobile solutions for chronic disease management, and social/behavioural factors with STI vaccines, especially in Indigenous and culturally and linguistically diverse (CALD) communities.

The Health Cluster as a community of practice included researchers with backgrounds from business information technology (IT), knowledge management (KM), and enterprise integration (EI). Some researchers were from a background in social research, others were involved in electronic document and records management solutions, sometimes with a focus on technology platforms. The challenge therefore, was to develop an overarching research position and framework that was embracing and accommodating, as well as extensible.

Within a community of practice, knowledge is developed. We posit that in the synthesis of knowledge and research themes as community of practice, there is development of explicit knowledge from the tacit. As a community of practice, knowledge is discovered through co-participation and codified in some form. The challenge then becomes one of knowledge from one community of practice to another, the purpose being the articulation and dissemination of new knowledge. Often, the problem of a multidisciplinary community of practice is the approach of research from different ontological traditions and perspectives. Further, the term "ontology" has taken upon different meanings in computer sciences as opposed to its use in sociology. As a community of practice, rather than defend particular ontological perspectives, our approach taken was embracing different research paradigms and to find a means to accommodate the growth of knowledge. The purpose of this paper is to present and discuss the emergence of a Health Cluster research framework, which was developed through a multi-disciplinary approach.

BACKGROUND AND LITERATURE

We situated this work in the literature of social learning, communities of practice and knowledge management within organizational learning. The social learning aspect of learning was discussed by (Wenger, 1998, 2011), and Lave and Wenger (1991), who describes learning as situations of co-participation.

Communities of practice are said to be different from teams as they are voluntary and are said to remain as long as they have value to their members (Burk, 2000). Burk (1999) further argued that knowledge management is a crucial aspect of communities of practice where communities of practice were part of a knowledge generating cycle.

Ah-Lian and Graham (2012) also discussed communities as practice, describing their shared trusts, beliefs, learned lessons, insights, narratives, anecdotes, and how they provide mechanisms for individual knowledge creation, information coding, and information sharing. In this respect, knowledge creation and organisational epistemology are viewed as social processes, where knowledge comprises experiences of people and is constructed within different contexts and with personal interpretation and reflection (Polanyi, 1962; Von Krogh, Ichijo, & Nonaka, 2000).

In our narrative, we also situated our literature base in the field of organisational learning. Organisational learning has been conceptualised in terms of three levels, namely single-loop, double-loop and triple-loop learning. Visser (2003) wrote that the original meanings of deutero-learning (the behavioral adaptation to patterns of conditioning in relationships in organizational contexts) have been reinterpreted and diverse (Tosey, Visser, and Saunders (2011); Visser (2003), 2007)), noted the lack of consensus on concepts and meanings of 'behaviour learning', particularly the tendency to conceptualise triple-loop learning in similar terms as deutero-learning. Visser (2007) distinguished deutero-learning as indi-

vidual and context based and separated deutero-learning from 'meta-learning' and planned learning. Deutero-learning, according to Visser (2007) does not seem always amendable to managerial steering and organizing.

Contributing to this debate, Rowe and Boyce (2009) emphasised the importance of the evolution of appropriate organizational structures in developing a leadership-driven learning process and creating an environment in which learning can occur, as opposed to reinforcing existing learning pathologies. Georges L. Romme and Van Witteloostuijn (1999) describe triple-loop learning as a higher order learning process or methodologies giving members of an organization the ability to re-frame and 'see things in totally new ways'. By examining the creation, codification and transmission of knowledge as a social learning process, we advance the work of Nonaka, Takeuchi, and Umemoto (1996) who coined the term "Ba" in describing the knowledge creation cycle as process centric and episodic.

THE HEALTH CLUSTER AS A COMMUNITY OF PRACTICE

We identified the Health Cluster as a community of practice, as it included researchers with backgrounds from diverse backgrounds and research traditions as previously described. The Health Cluster experienced a number of challenges when exploring the use of knowledge management for the Health Cluster. Firstly, Knowledge Management (KM) is often seen as technologically and process driven. Secondly, the were terminology differences in the use of "ontology" which represents the assumptions we make about knowledge or truth, or "ontology" as a model or knowledge base in the field of knowledge management. We were therefore aware of the importance of choosing a research framework which accommodated both senses of "ontology" in the research cluster.

The fields of qualitative research and KM are often viewed as separate disciplines with different ontological roots. KM is traditionally information technology in origin, still related to the computer-based system definition of Alavi and Leidner (2001). Information Technology (IT) based KM systems have been used since the early 1980s (Kamara, Anumba, & Carrillo, 2002). Avgerou (2000) noted that the computer sciences and information systems research traditionally adopted a positivist epistemology, but interpretivist approaches have gradually become more accepted.

Earlier, we also mentioned the extension of the work of (Nonaka et al., 1996), who popularised the knowledge creation cycle "Ba" in the field of KM. Here, by recognising the knowledge creation cycle as a social process, members of the Health Cluster were aware of the methodological approaches in multi-disciplinary research. Therefore, qualitative research provides the tools, methods and approaches to study and in some way capture this phenomenon (Creswell, 2012). Ontology and epistemology relate to assumptions about truth and how knowledge may be accessed, captured, codified and re-used (Lejeune, 2011; Nonaka, 1994; Schwartz, 2006), therefore highlighting the dependent relationships between KM and qualitative research. In some respects, we recognised that the cycle of "Ba" and thematic-analysis, were inextricably linked in how knowledge emerges out of unstructured data and when knowledge is tacitly held. At a meta-theoretical level, we were therefore aware of the different ontological and epistemological assumptions that underpinned knowledge creation and codification. In this respect, members of the Health Cluster, as a community of practice, were fulfilling conditions for triple-loop learning. Members were also aware of 'ontology' as a meta-theoretical concept, and 'ontology' as KM technology and schema.

DEVELOPING A KNOWLEDGE CAPTURE FRAMEWORK

In relation to this, the capture of knowledge, organisation of knowledge and dissemination was therefore considered from a number of perspectives within a knowledge capture framework. The framework included how knowledge was codified and organised. We first examine the nature of knowledge within a community of practice. Knowledge is highly individualised and has been described as socially constructed (Berger & Luckmann, 1991). Knowledge comprises experiences of people and is constructed within different contexts and with personal interpretation and reflection (Polanyi, 1962). (McDermott (1999); Meyer and Rowan (1977)) argue that knowledge is illusive and cannot be delivered solely by information technology. Knowledge is scattered, and often unstructured, with tacit knowledge existing within peoples' heads or it may be augmented or shared via interpersonal interaction and social relationships (Nwilo & Osanwuta, 2003). Knowledge is recognised as a corporate asset and the same care should be paid to getting value as is paid to more tangible assets (Alavi & Leidner, 2001; Bartholomew, 2009; Davenport & Prusak, 1998).

KNOWLEDGE CODIFICATION IN COMMUNITIES OF PRACTICE

The approach driving the Cluster was based around an awareness that knowledge cannot easily be stored and its successful management depends on KM strategy, a point made by Gopal and Gagnon (1995). In developing a philosophy for capturing the Cluster's knowledge, we were aware of the limitations of taking a process centric approach. Duguid (2005) introduced the 'knowledge paradox' which arises, because the dimensions of knowledge were often confused when it was assumed that tacit knowledge can be represented as process models. We looked towards the field of qualitative research and how knowledge or themes emerged out of unstructured data, through the process of coding. We were aware of how the Health Cluster was involved in a learning process where there was the tacit and socially constructed form of knowledge, a crucial part of community of practice. Of what he called the 'knowledge paradox', Duguid (2005) stated *Nowhere, perhaps, is this more evident than in the endless problems of "best practice" diffusion. On the one hand, theorists of "best practice" put their finger on the essential point: Practice is critical. On the other, they regularly attempt to move a best practice from one community to another by codifying and circulating the explicit knowledge. What, of course, is truly critical is the knowing how embedded in the practice and wrapped around with ethical and epistemic commitments*. The influence of Dugid's work on the Health Cluster emphasised two factors; firstly, there was the emphasis on how the group functioned as a community of practice and secondly, the codification of knowledge for the purpose of circulation or dissemination. As a community of practice, members of the Health Cluster were also aware of the learning processes, as a form of social learning. In relation to this, Duguid (2005) stated that *Codification is remarkably powerful, but its power is only released through the corresponding knowing how, which explains how we get to know and learn to do*. We now present our examination of how knowledge was to be captured as taxonomy, folksonomies, or ontology.

TAXONOMIES, FOLKSONOMIES, OR ONTOLOGY?

Taxonomies, as Lambe (2014) described, are a structured set of names and descriptions used to organise, or 'render' information in a usable and consistent way at the point of need. Taxonomies are developed by teams equipped with the necessary knowledge and skills, used to represent knowledge within a particular subject area and are classified as one of the formal sense-making tools, purpose-built to cover all possibilities within a specific subject area (Ashdown, Douglas-Savage, Harte, & Low, 2012). Taxonomies are the mapping and categorisation of tacit knowledge embedded in staff expertise (Pellini & Jones, 2011). As a departure from how taxonomies were developed for the field of biology, Pellini and Jones (2011) stated that organisational taxonomies are now developed through mapping of working processes, i.e. a taxonomy is a deliverable, generated out of analysis of IT systems, analysis of key terminology, consolidation of vocabularies. If viewed as a consequence of development activities, Whittaker and Breininger (2008) define taxonomy as a controlled vocabulary, in which each term usually has hierarchical relationships, which means that a taxonomy imposes a topical structure on information. It uses a logical arrangement and does not usually account for users' specific decision-making and action-taking needs.

With the advent of social media, a term has emerged, which is different to taxonomies, to indicate an organisation of knowledge, or datasets that are more fluid or elastic in nature. We use the term 'elasticity' to indicate how each user created dataset or folksonomy represents the emergent semantics of the community of a particular topic area. Whereas taxonomies imply the degree of formality, or a controlled vocabulary to aid sense making, as explained by Whittaker and Breininger (2008), folksonomies are labelling systems which result from collaborative tagging (Wu, Zubair, & Maly, 2006). Van Damme, Hepp, and Siorpaes (2007) described the tagging process, where individual actors (people) express and reflect their subjective level of knowledge on and their interest in the respective object, using their own, freely chosen vocabulary, usually in order to facilitate a later retrieval process. As a reflection of the emerging community semantics, Jäschke, Marinho, Hotho, Schmidt-Thieme, and Stumme (2007) described the process whereby keywords or tags are used for navigation or finding resources as 'serendipitous browsing'.

The concept of "ontology", when related to the computer or information science, refers to the semantics that give meaning to a set of vocabulary, including rules that govern data exchange, with respect to a particular domain. An early example of ontology in this sense may be found in Neches et al. (1991) and Musen (1998). Examples of ontologies may be found in manufacturing and health.

In terms of automation, "ontology" tends to be based upon organisational functionality, in the form of service or process models and (event based) execution (Bußler, 1996; Davenport & Short, 2003; Musen, 1998; Neches et al., 1991; Scheer & Nüttgens, 2000). Organisational ontology is both complex and extensive, but ontologies developed in the fields of enterprise modelling tend to view business operations from a perspective of functionality and information integration (Davenport & Short, 2003). Business functionality has also been described in terms of contracted services between an organisation and its employees or customers (Wegmann, Regev, Garret, & Maréchal, 2008; Weske, 2012).

Enterprise Integration results in a focus on business where ontology comprises processes and information schemas. The epistemology is based on using modelling languages that record as many facts as possible from data models, function trees and organization views. Therefore, process and information models form the constructs of many enterprise modeling architectures (Vernadat, 2002).

In the medical field, substantial growth in the development of commercial clinical information systems has resulted in multiple vocabularies and many information sources, which are fundamental barriers to the application of information technology to medicine (Humphreys, Lindberg, Schoolman, &

Barnett, 1998). It was proposed that a solution to this medical information problem was the development of conceptual links among disparate classification schemes as the Unified Medical Language System (Humphreys et al., 1998).

IMPLICATIONS FOR A COMMUNITY OF PRACTICE

The development of taxonomies was partially influenced as a formal classification system. Knowledge taxonomies provide a hierarchical structure, indicating abstracted or parent-child relationships in organising concepts. Taxonomies, through their parent-child or abstraction provide some self-documenting ability where concepts are related through inheritance or relationships, in much the same way class structures are developed in modelling languages such as the Unified Modelling Language (UML).

There are implications, where there may be conceptual or thematic issues, unless concepts are developed with rigour, in the sense of reaching documented agreement within the team. This leads to the subjectivity of interpretation that is introduced when individual actors (people) express or reflect their different understandings of concepts even within a particular domain. The example illustrated Figure 1 is one where two concepts, "Logistics" and "Supply Chain" may be described, as a parent-child relationship through two abstractions. In this example, there are accounts where supply chain strategy is an abstract concept of logistics management and vice versa. There may be similarly other, sometimes intractable differences in interpretations, in the development of knowledge taxonomies. The example in Figure 1 illustrates perhaps why knowledge taxonomies, through their formal development, become inflexible or located within in a community of practice, where knowledge has been created through social interactions, internalised by individuals, becomes shared and utilized.

Tensions become created between the technical and logical views, and how users "interact" with knowledge. Oftentimes, tensions occur between the formal and informal structures of knowledge (taxonomy, ontology and folksonomies) and this is presented in Figure 2. Furthermore, the knowledge creation cycle "Ba" described by Nonaka et al. (1996) is often not captured as knowledge, caused when creators of knowledge based systems omit ontological assumptions. This omission of knowledge assumptions, as philosophy knowledge, often results in systems methodologies and invariably KM, being labelled as "modernist" and design as positivist epistemology. Again, this points out the tensions that occur in differences in jargon, where researchers in the Health Cluster were aware of 'ontology' as a meta-theoretical concept, and 'ontology' as KM technology and schema.

Figure 1. Difference in abstraction in an inheritance class structure

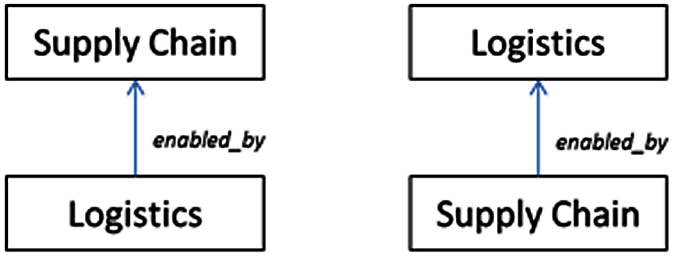
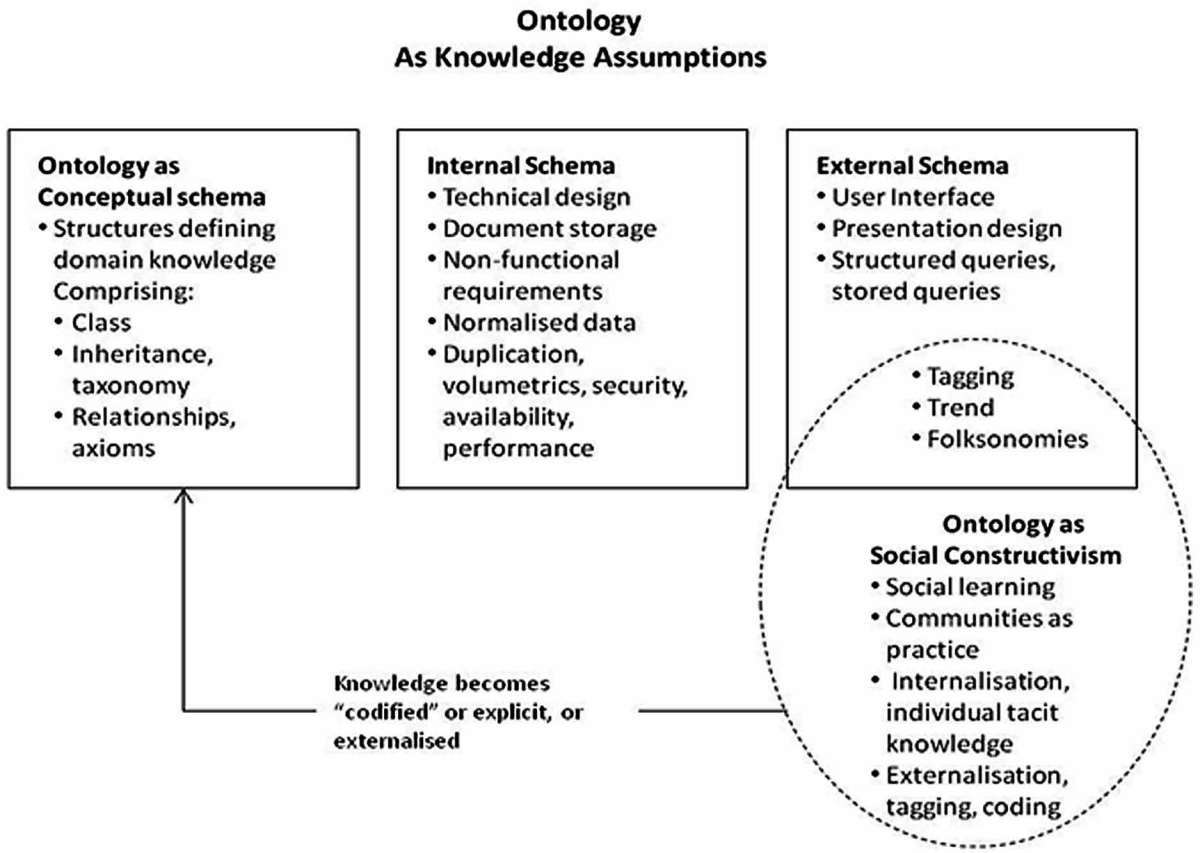


Figure 2. Tensions between technical, logical, and user-oriented domains



There is an historical aspect of this practice, where the development of knowledge taxonomies may have its heritage in data modelling and rules of data normalisation and more recently, on the formal languages of the Web Ontology Language (OWL). These tensions are not new and we depict this "contemporary" problem of knowledge management against the three schema architecture proposed originally in 1978, developed as the ANSI/X3 SPARC DBMS architecture (Tsichritzis & Klug, 1978).

With reference to Figure 2, agreed structures of knowledge, called "conceptual schemas" used as early as 1981 to describe the data structures of knowledge based systems (Sowa, 1980). Conceptual schemas are meta-models, describing structures of knowledge as ontology, taxonomy, or class diagrams. Where many organisations still retain the use of conceptual schemas as Entity Relationship Attribute (ERA) models or UML class diagrams.

In turn, the conceptual schema became the driver for the internal schema, where for example, the process of data normalisation was carried out to maintain logical constraints. The three schema architecture also illustrates how with its origins in technical design, knowledge structures are still influenced by technical design methods. Figure 2 depicts the technical constraints as "Internal schema", which identifies how data is stored, definitions of the stored records, the methods of representation, the data fields, and indexes. At the technical level, or as internal schema, data normalisation ensures that semantic consistency is maintained; there are technical requirements such as achieving storage efficiency, and the

consistency of relational data (elimination of data redundancies, maintaining data integrity by avoiding insertion and deletion anomalies).

By virtue of their development and technological considerations, taxonomies therefore tend to be treated as immutable (Whittaker & Breininger, 2008), by contrast to the more subjective structures created through collaborative tagging (Wu et al., 2006). Examples of "enterprise" taxonomies may be found in the works ofWhitman, Ramachandran, and Ketkar (2001), where the development of the enterprise knowledge taxonomy is controlled and where the process may be governed through change control procedures. Tensions therefore occur, where systems have to cope with both formal, immutable taxonomies and the parallel existence of informal and subjectively interpreted folksonomies created through social interactions.

The introduction of social learning and the ideas of community as practice, provides an extension to the three schema architecture. When depicted traditionally as the external schema, or the "presentation layer", the three schema architecture tends to exclude the considerations of ongoing knowledge creation as a social process. The ongoing knowledge creation has been discussed extensively by the works of Nonaka (1994). We build around the external schema and link this to communities as practice and social learning. By linking the social process and digital system through the external schema, we define how users interact with the digital environment. The process by which knowledge is codified informally, described previously as "tagging" or the creation of folksonomies, becomes described by the external schema, when systems provide the ability for users to "tag" information contained in various forms.

Tagging may provide a user interpreted account of knowledge, and where tacit knowledge is personal, context-specific, and therefore hard to formalize and communicate. In a collaborative environment, or in the context of social learning, tagging may assist in making knowledge 'visible', as explicit or codified knowledge. The codified knowledge refers to knowledge that is transmittable in formal, systematic language (Nonaka et al., 1996). However, as indicated in Figure 2, when rooted as social constructivist ontology, which is subjectivist in epistemology, the creation of folksonomies as information and unstructured tags, may provide or facilitate the creation of knowledge (internalisation and externalisation), but the consequent folksonomy may not result in changes to organisational knowledge taxonomies.

KNOWLEDGE CONCEPTS FOR THE HEALTH CLUSTER

At a macro level we proffer the following as a suitable ontology for the Health Cluster albeit recognizing the challenge posited by Kuziemsky and Lau (2010) of accurate representation. As can be seen in Figure 3 this takes into account the essential domains within healthcare operations as well as identifying relevant ontological and epistemological components. It is our belief that such a conceptualisation will enable the full potential of the cluster to be leveraged and realised.

DISCUSSIONS

We illustrate the following: Ontology of Community of Healthcare Practice Knowledge Management. The ontology of Community of Healthcare Practice Knowledge Management is shown in Figure 4. In the following we discuss the construction of the ontology and illustrate its application.

Figure 3. Ontology for the health cluster

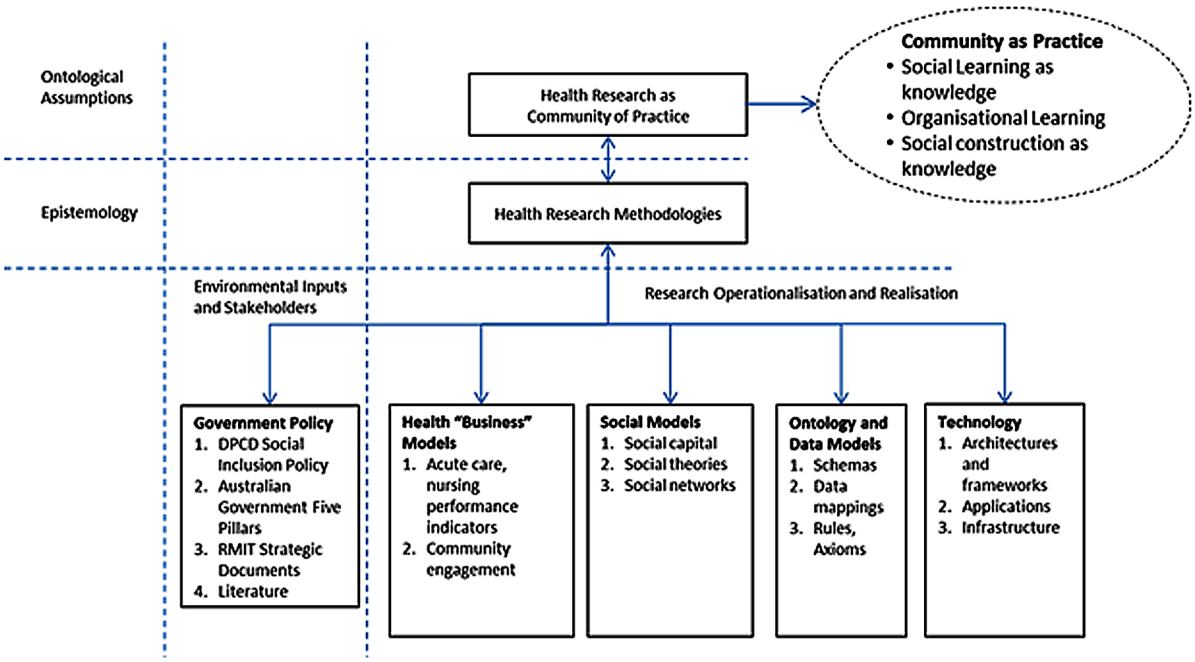


Figure 4. Ontology of community of healthcare practice knowledge management

Knowledge Management					Community of Healthcare Practice				
Process		**Type**		**Entity**	**Community**		**Outcomes**		**Healthcare**
Generation	[of]	Explicit	[+]	Individual	Providers	[for]	Efficacy	[of]	Urgent
Single-loop		Tacit		Provider	Physicians		Effectiveness		Ambulatory
Double-loop				Recipient	Nurses		Efficiency		Surgical
Triple-loop				Care Taker	Surgeons				Acute
Articulation				Organization	Pharmacists				Chronic
Codification				Hospital	Recipients				Palliative
Taxonomic				Insurer	Psychologists				
Folksonomic				Gov. Agency	Sociologists				
Ontologic				Social	I Technologists				
Assimilation				Community	Educators				
Synthesis				Patient Group	Administrators				
Dissemination									
Application									

[knowledge by] [care practice]

The domain is on how a community constituted of healthcare practitioners can manage its knowledge to improve the outcomes of their practice. We can deconstruct the domain into two major dimensions:

1. Community of Healthcare Practice, and
2. Knowledge Management.

The first dimension is represented by the right half of the ontology and the second by the left half. (Note: Terms in the ontology are capitalized in the text.)

The Community of Healthcare Practice is further deconstructed into three component dimensions. They are:

1. Community,
2. Outcomes, and
3. Healthcare.

Each dimension is articulated by taxonomy of constituted elements. The Community dimension includes the categories of participants who may be part of it. It includes the Providers of healthcare, Pharmacists, Recipients, Psychologies, Sociologists, Information Technologies, Educators, and Administrators. The Providers, at the second level, include Physicians, Nurses, and Surgeons. The taxonomy can be extended by adding more elements, reduced by deleting elements, refined by adding sub-categories and sub-sub-categories of elements, and coarsened by combining elements. Thus the connotation of the Community in a particular context can be adapted as necessary. The elements of the Community are not presented in any particular order – they are nominal.

The Outcomes dimension of the Community of Healthcare Practice articulates the intents of care. They are:

1. Efficacy,
2. Effectiveness, and
3. Efficiency of care.

Care is efficacious when it can attain the desired results in a controlled setting. It is effective when it can do so in a normal setting. And, it is efficient when it can do so with minimum expenditure of resources. A non-efficacious care cannot be effective, and non-effective care cannot be efficient. Thus, the three categories are in ordinal order – Efficacy preceded Effectiveness, and Effectiveness precedes Efficiency. The categories of Outcomes can also be extended, reduced, refined, and coarsened.

The taxonomy of Healthcare includes the common types of practice. They are:

1. Urgent,
2. Ambulatory,
3. Surgical,
4. Acute,
5. Chronic,
6. Palliative,

This taxonomy too can be adapted as described earlier.

Thus, the right half of the ontology articulates the components of Community of Healthcare Practice. Each concatenation of an element from the three columns in conjunction with the adjacent word/phrase is a component of the community. Thus it includes:

1. Providers Physicians for efficacy of urgent care practice,
2. Pharmacists for effectiveness of chronic care practice,
3. Administrators for efficiency of acute care practice, and
4. 177 other components (10*3*6 -3).

Not all the 180 components may be relevant in a particular context; some may be very important, some slightly important, and some not at all important. Further, new elements at different levels of granularity may emerge if the dimensions are extended, reduced, refined, or coarsened.

The Knowledge Management dimension is further deconstructed into three component dimensions:

1. Process,
2. Type, and
3. Entity.

The Process (of knowledge management) is articulated by a two-level taxonomy. At the first level it includes:

1. Generation,
2. Articulation,
3. Codification,
4. Assimilation,
5. Synthesis,
6. Dissemination, and
7. Application of knowledge.

They are generally in the order in which they occur, although the adherence may not be strict. Further, the Process elements are likely to be iterative in the process of creation-translation of knowledge. Some of the elements are refined at the second level of the taxonomy. Generation may be

1. Single-loop,
2. Double-loop, and
3. Triple-loop.

They are generally sequential. Similarly, Codification may be:

1. Taxonomic,
2. Folksonomic, and
3. Ontologic.

They are also generally sequential.

Two type of knowledge are included in the Type dimension:

1. Explicit, and
2. Tacit.

This dichotomy is widely used. Usually Knowledge Management entails the conversion of Tacit knowledge to Explicit knowledge.

The last dimension is the Entity managing knowledge. The Entity may be:

1. An Individual,
2. An Organization, or
3. Social.

The Individual may be a Provider of healthcare, its Recipient, or a Care Taker of a Recipient. Similarly, the Organization managing knowledge may be a Hospital, the Insurer, or a Government Agency. Last, the Social Entity may be a Community (religious, ethnic, geographical, etc.) or a Patient Group. This dimension too may be extended, reduced, refined, and coarsened.

Thus, the left half of the ontology encapsulates the components of Knowledge Management. It includes:

1. Generation single-loop of explicit individual provider knowledge,
2. Codification ontologic of tacit organization hospital knowledge, and
3. 174 (11*2*8 - 2) other components.

All the 176 components may not be instantiated in a community of healthcare practice; some may be instantiated frequently, some infrequently, and others not at all.

The combination of the two halves results in 176*180 = 31,680 potential components of Community of Healthcare Practice Knowledge Management. These components define the domain. The ontology deconstructs the combinatorial complexity of the domain and represents it parsimoniously. It can be used as a lens to study the domain – its 'bright', 'light', and 'blind/blank' spots. It can be used to map the research, policies, and practices in the domain. Such a mapping can be the basis of roadmaps for the future.

CONCLUSION

We set out to discuss the need for an ontological view of Health Clusters as a way to frame and capture essential critical components. We illustrated this using the example of a healthcare knowledge cluster. Our initial analysis has demonstrated that such a mapping requires an appreciation of all domains that are relevant in the healthcare space. To capture this we proffer an ontology. The limitation of this paper is the fact that our ontological method was developed in one very specific domain area or 'health clusters'. Our future research will be focussed on demonstrating the benefits and legitimacy of this mapping as an innovative means of capturing knowledge for the Health Cluster.

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KEY TERMS AND DEFINITIONS

Community of Practice: A group of individuals with a shared interest who interact and work together.

E-Health: Providing healthcare using technology most especially computers.

Health Knowledge Management: Understanding know what and know how in the healthcare context.

Health Ontology: A mapping of the health space to ensure accurate and shared knowledge capture and meaning.

Taxonomies: A structured set of names and descriptions used to organize.

Chapter 40
Adoption of Mobile Devices in the Australian Healthcare: A Conceptual Framework Approach

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ABSTRACT

In recent years, the potential use of mobile devices has significantly positively impacted healthcare globally. Despite global claims of widespread use of mobile devices in healthcare, its adoption in the Australian healthcare context is slow. Limited research is available on slow adoption of mobile devices in the Australian healthcare context. Therefore, this chapter is designed to investigate the factors influencing adoption of mobile devices from healthcare professionals' perspective and develop a health specific conceptual framework. The influential factors for the adoption of mobile devices in the Australian health context may be intention, individual readiness, advantages, safety issues, features, self-efficacy, complexity, training, compatibility, social influences, age and gender.

INTRODUCTION

The penetration rate of mobile devices such as smartphone and tablet computers has increased globally and will continue to increase in the future. The number of global smartphone subscribers is expected to reach 3.5 billion by 2019 ("Forrester Research World Mobile and Smartphone Adoption Forecast, 2014 To 2019 (Global)," 2016). Due to the attractive features such as cost-effective sensors and wireless communication capabilities mobile devices have received great attention in the healthcare context. Kang et al. (2010) have notion that the ability to monitor patients' health remotely is making mobile devices popular in the health domain. Mobile devices such as smartphone can measure heart rate, count the steps walked, and can tell calories consumed and utilized (Yu Rang, Yura, Guna, Jae Ho, & Soo-Yong,

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2015). Mobile devices are being used in health care in different ways. For instance, patients are using mobile devices for consultation with doctors (Korzep, 2010). On the other hand, doctors are using mobile technology for real time monitoring/tele monitoring of patients (Slaper & Conkol, 2014; Zangbar et al., 2014). Therefore, mobile devices are changing the way healthcare is delivered and are offering mobility, flexibility, convenience and real time communication in healthcare.

The concept of using mobile devices in healthcare can be viewed as follows: any equipment (with different sensors) which can be worn as wrist band, implanted in the body or embedded with the living species, measuring different physical changes of the patients, monitoring physical activities, analyzing, alerting and communicating with healthcare professionals and patients from remote places (Dwivedi, Shareef, Simintiras, Lal, & Weerakkody, in press). The use of mobile devices in healthcare is benefiting the healthcare domain in many ways such as reducing cost and traveling time for patients and healthcare professionals. Hence, the concept of using mobile devices in healthcare is more beneficial than traditional healthcare services where patients have to wait in long queues and doctors remained overburdened.

The use of mobile devices in healthcare has enhanced the scope of health care services and in the near future will make health services more flexible (Agosti, Graziano, Artiaco, & Sorrentino, 2009; Ben-Zeev et al., 2013; I.-L. Wu, Li, & Fu, 2011). For example, Rana, Hume, Reilly, and Soar (2015) proposes an ensemble sensing network named w-health (wireless health) which can combine smart phone, smart watch and smart glass in one network and can be used in telehealth in the near future. Andersen, Lindgaard, Prgomet, Creswick, and Westbrook (2009) think nurses and clinician tasks performed during ward rounds, require highly mobile computing devices. With a clinical alert system, a message can be sent to doctors or nurses mobile device and they can talk while they walk. Further, use of mobile devices such as smartphones, pagers, tablets and Wi-Fi phones can speed up admit and discharge process, response quickly to patients, promote direct communication between clinicians and can communicate test results efficiently. However, the Academy of Australian Technology, Science and Engineering (ATSE) report says that assistive technologies such as mobile devices could play a vital role in reducing health care cost when they are socially accepted and widely adopted. Although, globally mobile devices are benefiting the healthcare system and widely used in healthcare however, their adoption is slow in the Australian healthcare system. Mobile devices such as tablets are used by doctors for only a small portion of clinical tasks such as sending reminders to the patients for next consultation. The Australian health department is in favor of using mobile devices (HCSC 2014). However, the majority of consultations are conducted face-to-face even after implementation of videoconferencing in primary care in Australia (Smith, Armfield, Croll &Gray 2012). An extensive systematic literature review reveals most of the mobile devices projects in the Australian healthcare system are implemented on a pilot basis. Hence, the uptake of mobile devices and their further use in the Australian healthcare is unknown.

Therefore, the objectives of this chapter are:

- To understand the perception of healthcare professionals about the use of the mobile devices in the Australian healthcare environment.
- To contribute to the knowledge of the adoption of mobile devices in the healthcare context.

The overall aim of this chapter is to develop a conceptual framework for the adoption of mobile devices in the Australian healthcare environment.

BACKGROUND

Literature review reveals factors influencing adoption of mobile devices can be studied both at hospital level and individual level (Andersen et al., 2009; Brown III, Yen, Rojas, & Schnall, 2013; Kay, 2011; Rana et al., 2015; Shareef, Kumar, & Kumar, 2014; West, 2012; Wu et al., 2011). This chapter is mainly focused on the individual user's (healthcare professionals) level of adoption of mobile devices in the Australian healthcare context because healthcare professionals such as doctors and nurses are one of the key users to use technology in healthcare. From literature it appears that even after implementation of mobile devices in the Australian healthcare system they are not used up to their full potential. Therefore, understanding the factors influencing adoption of mobile devices at the healthcare professional's level may increase the use of mobile devices in healthcare. The increased use of mobile devices can ensure the long term profitability and reduction in healthcare cost (Boulos, Wheeler, Tavares, & Jones, 2011; Lim et al., 2011; Xue et al., 2012). Hence, the conceptual framework in this chapter is developed from the healthcare professional's perspective.

Use of mobile devices in healthcare is a new concept globally including Australia (Dwivedi et al., in press). Therefore, an extensive literature review is conducted for the adoption of various kinds of Health Information Technology in the healthcare domain. Literature review conducted for the purpose of this chapter resulted many factors influencing adoption of various technologies in the healthcare environment (Baig, 2010; Brewster, Mountain, Wessels, Kelly, & Hawley, 2014; Furukawa, Raghu, Spaulding, & Vinze, 2008; Gagnon et al., 2012). However, all factors given in reviewing the literature cannot be considered important to understand the adoption of mobile devices in the Australian healthcare environment because of the cultural differences (Michael J. Ackerman, Rosemarie Filart, Lawrence P. Burgess, Insup Lee, & Poropatich, 2010; Peddle, 2007; Tiong, Hafeez-Baig, Gururajan, & Soar, 2006). Further, some factors for the adoption of technology in healthcare are given from other perspectives such as organizational perspective and not from the healthcare professionals' perspectives. To understand factors in this study the authors have given importance to three dimension: technology (mobile device), context (healthcare) and individual (healthcare professionals) (N. K. Bradford, Young, Armfield, Herbert, & Smith, 2014).

First component: technology is considered important to design the conceptual framework in this chapter because the healthcare domain is concerned with the health of a person and technology used should have good supporting features. Ben-Zeev et al. (2013) developed a smartphone system for self-management of Schizophrenia named FOCUS and (during first testing of system) found that individuals were facing problems in using mobile devices in healthcare. The problems were: with abbreviations, large amount of text, difficult wording, font size, smaller touch space, small diameter of the buttons and smaller touch sensitivity. This means mobile devices used should have favoring features with the healthcare domain which healthcare professional can easily understand and operate. Further, health care professionals are responsible for the life of the patient and the technology used should be secure (Bønes, Hasvold, Henriksen, & Strandenæs, 2007). Therefore, technology context is considered important and the factor considered in technology component are: features of mobile devices and security issues.

The second component: context (environment) is considered important to design the conceptual framework because uses of mobile devices have different influence on different domains. To choose this component mobile devices uses are linked with the healthcare context. In this component the main emphasis is given on how the use of mobile devices bring changes in clinical processes and healthcare professionals style of working. Healthcare professionals like the technology that can do clinical work efficiently and is compatible with the clinical work process. Mobile devices have potential to do clini-

cal tasks efficiently. So the use of mobile devices in clinical context is considered important and factors considered in 'context' component are: advantages, complexity and compatibility.

The third component: healthcare professionals are considered important to design the conceptual framework because they are the main users of the technology in the healthcare system. If heath care professionals consider that the use of mobile devices in healthcare is advantageous their intention will be strong to adopt mobile devices (I.-L. Wu et al., 2011). The factors considered in the individual component are: self-efficacy, individual readiness, social influences, intention, age, gender

Theory of planned behavior (TPB) and diffusion of innovation theory (DOI) are used as an underlying theory for developing the conceptual framework in this chapter. Several researchers have used various theories and models such as Technology Acceptance model (TAM), Theory of Reasoned Action (TRA), Theory of Planned Behavior (TPB), Diffusion of Innovation Theory (DOI), Unified Theory of Technology Acceptance and Utilization (UTAUT) to understand individual adoption of technology behavior (Daim, Basoglu, & Topacan, 2013; Deng, Mo, & Liu, 2013; Dwivedi et al., in press; Saad, Alias, & Ismail, 2013; Sanders et al., 2012). TAM is the most widely used model in literature to understand adoption of technology behavior. However, TAM is not suitable to understand adoption behavior in this research because TAM does not include the influence of social norm. The influence of social norms is important in this research context and can be explained using TRA. However, TRA does not include the basic predictors that is perceived usefulness and perceived ease of use from TAM. The basic predictors of TAM and TRA are included in the TPB. Therefore, TPB is the first underlying theory in this research. Further, Wu, Li and Fu (2011) explains psychological state is critical to determine individual behavior for the adoption of technology. TAM and DOI can easy explain the psychological state of the individual behaviour. However, TAM and DOI are extremely similar in some constructs and also supplements each other. While relative advantages are similar to perceived usefulness, complexity is similar to perceived ease of use (Wu, Wang & Lin 2007). Therefore, Both TAM and DOI can explain the psychological state of the individual behaviour without TAM. However, TAM cannot explain the compatibility factor which cannot be ignored in this research context because if technology used in healthcare is not compatible with the healthcare process then it is useless. For example, if a doctor is treating patients in emergency and technology used in that treatment is causing any inconvenience for it may divert doctor attention and may leads to wrong treatment. Therefore, compatibility of the technology with the healthcare process is important. Hence, DOI theory can explain the second component that is 'context' in this research (Ghodeswar & Vaidyanathan, 2007). Therefore, the second underlying theory in this research is DOI.

Note: The third component: technology in this research is a component which is derived from literature review on adoption of various kinds of technologies in the healthcare and not from any adoption theory or model.

MAIN FOCUS OF THE ARTICLE

Through the extensive literature review, it is found that there is limited research for the adoption of mobile devices (by healthcare professional) in the Australian healthcare context. From literature, it also appears that some healthcare facilities are already using mobile health services but their scope is limited to that environment. A major implication of such narrow adoption is lack of understanding of how mobile devices are adopted in the healthcare environment. Further, it appears from literature that even

after implementation of technology in the Australian health organizations the adoption is not as much as expected. For example, although in July 2011, the Australian government has introduced funding for video-consultations in primary care yet, the adoption is not as much as expected (Smith et al. 2014). The majority of consultations in the Australia are conducted face to face compared with video consultation (Smith et al. 2012). Therefore, this study is focused on:

- Understanding factors influencing adoption of the mobile devices in the Australian healthcare environment.
- Developing a conceptual framework which can support adoption of mobile devices in the healthcare domain.

The various constructs used in the conceptual framework developed in this chapter and their operationalization is given in the next section.

DISCUSSION ON SOLUTIONS

The conceptual framework in this chapter is developed in two steps:

Step 1: Thorough Study of the Literature to Understand Factors Influencing Adoption of Various Kinds of Technology in the Healthcare Environment

In this phase various factors influencing adoption of technology are identified. This step provides a broad view of all the factors which can influence adoption of technology in the healthcare environment. Factors identified in this step are related to adoption of technologies such as electronic health records, wireless technology, health information technology, telehealth, home tele monitoring, eHealth mobile computing and mobile health (Daim et al., 2013; Deng et al., 2013; Heidarian & Mason, 2013; Singh, Lichter, Danzo, Taylor, & Rosenthal, 2012; Wang, Redington, Steinmetz, & Lindeman, 2010; Zinszer, Tamblyn, Bates, & Buckeridge, 2013). In step1 it is identified that some factors for the adoption of technology in the healthcare appears to be individual factors and some of them appears to be organizational factors. The list of the factors for the adoption of various technologies in the healthcare environment is given in the Appendix 1.

Step 2: Selection of Appropriate Factor for Understanding Adoption of the Mobile Devices in the Australian Healthcare from the Healthcare Professionals' Perspective

To select the most appropriate factors the authors have given emphasis to understand technology, health environment and healthcare professionals' components. To understand the factors from technology aspect the authors have tried to understand the factors from the previous articles which were focused on mobile computing, mobile wireless devices, and wireless devices (M.-P. Gagnon, Ngangue, Payne-Gagnon, & Desmartis, 2016; Goswami & Chandra, 2013; I.-L. Wu et al., 2011; J.-H. Wu, Wang, & Lin, 2007; Yangil & Chen, 2007). To understand the Australian health context, the authors have tried to read and critically analyze the research articles based on use of mobile devices or mHealth from 2007-2016.

A systematic literature review to understand the use of mobile devices in the Australian health domain is given in in Appendix 2. To understand the factors from the healthcare professionals' perspective the authors have emphasized on various theories/model and literature based on understanding individual behavior for the use of technology in healthcare.

It was a difficult decision to choose which factors can be selected and which can be discarded. Therefore, each construct is operationalized to understand the meaning of the construct. Construct operationalization is a process of achieving clear and practical meaning of the constructs to the chosen context. It includes an agreed definition of the constructs from literature, clear meaning of the constructs that is also suitable for the research and identifying key concept properties describing constructs (Ayers & Olander, 2013; Bhattacherjee, Hikmet, Menachemi, Kayhan, & Brooks, 2007). Operationalization of constructs is also helpful to understand constructs and apply them in a particular research context. Therefore, each construct considered for the development of conceptual framework in this research is operationalized below:

1. **Intention:** Intention in this research refers to the measure of the likelihood to use mobile devices in the healthcare process. User intention is a good indicator of how a system will be accepted. Intention to adopt mobile devices in healthcare may depend upon many factors. Therefore, intention to adopt mobile devices is a dependent variable and all the other factors explained below are independent variables.
2. **Readiness:** Readiness refers to the individual propensity to embrace and use mobile devices in health care. Individual readiness to adopt technology is influenced by the individual's positive and negative feelings. Positive feelings allow individuals to adopt technology while negative feelings distract from adopting technology. Parasuraman (2000) has considered positive feelings as 'optimism', one of the contributors of technology readiness. Optimism as 'a positive view of using technology and a belief that it offers people increased control, flexibility and efficiency in their lives. This clearly shows that individual readiness/ attitude to adopt technology is positively influenced by advantages provided by technology. On the other hand, negative feelings which create inconvenience make individuals less confident to adopt technology (Caison, Bulman, Pai, & Neville, 2008). In Australia, mobile devices use in healthcare is still in its infancy. Thus, healthcare professionals' readiness may be weak or strong depending on whether health professionals perceive disadvantages or advantages of mobile devices. Therefore, it can be concluded that induvial intention to adopt mobile devices in the healthcare may be influenced by readiness for the adoption of mobile devices which may further be influenced by the advantages and disadvantages of using the mobile devices in the healthcare domain.
3. **Advantages:** Advantages refer to the benefits of mobile devices in the healthcare processes. Advantages of technology can be measured using various parameters such as cost, features and compatibility. Benefits offered by technology positively impact individuals to adopt technology (Wang et al., 2010; I.-L. Wu et al., 2011). Previous research studies explain the benefits of using technology in healthcare and their positive influence on individual perception (Daim et al., 2013; M. P. Gagnon et al., 2012; D. Kim, 2009). The Australian healthcare domain is under tremendous pressure due to rising healthcare costs, shortage of qualified staff and a growing demand of services (AIHW, 2014; Croll, Norton, Gray, Bryett, & Smith, 2012). Mobile devices such as smart phone in the Australian health context can help in promoting and facilitating health services, quality of life

and reducing healthcare cost (Gee, 2015). Therefore, the various benefits of using mobile devices in the Australian healthcare context may influence healthcare professionals' intention for the use of mobile devices in the healthcare environment.

4. **Safety Issues:** Safety issues in this research refer to individual understanding of patient's privacy and confidentiality while using mobile devices for healthcare purpose. In health domain where patients' data is transferred from one point to another its integrity, safety, security, privacy and confidentiality needs to be maintained. While using mobile devices in healthcare safety of data being transferred is very important (M.-P. Gagnon et al., 2016; Michael J. Ackerman et al., 2010; Peddle, 2007). For example, if a patient is in emergency unit and patient's data gets modified intentionally or unintentionally then patient will get wrong treatment which can decrease his/her chances of recovering from the disease quickly (Cinque, Coronato, & Testa, 2013). Further, use of mobile devices could also create another security risks such as malware, spear phishing and losing equipment risk (Testa, Cinque, Coronato, & De Pietro, 2015) and these risk cannot be avoided in any country's health context unless a strong security measures are not available. Hence, the use of mobile devices in healthcare is at the same time a great opportunity and a great risk (disadvantage) in the health domain. Therefore, it is important to study security factor while understanding adoption of mobile devices in healthcare.
5. **Features:** Features refer to the functional features such as battery life, screen size of mobile devices which may influence healthcare professionals for the adoption of mobile devices. In the healthcare the most important concern is a person's health and adopted technology should have good supporting features with healthcare process (I.-L. Wu et al., 2011). Zhang et al. (2014) have idea that adoption of technology in healthcare depend on performance of technology and technology features are responsible for performance of technology. (Ghodeswar & Vaidyanathan, 2007) Therefore, whatever technology is used it should have good supporting features in healthcare (Massey, Khatri, & Montoya-Weiss, 2007). EMarketer 2012b cited in Ally and Gardiner (2012) support the notion that features of mobile devices such as touch screen, voice and user interface influence adoption of mobile devices in the market. Further, each healthcare domain is responsible for the life of people and if technology features create any kind of inconvenience with the health care process, then technology is useless in the health environment. Hence, it is important to consider the impact of functional features for the adoption of mobile devices in the Australian healthcare context.
6. **Self-Efficacy:** Bandura have introduced the concept of self-efficacy, which is defined as the expression of self-ability and confidence in successfully reaching goals in certain circumstances (Bandura 1997). Many researchers have used self-efficacy as a variable for information system adoption, and they have de-fined it as the degree of perceiving the need for a certain ability, technique, or piece of knowledge when an individual attempt to use a certain information technology system. Self-efficacy has been considered as an important factor for the adoption of mobile banking and smartphones (Luarn & Lin 2005; D. 1989). Many researchers have demonstrated self- efficacy as an important construct for the adoption of technology (Lim et al., 2011; J.-H. Wu et al., 2007; Yangil & Chen, 2007). Mobile devices are a new technology in the healthcare and in the Australian healthcare it is in its infancy stage. Therefore, some of the individuals may not be confident to use the new technology and hence their intention may be influenced by the self-efficacy to use mobile devices. However, if training is provided to the individual their confident level to use technology is increased.

7. **Training:** Training in this research refers to the hospital's support to update the healthcare professionals about the use of mobile devices in healthcare. Training is useful for the employees (Zolfo et al., 2010). Zolfo et al. (2010) in their research resulted that providing training to health worker is useful in scaling up the HIV/AIDS care in resource-limited settings. Providing training to use mobile devices in healthcare is also important because there is a difference between health professionals and the typical technology users. Health professional work is critical and time sensitive and if mistake is done it may cost the life of a patient. Further, in the Australian health system is facing shortage of staff. Therefore, proving training may reduce the complexity level of healthcare professionals to operate the mobile devices in the health domain and can bring productivity and efficiency even with the limited staff.
8. **Complexity:** Complexity refers to the degree to which healthcare professionals may experience difficulties in using mobile devices for health care services. Rogers (2003, p. 257) states complexity as the degree to which an innovation is perceived as relatively difficult to understand and use. In the context of adoption of mobile devices in healthcare, if an individual has to struggle with the use of technology in the health process, then the individual's intention for the adoption of mobile devices will be weak. However, complexity can be reduced by providing training to the health professionals. Many researchers proposed complexity as one of the major factors for adoption of technology in healthcare, with antonyms like simple/ easy to use/perceived easiness, perceived ease of use (Daim et al., 2013). Complexity can be an important factor for adoption of mobile devices in the healthcare environments because if HCPs find it difficult to operate mobile devices in healthcare process the intention for the adoption will be low. In the Australian health environment use of mobile devices in on a pilot basis and the future of the pilot projects is unknown. Therefore, it is important to understand the complexity construct to expand the mobile health on large scale in Australia. Thus, complexity influences adoption of mobile devices and is included in the conceptual framework.
9. **Social Influences:** Social influences are defined as the influences of people (who are in the social circle such as colleagues of healthcare professionals) on healthcare professionals for the adoption of mobile devices in healthcare services. In the theory of reasoned action (TRA), TAM2, TPB, C-TAM-TPB the term social norm is used and has the same meaning as social influences. Social influences are the influences of peers on the individual (Morris, Venkatesh, & Ackerman, 2005). Social influences have a great influence on individual adoption of innovation (Rogers, 2003) and is therefore, considered one of the essential constructs in adoption of mobile devices in the Australian healthcare context.
10. **Compatibility:** Compatibility refers to the degree to which mobile devices are perceived as consistent with the existing healthcare process and needs of the healthcare professionals. Literature reveals HCPs show less interest for the adoption of new technology (Rogers, 2003; I.-L. Wu et al., 2011). However, if the technology is compatible with healthcare professional's work process, they like to adopt it (Xue et al., 2012). Additionally, in the health care environment new technology is adopted if it supports the existing system and adds newness to the system and mobile devices have that potential. Therefore, compatibility construct is added in the conceptual framework.
11. **Age:** Age in this research is defined as how old a health professional is who is working in the Australian healthcare. Age is also one of the important factors that affects the adoption of information systems. Several researchers found young people more actively use mobile telecommunications

(Brown, Cajee, Davies, & Stroebel, 2003; Nikou, 2015). However, elderly people are resistant to technology change. Skiba (2015) says that '60- plus crowd' crowd is not technology averse. Further, most of the old people are dominated by various kinds of physical problems such as poor eyesight (Leventhal, 2008; Zhang et al., 2014). If a person has poor eyesight he/she will more likely to prefer mobile devices with the bigger screen size (Boulos et al., 2011). Caison et al. (2008) results shows that young male medical students have more curiosity for using technology. Therefore, researcher expect that age would be a significant factor in the adoption of mobile devices among the Australian healthcare professionals.

12. **Gender:** Gender in this research is defined as whether a healthcare professional working in the Australian health domain is male, female or other. Gender difference is also considered one of the factor for understanding the adoption of mobile devices in the Australian healthcare domain. Imhof, Vollmeyer, and Beierlein (2007) explains male computer users use computer more frequently for games, music and video players, or Internet shopping than their female counterparts. Lim et al. (2011) think women who do not have prior experience with technology may feel more uncomfortable in using technology. Further, previous literature indicates that men are task oriented and like to finish their office work efficiently and timely and if technology is compatible with their style of working and can help to finish their office work timely their intention to use technology is strong (Roberts & Bell, 2000). In the healthcare domain, healthcare professionals need to interact with various patients and their family members and friends to explain the disease condition of a patient. Therefore, gender difference could play a role for the use of mobile devices in the health domain.
13. **Other Factors:** Other factors refer to the factors which can be further added in the conceptual framework developed in this chapter. Other factors may be organizational factors, cultural differences and government policies and procedure to implement mobile devices in the healthcare system. These factors are not included yet in the conceptual framework because every country has its own health system. Others factors mentioned above may be influencing or may not be influencing in the Australian healthcare context. These factors may be added in the conceptual framework further by conducting exploratory study.

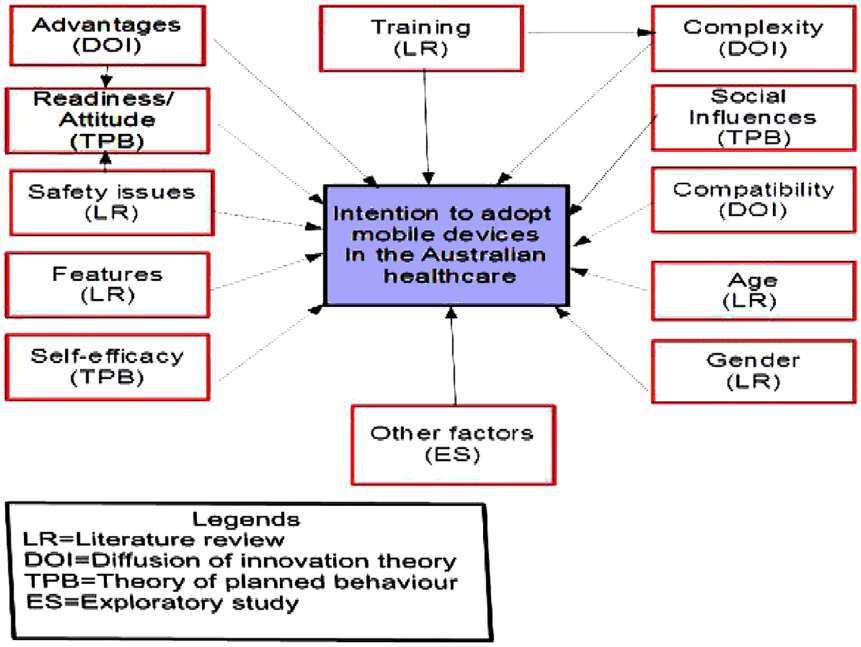
FUTURE RESEARCH DIRECTIONS

This research can provide avenues for future researchers for conducting further research. Future research can be conducted for the adoption of mobile devices in the Australian healthcare domain from other perspectives such as patients and management perspective. Also, the conceptual framework developed in this research can further be extended by conducting exploratory study to find out the other factors in the Australian health context.

CONCLUSION

This chapter concludes that there are many factors, which are influencing healthcare professionals for the adoption mobile devices in the Australian healthcare environment. The main factors which may

Figure 1. Conceptual framework for adoption of mobile devices in the Australian healthcare context



influence healthcare professionals in the Australian healthcare context for the adoption of mobile devices proposed from literature are: intention, individual readiness, advantages, safety issues, features, self-efficacy, complexity, training, compatibility, social influences, age and gender. Other factors in the conceptual framework developed in this chapter can be added depending on the Australian health context.

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APPENDIX 1: LIST OF FACTORS

1. (J.-H. Wu et al., 2007)
    1.1. Compatibility
    1.2. Perceived usefulness
    1.3. Perceived ease of
    1.4. MHS self-efficacy
2. (S. Kim & Garrison, 2008)
3. Cognitive Influence Process
    3.1. Job relevance
    3.2. Perceived ease of use
    3.3. Perceived usefulness
4. Technological Influence Process
    4.1. Ubiquity
    4.2. Reachability
5. (Furukawa et al., 2008)
    5.1. Technology
    5.2. Geographic location
    5.3. Patient safety
6. (Michael J. Ackerman et al., 2010)
    6.1. Lack of technology integration
    6.2. Interoperability,
    6.3. Standardization
    6.4. Limited financing
    6.5. Lack of data standards
    6.6. Cultural barriers
    6.7. Usability
    6.8. Ease of use
    6.9. Security
    6.10. Privacy
    6.11. Trust
7. (Wang et al., 2010)
    7.1. Cognitive, physical limitation
    7.2. Health status
    7.3. Disease conditions
    7.4. Technology literacy
    7.5. Perceived Usefulness of technology
8. (I.-L. Wu et al., 2011)
    8.1. Personal innovativeness
    8.2. Availability

9. (Kluge, 2011)
    9.1. Liability
    9.2. Interoperability
    9.3. Legacy
10. (Singh et al., 2012)
    10.1. Financial constraints
    10.2. Return on investment issues
    10.3. Initial data entry labour intensive
    10.4. Initial loss of productivity
    10.5. Training burden for physicians
11. (Davis, 1985; M. P. Gagnon et al., 2012)
    11.1. Perceived usefulness
    11.2. Perceived ease of use
12. (Goswami & Chandra, 2013)
    12.1. User interface clarity
    12.2. Usage friendliness
    12.3. Social influence
    12.4. Support of product and service providers
    12.5. Learning predispositions
13. (Heidarian & Mason, 2013)
    13.1. Technology updates
    13.2. Cost
    13.3. Lack of time
    13.4. Equipment integration
14. (Zinszer et al., 2013)
    14.1. Lack of national vision
    14.2. Lack of leadership
    14.3. Insufficient investment
    14.4. Poor conceptualization of the priority areas
15. (Daim et al., 2013)
    15.1. Usefulness
    15.2. Quality of Services
    15.3. Compatibility With User's Life Style
    15.4. Quality of Support
    15.5. Quality of Information
    15.6. Image of Technology
    15.7. Usages Time
    15.8. Accessibility
    15.9. Easy to Use

16. (Goswami & Chandra, 2013)
    16.1. Interface clarity
    16.2. User friendliness
    16.3. Social influences
    16.4. Support of product and services provided
    16.5. Learning predisposition
17. (Deng et al., 2013)
    17.1. Physical condition
    17.2. Resistance to change
    17.3. Technology anxiety
    17.4. Self-actualization needs
18. (Cimperman, Brenčič, Trkman, & Stanonik, 2013)
    18.1. Security
    18.2. Usability
19. (Brewster et al., 2014)
    19.1. Staff-Patient interaction
    19.2. Credibility
    19.3. Negative impact of service change
    19.4. Autonomy
    19.5. Technical issues
20. (Daniel Castro, Ben miller, & Nager, 2014)
    20.1. Standard of care
    20.2. State licensing policies
    20.3. Compatibility
    20.4. Interoperability
21. (N. K. Bradford et al., 2014)
    21.1. Technical (setting up equipment, username and password)
    21.2. Individual (culture, linguistic and social variations)
    21.3. Service factors (Lack of staff)
22. (M.-P. Gagnon et al., 2016)
    22.1. Perceived usefulness
    22.2. Ease of use
    22.3. Design and technical concerns
    22.4. Cost
    22.5. Time
    22.6. Privacy and security issues
    22.7. Familiarity with the technology
    22.8. Risk-benefit assessment
    22.9. Interaction with others (colleagues, patients, and management).

APPENDIX 2

Table 1. A systematic literature review to understand the use of mobile devices in the Australian health context

Title and Authorship	Research Design	Results
Intelligent human activity recognition scheme for eHealth applications (Chetty & Yamin, 2015)	A Samsung Galaxy S2 smartphone was used for quantitative data collection, which contains an accelerometer and a gyroscope for measuring 3-axial linear acceleration and angular velocity respectively at a constant rate of 50Hz, which is sufficient for capturing human body motion.	For single model experiments, we found optimal attribute selection Techniques based on information theory based ranking leads to better performance. For multimodal experiments, a combination of supervised and unsupervised yields best performance.
'TXT2BFiT' a mobile phone-based healthy lifestyle program for preventing unhealthy weight gain in young adults: study protocol for a randomized controlled trial (Lana Hebden et al., 2013)	Nine month two-arm parallel-group randomized controlled trial in Sydney, New South Wales, Australia is conducted. Participants are recruited from primary medical care clinic using random sampling.	The results of this study are not given in the paper. The results may be found in the further publications
Integrating mobile-phone based assessment for psychosis into people's everyday lives and clinical care: a qualitative study (Palmier-Claus et al., 2013)	Qualitative interviews were conducted in order to explore participants' perceptions and experiences of the devices. 24 community based individuals with non-affective psychosis completed a randomised repeated-measure cross-over design study, where they filled in self-report questions about their symptoms via text-messages on their own phone, or via a purpose designed software application for Android smartphones, for six days.	Three themes emerged from the data are: i) the appeal of usability and familiarity, ii) acceptability, validity and integration into domestic routines, and iii) perceived impact on clinical care. The mobile-phone assessment procedure itself may need to be tailored to the individual, potentially through machine learning, in order to maximise compliance
A Comparison of the Reliability of Smartphone Apps for Opioid Conversion (Haffey, Brady, & Maxwell, 2013)	Between 28 January and 5 February 2012, the major online app stores (Android 'Google Play' store, iOS 'App Store', BlackBerry 'Blackberry App World', Windows Phone 'Marketplace', Symbian 'Ovi (Nokia)' store and Bada 'Samsung Apps' store) are searched using relevant terms (opioid, morphine, medical calculator, conversion) to identify apps that had opioid dose/formulation conversion capabilities..	We have demonstrated that opioid calculator conversion outputs are highly variable between apps. Evidence of medical involvement in app creation or referencing of primary sources is lacking in many cases, and a statistically significant difference was found in conversion outputs of hydromorphone in those apps with and without stated medical involvement Despite large developments in Internet technology and growth in the knowledge of how to develop more effective web-based interventions, overall website quality was low and the majority of freely available physical activity websites lack the components associated with behavior change.
The effectiveness of a suicide prevention app for indigenous Australian youths: study protocol for a randomized controlled trial (Shand, Ridanir, Tighe, & Christensen, 2013)	A Pilot study will be conducted in this research. Use of the app (that is, login and logout times, activities completed, time spent in each section, answers to self-Assessment questions) will be tracked within the device, and downloaded to secure servers whenever internet connectivity is established. The app will require a security pin for access and any data stored on the device will be encrypted and hidden within the app coding. Answers to self-assessment questions will be coded so that they are unintelligible to anyone not connected with the study.	The primary outcome measure is a reduction in frequency and intensity of suicidal thoughts. Secondary outcome measures are the reduction of depression, anxiety and impulsivity. .

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Table 1. Continued

Title and Authorship	Research Design	Results
Telehealth and ubiquitous computing for bandwidth-constrained rural and remote areas (Steele & Lo, 2013)	review article	In this article, we review the benefits of ubiquitous computing for rural and remote telehealth including social media based preventative, peer support and public health communication, mobile phone platforms for the detection and notification of emergencies, wearable and ambient biosensors, the utilization of personal health records including in conjunction with mobile and sensor platforms, chronic condition care and management information systems, and mobile device–enabled video consultation.
Obesity and outpatient rehabilitation using mobile technologies: the potential mHealth approach (Castelnuovo et al., 2014)	Review article	To conclude, further studies should investigate both possible advantages and applications of Internet and mHealth technologies in the treatment of obesity. In spite of promising preliminary reports, the evidence-base for the effectiveness of mHealth applications is meagre and it remains too early to be able to recommend it for use in clinical settings
Safety for home care: the use of Internet video calls to double-check interventions (N. Bradford, Armfield, Young, Ehmer, & Smith, 2012) -RCH in Brisbane	This research is a trial research. The devices were taken on scheduled home visits to patient homes and video calls with a second clinician were conducted to double-check various items associated with the clinical care of the patient. Over a 14-month period, 88 video calls were conducted during which a total of 600 checks were completed. The items checked included medication names, doses, segmentations on syringes and details of ventilator settings.	The quality of the video call was acceptable on 97% of occasions. On three occasions (3%) it was not possible to establish a connection and the double check was not achieved. The use of Internet video calls is feasible for double-checking and has the potential to improve patient safety and reduce costs
Clinical use of Skype: a review of the evidence Base (Armfield, Gray, & Smith, 2012)	This articles is a literature review article. Five electronic databases were searched to identify relevant studies (CochraneLibrary, DARE,Medline,EMBASE,CINAHL). The search terms were: Internet; video; remote consultation; Skype; teleconsultation; telehealth; telemedicine.	One small (n=7) controlled clinical trial had assessed the effect of nursing communication using Skype on elderly patients with dementia and their careers. While there were many case reports and small studies, no firm evidence either in favour of, or against the use of Skype for clinical telehealth was found.
The smart therapist: A look to the future of smartphones and mHealth technologies in psychotherapy (Clough & Casey, 2015)	Review article.	Research indicates that consumers want to engage in mHealth interventions, although only a limited number of empirically supported options currently exist. Weakness Much of the research to date is lacking in methodological rigor, and reliance on standard research designs often used in other areas of psychological research may constrain development of interventions. Strength:The main areas of research identified included the use of SMS technologies, ecological momentary assessment, online and software application based interventions and the recent integration of sensor and data mining technologies.
Quantifying the body: monitoring and measuring health in the age of mHealth technologies (Lupton, 2013)	Review article.	Given that mobile digital technologies are so novel, research directed at how people actually use them for health purposes – how they 'domesticate' them and incorporate them into their everyday lives – has yet to be published. What types of people self-track? How do the devices they use come to acquire meaning in the context of everyday use? What are the social lives of these commodities? Aspects of how and to what extent these devices are incorporated in concepts of selfhood and embodiment also remain to be fully explored.

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Table 1. Continued

Title and Authorship	Research Design	Results
Testing the feasibility of a mobile technology intervention promoting healthy gestational weight gain in pregnant women (txt4two) - study protocol for a randomised controlled trial (Willcox et al., 2015)	txt4two is a parallel randomised control trial	Findings will inform the development of larger-scale Digitally based programmes to improve the delivery of healthy pregnancy nutrition, physical activity and healthy GWG. The findings of this trial will contribute to the literature on promotion of healthy lifestyles in pregnant women.
Iterative development of MobileMums: a physical activity intervention for women with young children (Fjeldsoe, Miller, O¿Brien, & Marshall, 2012)	Focus groups with women with young children to explore their perceptions of and needs for physical activity interventions were conducted. Women were recruited via posters and flyers displayed in general practice clinics, Playgroup locations, the public hospital antenatal clinic, and the public library of a community located in Queensland, Australia. To be eligible to participate, women had to have at least one child aged less than 5 years, and be able to speak and understand English. In pre-testing To be eligible to participate, women had to have at least one child aged less than 5 years, and be able to speak and understand English.	Key findings identified throughout the development process that shaped the MobileMums program were the need for: behaviour change techniques to be grounded in Social Cognitive Theory; tailored SMS content; two-way SMS interaction; rapport between SMS sender and recipient; an automated software platform to generate and send SMS; and, flexibility in location of a face-to-face delivered component.
A mobile health intervention for weight management among young adults: a pilot randomised controlled trial (L. Hebden et al., 2014)	This was a prospective randomised controlled trial, conducted from July to the end of December, 2011. In total, 192 gender-specific SMS text messages were developed (24 SMS for each of four behaviours and two genders). Text messages were tailored to the processes of change identified in the Transtheoretil Model (Prochaska et al., 1992), and moved from addressing cognitive to behavioural processes to facilitate movement through stages of change. Four smartphone applications were developed by the investigators (one per behaviour).Briefly, each application enabled users to record their behaviour (e.g. daily minutes of physical activities performed, daily servings of fruit and vegetables, or weekly frequency, and energy and fat content, of take-away meals) and to then receive instantaneous tailored motivational advice, as well as feedback in reference to population health guidelines	All analyses were conducted using SAS, version 9.2. Data were analysed according to the intention-to-treat principle with baseline values imputed for missing follow-up data. Descriptive statistics were used to summarise baseline differences in participant characteristics between intervention and control groups. Changes within groups pre- to post-intervention were tested using paired sample t-tests (continuous normal data), Wilcoxon signed ranks Z-tests (ordinal data; i.e. fruit and vegetable servings) or Pearson chi-square tests (categorical data). The effect of the mHealth intervention on primary and secondary outcomes was analysed using analysis-of-covariance models for quantitative outcomes and logistic regression models for dichotomous outcomes
Effects of mental health self-efficacy on outcomes of a mobile phone and web intervention for mild-to-moderate depression, anxiety and stress: Secondary analysis of a randomised controlled trial (Clarke et al., 2014)	Randomized controlled trial is conducted in this research.	Mental health self-efficacy influences symptom outcomes of a self-guided mobile phone and web-based psychotherapeutic intervention and may itself be a worthwhile target to increase the effectiveness and efficiency of online treatment programs.
A framework for cloud-based healthcare services to monitor non communicable diseases patient (Al-Qurishi et al., 2015)	A framework is proposed in this research.	Analysis is conducted using AHP techniques.
Electronic psychosocial assessment tool: Concept development and identification of barriers to successful implementation (S. Bradford & Rickwood, 2014)	Interview is conducted in this research. At the beginning of each interview, participants are informed of the purpose of the study.	By engaging the stakeholders in this early process researchers were able to identify a range of software functionalities that are likely to improve the applicability for users, as well as identify possible barriers to implementation.

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Table 1. Continued

Title and Authorship	Research Design	Results
An empirical study to determine factors that motivate and limit the implementation of ICT in healthcare environments (Gururajan & Hafeez-Baig, 2014)	Mix methodology is used in this research. 80 staff are interviewed. Once the initial motivators were identified, a focus group is conducted.	This research paper provides some initial findings of the factors that motivate and limit ICT implementation in healthcare organisations. A list of themes which can influence the ICT implementation in a healthcare environment was identified. Some of the themes were already identified in the literature review; however this research also identified new themes, in the form of internal and external factors, which contribute to the general research domain.
Adoption phenomena for wireless handheld devices in the healthcare environment (Gururajan & Hafeez-Baig, 2014)	Survey	All the three constructs, CP, SD and Comp for the adoption of wireless handheld devices represent good measurements for the intention-to-use these devices in the healthcare setting. Whereas SD is strongly influenced by CP and Comp as determinants for their intention, in spite of the direct effects of CP and Comp on the intention.
Use of information and communication technology to provide health information: what do older migrants know, and what do they need to know? (Goodall, Ward, & Newman, 2010)	Qualitative study (Focus group discussion) method is used in this research	
What's in a message? Delivering sexual health promotion to young people in Australia via text messaging (Gold, Lim, Hellard, Hocking, & Keogh, 2010)	Eight gender-segregated focus groups were held with 21 males and 22 females in August 2008.	Text messages were viewed as an acceptable and 'personal' means of health promotion, with participants particularly valuing the informal language. There was a preference for messages that were positive, relevant and short and for messages to cover a variety of topics. Participants were more likely to remember and share messages that were funny, rhymed and/or tied into particular annual events. The message broadcasting, generally fortnightly on Friday afternoons, was viewed as appropriate. Participants said the messages provided new information, a reminder of existing information and reduced apprehension about testing for sexually transmitted infections.

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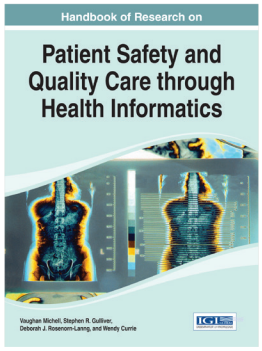

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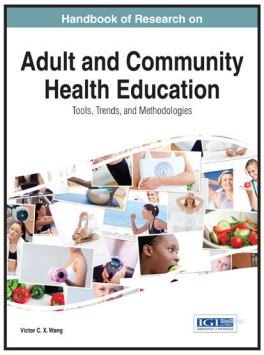

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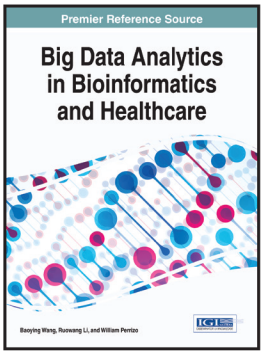

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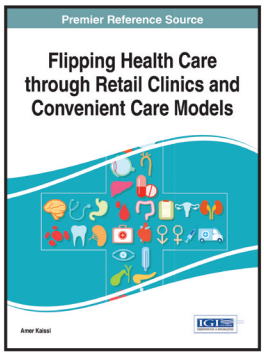

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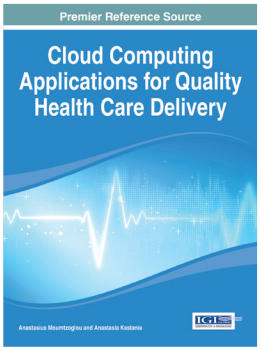

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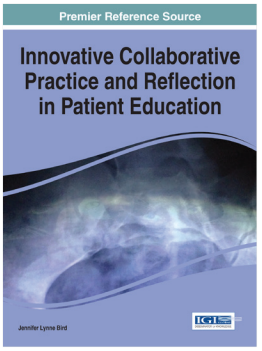

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