Handbook of Research on

Optimizing Healthcare Management Techniques

Nilmini Wickramasinghe

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The **Advances in Healthcare Information Systems and Administration (AHISA) Book Series** aims to provide a channel for international researchers to progress the field of study on technology and its implications on healthcare and health information systems. With the growing focus on healthcare and the importance of enhancing this industry to tend to the expanding population, the book series seeks to accelerate the awareness of technological advancements of health information systems and expand awareness and implementation.

Driven by advancing technologies and their clinical applications, the emerging field of health information systems and informatics is still searching for coherent directing frameworks to advance health care and clinical practices and research. Conducting research in these areas is both promising and challenging due to a host of factors, including rapidly evolving technologies and their application complexity. At the same time, organizational issues, including technology adoption, diffusion and acceptance as well as cost benefits and cost effectiveness of advancing health information systems and informatics applications as innovative forms of investment in healthcare are gaining attention as well. **AHISA** addresses these concepts and critical issues.

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This book is dedicated to Goody and the memory of Aunty Nina

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Detailed Table of Contents

Many apps and analyzers based on machine learning have been designed to help and cure the stress issue. The chapter is based on an experimental research work that the authors performed at Research Labs and Scientific Spirituality Centers of Dev Sanskriti VishwaVidyalaya, Haridwar and Patanjali Research Foundations, Uttarakhand. In the research work, the correctness and accuracy have been studied and compared for two biofeedback devices named as electromyography (EMG) and galvanic skin response (GSR), which can operate in three modes—audio, visual, and audio-visual—with the help of data set of tension type headache (TTH) patients. The authors have realized by their research work that these days people have lot of stress in their lives, so they planned to make an effort for reducing the stress level of people by their technical knowledge of computer science. In the chapter, they have a website that contains a closed set of questionnaires from SF-36, which have some weight associated with each question.

Governments often create policies that rely on implementation by arm's length organizations and require practice changes on the part of different segments of the healthcare system without understanding the differences in and complexities of these agencies. This research describes 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 chapter explains that the outcome of health policy implementation determines the availability, quality, and equability of program service delivery. The chapter further argues that policy implementation barriers affect the poor and vulnerable groups from benefiting from public spending on public health policies and programs.

Telemedicine maturity models aim to support telemedicine scaling up. Even though a diversity of telemedicine maturity models, and further support tools, exist, they are often unable to support users proactively or offer substantial guidance for the improvement of the status quo. A new maturity model is therefore needed that overcomes the shortcomings evident in existing approaches. This chapter aims to identify requirements that such a model has to fulfil based on an analysis of existing maturity models. The results guide future research and can support the scaling up of telemedicine initiatives.

Blockchain is a decentralized, digital ledger that keeps a permanent, unalterable record of transactions between users. One of the greatest advantages of Blockchain is that it is much more secure than other data storage platforms, and thus particularly relevant for healthcare. The chapter serves to outline areas and opportunities for deploying this technology into key healthcare contexts to support effective and efficient operations as well as heightened transparency and trust around activities between and within stakeholders.

3D printing has developed as a modification of an old injection printer. Today, it is rapidly expanding offering novel possibilities as well as new exciting applications for various sectors including healthcare, automotive, aerospace, and defense industries. This chapter presents key application areas within the healthcare sector. In medicine, 3D printing is revolutionizing the way operations are carried out, disrupting prosthesis and implant markets as well as dentistry. The relatively new field of bioprinting has come to be because of advances with this technology. As will be discussed, numerous applications of 3D printing in healthcare relate to personalized medicine. For instance, implants or prostheses are 3D printed for a specific user's body, optimizing the technology to work for an individual, not an average user as with most mass-produced products. In addition, 3D printing has applications on the nanoscale with printing of drugs and other smaller items. Hence, 3D printing represents a disruptive technology for healthcare delivery.

Cancer is among the top three chronic diseases both in developed countries as well as underdeveloped countries. The diagnosis, medication, and treatment for cancer is extremely costly. Typically, cancer treatment involves surgery, radiotherapy, and chemotherapy. Owing to the extremely high price of medicine and treatment along with cytotoxicity of medication, cancer treatment warrants extraordinary care in treating cancer patients. Oncology information systems (OIS) provide an all-in-one solution for such problems. The OIS can integrate different treatment protocols and update change in dose and treatment in real time.

On the one hand, predictive analytics is an important field of research in information systems; however, research on predictive analytics in healthcare is still scarce in IS literature. One area where predictive analytics can be of great benefit is with regard to unplanned readmissions. While a number of studies on readmission prediction already exists in related research areas, there are few guidelines to date on how to conduct such analytics projects. To address this gap the chapter presents the general process to develop empirical models by Shmueli and Koppius and extends this to the specific requirements of readmission risk prediction. Based on a systematic literature review, the resulting process defines important aspects of readmission prediction. It also structures relevant questions and tasks that need to be taken care of in this context. This extension of the guidelines by Shmueli and Koppius provides a best practice as well as a template that can be used in future studies on readmission risk prediction, thus allowing for more comparable results across various research fields.

This study aims to identify predictors for patients likely to be readmitted to a hospital within 28 days of discharge and to develop and validate a prediction model for identifying patients at a high risk of readmission. Numerous attempts have been made to build similar predictive models. However, the majority of existing models suffer from at least one of the following shortcomings: the model is not based on Australian Health Data; the model uses insurance claim data, which would not be available in a real-time clinical setting; the model does not consider socio-demographic determinants of health, which have been demonstrated to be predictive of readmission risk; or the model is limited to a particular medical condition and is thus limited in scope.

Intelligent tools and collaborative systems can be used in healthcare contexts to support clinical decision making. Such an approach is concerned with identifying the way in which information is gathered and decisions are made along specific care pathways. This study develops a real-time collaborative system using an intelligent risk detection model (IRD) to improve decision efficiency in the clinical case of patients undergoing hip or knee arthroplasty. The benefits of adopting this improved clinical decision-making solution include increasing awareness, supporting communication, improving the decision making process for patients and caregivers while also improving information sharing between surgeons as key collaborative parties in the research case. This in turn leads to higher levels of patient and clinical satisfaction and better clinical outcomes.

Diabetes type 2 is a chronic condition that currently has no cure. Hence, proper management is key as the best approach to ensure the wellness of sufferers. To establish the attitudes of self-care patients towards the management of this ailment, the authors designed a study that targeted 100 Australian residents in the first phase. These participants provided quantitative and qualitative information about various diabetes type 2 management practices that include exercising and diet management and the co-morbidities they currently suffer.

Today most people have at least one smart phone irrespective of socio-economic standing. Such a penetration of mobile phones has enabled mobile health to rapidly develop over the last 5 years. There are many benefits to patients and clinicians afforded by mobile health including the convenience of any time anywhere access to data and information and the possibility to monitor so that critical issues can be caught early. One key area is in the post discharge phase as patients return home to ensure they are making good progress. This chapter discusses developments of mobile health solutions and precision post-operative wellness monitoring solutions.

Arguably, the most prevailing chronic disease today is diabetes. The World Health Organization (WHO) notes that diabetes is a silent epidemic, and by 2020, there will be a 54% rise in the total number of individuals diagnosed with this disease. These are distressing figures. Many are turning to technology solutions to assist. What becomes important is the ability to rapidly design and develop appropriate digital health and wellness solutions.

The U.S. healthcare system has been often characterized as fragmented and disconnected. Lack of effective and concurrent adoption of information technology has been known to be a factor that contributes to the decentralization of healthcare systems. Fragmented systems are also responsible for creating silos that operate with minimal coordination. Clinicians in such systems are providing duplicate services because they are not aware of patient care plans set by other practitioners. These duplications could lead to prescription drug errors due to inconsistencies and lack of coordination in the treatment services and in some cases drug-drug interactions. The following suggests a role for technology to facilitate better care coordination.

Foreword

The health and wellbeing of individuals and their families is one of the most important underpinnings of personal happiness and of a productive society. It is a universal focus of human experience, spanning cultures, societies and history.

At heart, it is the aspiration and desire of all healthcare stakeholders – including clinicians, organisational leaders and managers, policy makers, funders, and of course citizens and their families – to seek to improve and continually ensure that the very best health and healthcare outcomes can be delivered for all members of society. However, the reality of the diverse contexts and perspectives of those stakeholders, the pressure of time and funding constraints, and the need to ensure that a myriad of compliance and performance requirements are met, often conspire to narrow the focus away from the potential to adopt novel approaches to achieve their common aspiration.

Therefore, a responsible approach to the deployment of such novel methods and tools, and especially of the burgeoning plethora of digital innovations, requires rigorous evaluation to ensure that the shared aspirations of all stakeholders to achieve a better future state of health and wellness for all can be achieved.

It is in that context that applied research in healthcare, and its deployment for the optimal benefit of individuals, communities and populations, continues to be one of the most promising, exciting and diverse areas of the pursuit of scientific knowledge. The exponential growth of innovation in research methods, the ubiquity of digital platforms, the development of intelligent systems, and new methods for rapid prototyping and deployment of novel solutions, in aggregate offer the promise of their application yielding enormous benefit to society.

However, the sheer volume and pace of innovation and the desire for finding perfect solutions to complex challenges, must also be tempered by ensuring that those innovative solutions do, in fact, deliver their intended benefits. It is therefore in the application of such solutions that a critical appraisal of their true value, as well as their limitations, and their optimal deployment, is required.

This Handbook of Research on Optimizing Healthcare Management Techniques presents a rich series of timely papers that report and critically appraise diverse approaches to the application of innovative tools and methods that seek to address serious, pressing challenges in health and healthcare management. In doing so it provides valuable and insightful guidance to key stakeholders involved in the delivery of healthcare – especially clinicians, organisational leaders and managers, policy makers, and funders – while also presenting valuable research insights for ongoing related theoretical and applied research.

The breadth of described applications – including for complex health conditions, aged care, mental health, communities of need, coordination of care, analytics, and self-care – are further expanded into the implications of the adoption of innovations from the perspectives of policy setting, planning for care, and management. Further, the rigor of scientific theory as a critical underpinning, is explored in several key and fascinating papers.

This Handbook is a current as well as a forward-looking resource for all stakeholders and offers insight into some of the most effective current applications of innovation in technologies and methods directed to optimizing healthcare management for the benefit of all. I recommend it highly.

John Zelcer
Swinburne University of Technology, Australia

Preface

PREFACE

The preface to the first edition of this Handbook started by noting that “Healthcare is an important industry that touches most, if not all of us at some time in our lives.” This certainly holds true today and one might even say, arguably, is even more important than ever before. Why? Simply stated, because of the challenges facing healthcare delivery including the exponentially increasing costs to keep everyone healthy and living longer, longer life expectancy, an aging population and the rapid rise of chronic conditions.

Indeed, healthcare or modern medicine 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 continues to be extremely slow to adopt technologies that focus on better practice management, support a superior patient experience and / or enable more effective and efficient administrative needs.

Presently, healthcare continues to grapple 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 or by making processes more efficient, effective and streamlined. Because of the rapidly decreasing cost structure of hardware, technology is now able to provide many functions that were not previously available, such as connectivity through mobile devices. Thus, digital health 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.

Unlike the first edition the chapters are not arranged into sections but rather flow logically from a more higher level of themes to more specific aspects. In addition, it is noted that chapters are sourced from around the world to provide insights into unique aspects in particular regions or countries but also to highlight that many of the issues are universal and affect healthcare stakeholders no matter in which country they live. Taken together they serve to underscore key enablers to facilitating appropriate healthcare administration and management, supporting a healthcare value proposition of improving access, quality, and value and providing a superior patient experience enabled by digital health technologies.

CHAPTER 1

This chapter serves to highlight the changing dynamics for healthcare organizations with the volumes and lakes of data they now must process. A situation that is further fueled by the advances in technologies and medical science and the incorporation of digital health solutions that enable us to isolate genome sequencing data. However, it is the thesis of this chapter that unless healthcare organisations become learning organisations and incorporate the techniques of knowledge management and organisational learning these large and essentially raw data assets will become a burden and not a benefit. Thus, healthcare systems need to be redesigned into intelligent health systems that maximises technology and utilises valuable knowledge assets. The chapter notes that to do this it is imperative to understand the link between the principles of organisational learning and Knowledge Management (KM) to facilitate the building of learning healthcare organisations.

CHAPTER 2

WhatsApp is evaluated in the presented study as a peer coach group support tool in a healthy lifestyle intervention with 15 young professionals. These individuals were time-constrained professionals, so two design challenges were to create enough attractiveness and quality in the peer group interactions. There were three main health domains: food, physical activity and mental energy. Based on the results, the authors hypothesize that user needs in the first five weeks were well supported, but that user support needs seemed to change after the initial five weeks, which impacted the perceived added value from the WhatsApp group.

CHAPTER 3

This chapter focusses on the fact that the growth of the healthcare sector has led to innovative ways to cater to consumers' needs, with some of the rich, developed countries at the forefront. Further, its thesis is that an in-depth understanding of them enables a successfully implemented and useful system for consumers. Thus, the authors in this chapter, take a general look at public reporting on health and social care services. They examine the existing reporting systems and the issues they encounter.

CHAPTER 4

This chapter reports on how interaction between family members and caregivers as perceived by family members could be improved via context-aware, imperceptible internet of things (IoT)-based solutions. The presented qualitative study focused on investigating experiences of the family members and the communication between caretakers in sheltered accommodation. Interviews including both open and closed questions revealed that there is high need for improving the communication, adding to the sparse earlier knowledge. The study revealed that the family members were willing to adopt an application to improve the communication that currently was experienced as too limited and vague. The results provide a fruitful base for further actions to improve communication between family members and professional caretakers.

CHAPTER 5

Using the Social Heuristic Theory, the Elaboration Likelihood Model and the Unified Theory of Acceptance and Use of Technology, the presented study in this chapter proposes a model that examines the persuasive mechanisms for the elderly to use patient portals. An empirical study involving 117 subjects in the United States was used to test the proposed model. Using the partial least squares method, social power and imitate-the-successful social heuristics were found to significantly influence patient portal acceptance among the elderly. These findings indicate that older people invest less effort cognitively elaborating when presented with technology acceptance decisions and accept influence from their higher status peers from their network.

CHAPTER 6

This chapter looks at the need for innovative technologies that monitor and assist independent living of elderly people in their homes is growing. The socio-economic benefits by utilizing such solution are shared between many parties including the elderly people, support services & caregivers and the medical system. Moreover, the chapter proposes the wearable smart clothing based monitoring system for home cared elderly patient. The development of the prototype smart cloth, which currently senses and alerts the body temperature is discussed in this chapter. The proposed system is expected to provide a more dignified life for the elderly home cared patients by maintaining their independence and privacy while saving public and private money.

CHAPTER 7

This Chapter notes that information technology has enabled healthcare providers such as hospitals to extend their internal operations into external facilities such as urgent and ambulatory care centers and optimize resources in support of patient care. Specifically, this chapter looks at hospital engagement with patients in two settings—the emergency room (ER) and the patient room (PR)—to illustrate both the opportunities and the strategies that help hospitals use patient touchpoints to improve continuity of care inside and outside hospital walls.

CHAPTER 8

The thesis of this chapter is that with the advancements of the technologies of the Internet of Things (IoT) we are witnessing great advances in the areas of analytics, sensors, platforms, 3D printing and mobile. At the same time and unrelated we are also witnessing a growing increase in the decreasing health and wellness of people in minority communities especially with regard to increase in chronic conditions such as diabetes and obesity. Thus, there exists an opportunity to leverage these IoT technologies to try to support better minority health and wellness.

CHAPTER 9

Many apps and analyzers based on machine learning have been designed already to help and cure the stress issue which is increasing as epidemic now a days' rapidly. The presented project that forms the focus of this chapter is based on an experimental research work that we have performed at Research Labs and Scientific Spirituality Centers of Dev Sanskriti VishwaVidyalaya, Haridwar and Patanjali Research Foundations, Uttarakhand. In this research work, the correctness and accuracy have been studied and compared for two biofeedback devices named as Electromyography(EMG) and Galvanic Skin Response (GSR) which can operate in three modes: audio, visual and audio-visual with the help of data set of Tension Type Headache (TTH) patients. The authors have realized by their research work that these days people have lot of stress in their life so we planned to make an effort for reducing the stress level of people by our technical knowledge of Computer Science.

CHAPTER 10

Governments often create policies that rely on implementation by arm's length organizations and require practice changes on the part of different segments of the health care system without understanding the differences in and complexities of these agencies. The research presented in this chapter describes 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 the health system as a framework of analysis, the chapter explains that the outcome of health policy implementation determines the availability, quality and equability of program service delivery.

CHAPTER 11

The focus of this chapter is on telemedicine maturity models which aim to support telemedicine scaling up. Moreover, the chapter notes that even though a diversity of telemedicine maturity models, and further support tools, exist, they are often unable to support users proactively or offer substantial guidance for the improvement of the status quo. A new maturity model is therefore needed, which overcomes the shortcomings evident in existing approaches. This chapter thus, aims to identify requirements that such a model has to fulfil, based on an analysis of existing maturity models. The results guide future research and can support the scaling up of telemedicine initiatives.

CHAPTER 12

This chapter presents a novel approach to solving a particular pain point in acute care contexts in Australia. For patients undergoing surgery in a multi-day admission, standard care requires that their surgeon will review the patient post-operatively to check on their progress. This is usually done by the specialist attending in person. However, in the Australian setting, most specialists work at multiple institutions. As a result, review ward rounds, especially of post-operative patients for example, can be delayed, which can delay management decisions and discharge, which in turn may lower patient satisfaction. A telemedicine solution is designed and results from a pilot test are examined to assess the benefits of incorporating an electronic discharge capability into the current process.

CHAPTER 13

Crowdsourcing has a role to play in solving health care based problems as it can tap into a vast pool of global medical knowledge. This chapter first categorizes the various problems in the health care industry. It then describes the differences in various medical traditions in solving medical problems. The chapter also discusses the challenges in identifying the ideal medical solution. It notes the various types of obstacles to adopting effective health care solutions and suggests crowdsourcing solutions that could build up an impetus for bringing about positive change. Finally, 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.

CHAPTER 14

The negative and unbalanced nature of media and social media coverage has amplified anxieties and fears about the Ebola outbreak. In this chapter the authors analyse news articles on the Ebola outbreak from two leading news outlets, together with comments on the articles from a well-known social media platform, from March 2014 to July 2015. The volume of news articles were greatest between August 2014 and January 2015, with a spike in October 2014, and were driven by the few cases of transmission in Europe and the USA. Sentiment analysis reveals coverage and commentary on the small number of Ebola cases in the Europe and the USA were much more extensive than coverage and commentary on the outbreak in West Africa. Articles expressing negative sentiments were more common in the USA and also received more comments than those expressing positive sentiments. The negative sentiments expressed in the media and social media amplified fears about an Ebola outbreak outside West Africa, which increased pressure for unwarranted and wasteful precautionary measures.

CHAPTER 15

Blockchain is a decentralized, digital ledger that keeps a permanent, unalterable record of transactions between users. One of the greatest advantages of Blockchain is that it is much more secure than other data storage platforms, and thus particularly relevant for healthcare. This chapter serves to outline areas and opportunities for deploying this technology into key healthcare contexts to support effective and efficient operations, as well as heightened transparency and trust around activities between and within stakeholders.

CHAPTER 16

3D printing has developed as a modification of an old inject printer. Today, it is rapidly expanding offering novel possibilities as well as new exciting applications for various sectors including: healthcare, automotive, aerospace and defense industries. This chapter presents key application areas within the healthcare sector. In medicine 3D printing is revolutionizing the way operations are carried out, disrupting prosthesis and implant markets as well as dentistry. The relatively new field of bioprinting, has come to be because of advances with this technology. As will be discussed, numerous applications of 3D printing in healthcare relate to personalized medicine. For instance, implants or prostheses are 3D printed for a specific user's body, optimizing the technology to work for an individual, not an average user as with most mass produced products. In addition, 3D printing has applications on the nanoscale with printing of drugs and other smaller items. Hence, 3D printing represents a disruptive technology for healthcare delivery.

CHAPTER 17

The number of cases claimed by cancer places it among the top 3 chronic diseases both in developed countries as well as underdeveloped countries. The diagnosis, medication and treatment for cancer is extremely costly. Typically, cancer treatment involves surgery, radio and chemo-therapy. Owing to the extremely high price of medicine and treatment along with cytotoxicity of medication, cancer treatment warrants extra ordinary care in treating cancer patients. Oncology information systems (OIS) provide an all in one solution for such problems. The OIS can integrate different treatment protocols, update change in dose and treatment in real time. This chapter provides an evaluation of different OIS.

CHAPTER 18

Patient lead time in emergency units is a critical factor for quality of care and patient safety. The object of this chapter is a public emergency care hospital of a Brazilian city, important for its localization in the second more populated area of the city. Green risk patients constitute more than a half of attendances and represent the largest volume of out-of-goal attendances in the hospital. Considering this analysis, it was conducted the process modelling in order to understand patient pathway and the main related problems. A list of undesirable effects was subsequently composed, allowing the construction of the Current Reality Tree (CRT). With the root causes identified, the literature suggested fast track as an alternative to reduce the average waiting time in queue until the medical care. The method used for testing scenarios of fast track was discrete events simulation.

CHAPTER 19

Digital Innovation for Health Data Analytics have faced obstacles in systems implementation & consumer acceptance. Research suggests that digital health innovation has been a challenge and a slow process for acceptance. At the same time it offers tremendous opportunities in Health Data Analytics for consumers of health services & service providers, such as health information portability, personalization of health information by consumers, easy access and usefulness of health information, better management of data records by institutions & government, and management of information by healthcare staff for patients' engagement and care. Health Data Analytics is the key for driving a Digital Systems for Health Innovation. The presented research in this chapter seeks to identify the digital health innovation opportunities and obstacles, develop a framework & a conceptual model for digital health innovation that empowers consumer of digital health to use the information to make informed decisions and choices.

CHAPTER 20

A key activity in healthcare is clinical decision making. This decision making typically has to be made rapidly and often without complete information. Moreover, the consequences of these decisions could be far reaching including the difference between life or death. Today analytics can assist in clinical decision making as the following chapter highlights. However, to gain the most from any type of analytics it is first necessary to fully understand the dynamics around the clinical decision making process as this chapter sets out to present.

CHAPTER 21

On the one hand, predictive analytics is an important field of research in Information Systems; however, research on predictive analytics in healthcare is still scarce in IS literature. One area where predictive analytics can be of great benefit is with regard to unplanned readmissions. While a number of studies on readmission prediction already exists in related research areas, there are few guidelines to date on how to conduct such analytics projects. To address this gap this chapter presents the general process to develop empirical models by Shmueli and Koppius and extends this to the specific requirements of readmission risk prediction. Based on a systematic literature review, the resulting process defines important aspects of readmission prediction. It also structures relevant questions and tasks that need to be taken care of in this context. The authors contend that this extension of the guidelines by Shmueli and Koppius provides a best practice as well as a template that can be used in future studies on readmission risk prediction, thus allowing for more comparable results across various research fields.

CHAPTER 22

The presented study in this chapter aims to identify predictors for patients likely to be readmitted to a hospital within 28 days of discharge and to develop and validate a prediction model for identifying patients at a high risk of readmission in an Australian healthcare context. Numerous attempts have been made to build similar predictive models. However, the majority of existing models suffer from at least one of the following shortcomings: the model is not based on Australian Health Data; the model uses insurance claim data, which would not be available in a real-time clinical setting; the model does not consider socio-demographic determinants of health, which have been demonstrated to be predictive of readmission risk; or the model is limited to a particular medical condition and is thus limited in scope.

CHAPTER 23

Intelligent tools and collaborative systems can be used in healthcare contexts to support clinical decision making. Such an approach is concerned with identify the way in which information is gathered and decisions are made along specific care pathways. This chapter presents research that develops a real-time collaborative system using an Intelligent Risk Detection Model (IRD) to improve decision efficiency in the case of Hip and Knee Arthroplasty. The benefits of adopting this solution include increasing awareness, supporting communication, improving decision making process and also improving information sharing between surgeons as key collaborative parties in the research case. This in turn leads to higher levels of patient and clinical satisfaction and better clinical outcomes.

CHAPTER 24

Diabetes type 2 is a chronic condition that currently has no cure. Hence, proper management is key as the best approach to ensure the wellness of sufferers. To establish the attitudes of self-care patients towards the management of this ailment, the authors in this chapter designed a study that targeted 100 Australian residents in the first phase. These participants provided quantitative and qualitative information about various diabetes type 2 management practices that include exercising and diet management and the co-morbidities they currently suffer.

CHAPTER 25

Today most people have at least one smart phone irrespective of socio-economic standing. Such a penetration of mobile phones has enabled mobile health to rapidly develop over the last 5 years. There are many benefits to patients and clinicians afforded by mobile health including the convenience of any time anywhere access to data and information and the possibility to monitor so that critical issues can be caught early. One key area is in the post discharge phase as patients return home to ensure they are making good progress. This chapter discusses developments of mobile health solutions and precision post-operative wellness monitoring solutions.

CHAPTER 26

Arguably, the most prevailing chronic disease today is diabetes. The World Health Organization (WHO) notes that diabetes is a silent epidemic, and by 2020, there will be a 54% rise in the total number of individuals diagnosed with this disease. These are distressing figures. Many are turning to technology solutions to assist. What becomes important is the ability to rapidly design and develop appropriate digital health and wellness solutions. The following chapter discusses key considerations around Design Science Research Methodology coupled with User-centred design principles and Co-creation as well as presents the Adaptive Mapping to Realization model.

CHAPTER 27

The U.S. healthcare system has been often characterized as fragmented and disconnected. Lack of effective and concurrent adoption of information technology has been known to be a factor that contributes to the decentralization of healthcare systems. Fragmented systems are also responsible for creating silos that operate with minimal coordination. Clinicians in such systems are providing duplicate services because they are not aware of patient care plans set by other practitioners. These duplications could lead to prescription drug errors due to inconsistencies and lack of coordination in the treatment services and in some cases drug-drug interactions. The following suggests a role for technology to facilitate better care co-ordination.

As noted in the first edition, 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. It serves to build on the first edition by incorporating new material and developments. This is thought to be especially prudent given the rapid and dynamic nature of digital health innovation; often what is possible today was not even imagined yesterday.

The book is targeted at all healthcare stakeholders who have an interest in the role of- and for digital health. It is useful for healthcare practitioners, healthcare executives, managers as well as researchers, consultants and students and/or even the population at large. It is expected that on reading this work not only will many questions be answered but many more will arise, because it is only through questioning, reflecting and discourse that we can ensure our healthcare delivery systems are continuously improving and incorporating the latest and best digital health solutions that enable the realisation of better quality, access and value as well as a superior patient experience. Healthcare affects us all, and it is my hope that on reading this you will feel inspired to move the needle in improving healthcare delivery.

The Editor

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This book would not be possible without the efforts of many people. First and foremost, a big thank you to all the authors who have contributed to this volume. I am also grateful to my institutions Swinburne University of Technology and Epworth HealthCare for affording me the time to work on pulling this Handbook together. I wish to express thanks to my colleagues around the world for time set apart for discussions of critical ideas and issues and their support and suggestions which have collectively made this volume a quality work. Lastly, a big thank you to Jan and the team at IGI for their assistance and efforts in progressing this book project to publication.

Chapter 1
The Need for Developing Learning Healthcare Organisations

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ABSTRACT

As the volumes of data generated in healthcare delivery grows, the need for embracing big data strategies and data analytic techniques to better navigate dynamic and complex healthcare environments becomes more and more pressing. This focus has been further fuelled by the advances in technologies and medical science and the incorporation of digital health solutions that enable us to isolate genome sequencing data. However, it is the thesis of this chapter that unless healthcare organisations become learning organisations and incorporate the techniques of knowledge management and organisational learning, these large and essentially raw data assets will become a burden and not a benefit. Thus, healthcare systems need to be redesigned into intelligent health systems that maximise technology and utilise valuable knowledge assets. To do this, it is imperative to understand the link between the principles of organisational learning and knowledge management (KM) to facilitate the building of learning healthcare organisations.

INTRODUCTION

In knowledge-based organizations, knowledge is an essential element that is generated, developed and circulated by knowledge workers and through doing so business growth, sustainability and competitive advantage are enabled (Ganguly et al., 2012). In fact, many have noted that knowledge is the only sustainable source of competitive advantage for organisations (Davenport & Prusak, 1998 Davenport & Grover, 2001; Wickramasinghe, 2003, 2005; Wickramasinghe & Lichtenstein, 2006; von Lubitz & Wickramasinghe, 2006). The change in knowledge occurs both at an individual level and at an organisational level when learning takes place (Senge, 1990) which is usually when new data and

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/or information are added to the extant knowledge base (Senge, 1990) .The longer-term impact of well-managed knowledge depends on the approach and systems tailored for the continuity of sharing of knowledge workers' skills and know-how (Senge, 1990) in which a significant part of this organizational knowledge is retained by the experienced employees. This is why organizations are affected when these employees leave and take with them their expertise as well as part of the organization's memory (Senge, 1990). In contrast, the ability to store generated knowledge and apply it to enhance superior decision making when required, as well as continue to build on this extant knowledge is quintessentially the domain of organisational learning (Ganguly et al., 2012). This not only ensures that the organisations horse power and intellect is applied to specific problems at all times but also ensures knowledge is not lost when knowledge workers leave the organisation. It is the thesis of this chapter that it would be prudent for healthcare organisations to develop into learning organisations and thereby, ensure that at all times the extant knowledge is applied to current problems as well as ensuring that the extant knowledge continually grows and is enriched as the organisation evolves with time. Given the current challenges facing healthcare of escalating costs, growing and aging populations as well as the rise of chronic diseases, this appears to be a prudent strategy. Moreover, given the rise of big data and data analytics, such a strategy would also ensure maximisation of current large amounts of raw data assets.

Generally, organisations have been slow to maximise the potential of their raw data asset while healthcare organisations have been particularly deficit. In the case of healthcare organisations, these data assets are generated during the care processes and are used in part to develop new treatment models and more efficient administrative processes between providers, insurers, payers and patients (Wickramasinghe and Schaffer, 2006). Given the significant volumes of heterogeneous data that are generated during the care processes and the considerable impact that these data can have on treatment outcomes, this current state of incomplete utilisation of knowledge assets is unacceptable. Creating a learning healthcare organisation requires the integration of organisational learning techniques and a process centric perspective to KM.

KM, Organisational Learning And The Learning Organisation

Knowledge management (KM) is a rapidly evolving domain aimed at addressing current challenges to increase efficiency and efficacy of core business processes while simultaneously incorporating continuous innovation. The need for knowledge management is based on a growing realisation by the business community that knowledge is central to organizational performance, and integral to the attainment of a sustainable competitive advantage (Davenport & Grover, 2001; Drucker, 1993). Such a fundamental macro-level shift also has consequent and significant implications upon both meso-level and the micro-level processes throughout organizations. Indeed the assimilation and implementation of knowledge management concepts, tools, techniques and strategies, i.e., the adoption of Knowledge Management Systems (KMS) and subsequent transforming to become a knowledge-based requires the correct choice of various tools and techniques to be applied in a coordinated fashion to all organizational operations so that knowledge driven and knowledge generating business process and activities result. To do this effectively and systematically, it is essential to have in place an appropriate KM strategy.

Siemens, affiliating with CIBIT (a Dutch knowledge management company), has developed a suitable Knowledge Strategy Process (KSP) (Hofer-Alfeis, 2003). This KSP can be used as a strategic tool by stakeholders and managers for assessing the intellectual capital in their organizations. This model of knowledge assessment has three dimensions; namely, proficiency, diffusion and codification.

As well as the KSP described above, a sound Knowledge Management Infrastructure (KMI) is a further critical consideration for organisations as they try to wrestle with current business challenges, to increase efficiency and efficacy of their core business processes, while simultaneously incorporating continuous innovation (Alavi & Leidner, 2001; Markus, 2001; Sharma, Gupta & Wickramasinghe, 2005). However, the connection between incorporating KM tools, techniques and strategies, and thereby, building a strong KMI, and simultaneously evolving into a learning organisation is less well discussed in the literature and even more poorly achieved in practice. By recognising the direct connection between organisational learning and KM, it is not only possible to develop a successful KM initiative but also more importantly make the transition to a learning organisation. Conversely, by ignoring this integral connection, it is highly probable that KM initiative will neither realise its anticipated goals nor be truly successful. Table 1 summarises the key elements of a suitable KMI. It is only by all these elements in turn that it is possible for an organisation to evolve into a learning organisation.

Table 1. Key elements of a KMI

Element of the Knowledge Management Infrastructure	Description
Infrastructure for Collaboration	The key to competitive advantage and improving customer satisfaction lies in the ability of organizations to form learning alliances; these being strategic partnerships based on a business environment that encourages mutual (and reflective) learning between partners (Holt et al., 2000). Organizations can utilize their strategy framework to identify partners, and collaborators for enhancing their value chain.
Organizational Memory	Organizational memory is concerned with the storing and subsequent accessing and replenishing of an organization's "know-how" which is recorded in documents or in its people (Maier et al 2000). Thus, strong organizational memory systems ensure the access of information or knowledge throughout the company to everyone at any time (Croasdell, 2001).
Human Asset Infrastructure	This deals with the participation and willingness of people. The human asset infrastructure then, helps to identify and utilize the special skills of people who can create greater business value if they and their inherent skills and experiences are managed to make explicit use of their knowledge.
Knowledge Transfer Network	This element is concerned with the dissemination of knowledge and information. Unless there is a strong communication infrastructure in place, people are not able to communicate effectively and thus are unable to effectively transfer knowledge.
Business Intelligence Infrastructure	In an intelligent enterprise various information systems are integrated with knowledge-gathering and analyzing tools for data analysis, and dynamic end-user querying of a variety of enterprise data sources (Hammond, 2001). The intelligence of a company is not only available to internal users but can even be leveraged by selling it to others such as consumers who may be interested in this type of informational intelligence.

LEARNING ORGANISATIONS

Learning is defined as acquiring new knowledge and enhancing existing knowledge (Simon, 1999). A learning organisation is an organisation that has an enhanced capacity to learn, adapt and change (Levine, 2001). Learning takes place at two levels – individual and organisational. Huber (1981, 1991) suggests that organisations do not have brains, but they have cognitive systems and memories (Popper and Lipshitz, 2000). As individuals develop their personalities, personal habits and beliefs over time, organisations develop their views and ideologies (Hedberg, 1981). Learning at both individual and organisational levels involves the transformation of data (un-interpreted information) into knowledge (interpreted information). Individual learning and organisational learning are similar except that organisational learning involves an additional phase, dissemination, i.e. the transmission of information and knowledge among different persons and organisational units (Popper & Lipshitz, 2000; Kapp, 1999; Markic, 2005; Senge, 1990, 1994; Simon, 1999).

Scholars and management theorists have noted that, the organisation that becomes a learning organisation will hold an advantage over its competitors because of its ability to learn faster (Markic, 2005; Senge, 1990, 1994; Simon, 1999). Learning organisations are generally described as those that continuously acquire, process, and disseminate knowledge about markets, products, technologies, and business processes (Argyris and Schon 1978; Argyris, 1982; Argote, 1999). This knowledge is often based on experience, experimentation, and information provided by customers, suppliers, competitors, and other sources (Senge, 1990, 1994; Ellinger, Watkins and Bostrom, 1999).

Today, with the embracement of technology we are generating more data than ever before; however turning this data into meaningful and useable, pertinent and germane knowledge has yet to be fully mastered. Organisations need to utilise knowledge across processes and functions, to become knowledge-driven organisations or learning organisations (Nevis, DiBella & Gould, 1997). Peter M. Senge (1990) introduced the concept of learning 'organisation' in his landmark book, The Fifth Discipline: The Art and Practice of the Learning Organisation. A learning organisation is a complex interrelationship of systems composed of people, technology, practices, and tools designed so that new information is embraced (Simon, 1999). Learning organisations are organisations that embed institutionalised learning mechanisms into a learning culture (Popper & Lipshitz, 2000). Further, it is essential that learning organisations continually expand their capacity to be creative and innovative. The only way to sustain competitive advantage is to ensure that the organisation is learning faster than the competition and this can be effectively achieved via incorporating a process perspective to KM.

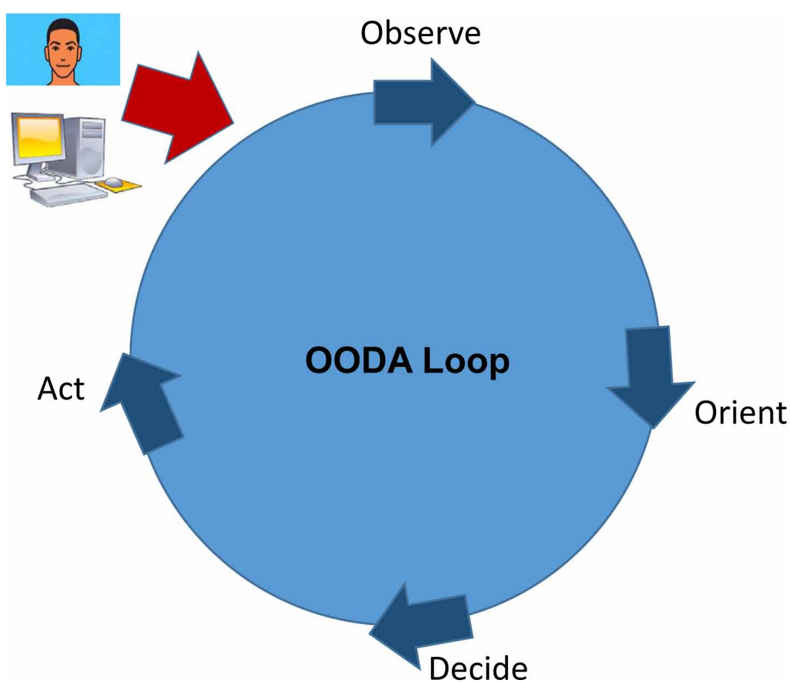
A PROCESS PERSPECTIVE TO KM

In this millennium, the most valuable resources available to any organisation are human skills, expertise, and relationships. KM is about capitalising on these precious assets (Duffy, 2001). Intangible assets include human capital (tacit knowledge and competencies), structural capital (intellectual property, methods and policies), social capital (relationships), and organisational capital (customer relationships and agreements). There are two levels of organisational learning – the contribution level (where people learn, collaborate and innovate) and the multiplier level (where what comes from the contribution level is passed along the rest of the organisation through processes such as mentoring, networking and inspiring (Sharma, Gupta & Wickramasinghe, 2005; Wickramasinghe & von Lubitz, 2007).

The connection between the process of organisational learning and KM can be seen on examining one of the key aspects of KM; namely the generation and acquisition of knowledge. Within KM, the two predominant approaches to knowledge generation are people centric and technology centric (Wickramasinghe, 2005). A people oriented perspective draws from the work of Nonaka as well as Blacker and Spender (Nonaka, 1994; Nonaka & Nishiguchi, 2001; Newell et al., 2002; Schultze & Leidner, 2002). Essential to this perspective of knowledge creation is that knowledge is created by people and that new knowledge or the increasing of the extant knowledge base occurs as a result of human cognitive activities and the effect of specific knowledge transformations (Nonaka, 1994; Nonaka & Nishiguchi, 2001; Newell et al., 2002; Schultze & Leidner, 2002). A technology driven perspective to knowledge creation is centred around the computerised technique of data mining and the many mathematical and statistical methods available to transform data into information and then meaningful knowledge (Adriaans & Zantinge, 1996; Fayyad, Piatetsky-Shapiro & Smyth, 1996; Cabena et al., 1998; Chung & Gray, 1999; Becerra-Fernandez & Sabherwal, 2001; Holsapple & Joshi, 2002; Bendoly, 2003; Choi & Lee, 2003; Award & Ghaziri, 2004).

In contrast, a process centric approach to knowledge creation not only combines the essentials of both the people centric and technology centric perspectives but also emphasises the dynamic, often complex and on-going nature of the process/processes under consideration. This view of knowledge generation is grounded in the pioneering work of John Boyd which he succinctly captured in the OODA Loop ie a systematic and connected process of Observation followed by Orientation, then by Decision, and finally Action (ie OODA loop), which serves to support rapid decision making and extraction of critical and germane knowledge (Boyd, 1987, 2002; von Lubitz & Wickramasinghe, 2006) as it is depicted in Figure 1.

Figure 1. Process perspective of KM
Source: Adapted from Wickramasinghe and von Lubitz (2006).



The loop is based on a cycle of four interrelated stages essential to support critical analysis and rapid decision making that revolve in both time and space: OODA. At the observation and orientation stages, implicit and explicit inputs are gathered or extracted from the environment (observation) and converted into coherent information (orientation). The latter determines the sequential determination (knowledge generation) and action (practical implementation of knowledge) steps. The outcome of the action stage then affects, in turn, the character of the starting point (observation) of the next revolution in the forward progression of the rolling loop. Hence, the generation and acquisition of new knowledge, which involves a change to the extant knowledge base reflects organisational learning or conversely organisational learning is closely associated with the process of knowledge creation, and knowledge creation is contingent on prior learning. However, neither learning nor knowledge creation are considered to be linear processes. Moreover OODA thinking support all types of learning.

TYPES OF LEARNING

There are two major types of learning (Duffy, 2000):

1. **Incremental:** Learning that is characterised by simple, routine problem solving and that requires no fundamental change to your thinking or system.
2. **Radical:** Breakthrough learning that directly challenges the prevailing mental model on which the system is built. Learning can be further classified as adaptive and generative learning (Wickramasinghe & von Lubitz, 2006).

The dominant view of organisations is based on adaptive learning, which is about coping (Wickramasinghe & von Lubitz, 2006). Senge (1990) notes that increasing adaptiveness is only the first stage; companies need to focus on generative learning or 'double-loop learning' (Argyris, 1982). Generative learning emphasises the continuous experimentation and feedback in an ongoing examination of the very way organisations go about defining and solving problems. In Senge's (1990) view, generative learning is about creating – it requires 'systemic thinking', 'shared vision', 'personal mastery', 'team learning', and 'creative tension'.

Generative learning, unlike adaptive learning, requires new ways of looking at the world.

In contrast, adaptive learning or single-loop learning focuses on solving problems in the present without examining the appropriateness of current learning behaviours. Adaptive organisations focus on incremental improvements, often based upon the past track record of success. Essentially, they do not question the fundamental assumptions underlying the existing ways of doing work. The essential difference is between being adaptive and having adaptability.

A learning organisation distinguishes itself, in particular, by a culture that encourages generative- or double-loop (Argyris, 1977) learning in addition to possessing receptivity to adaptive or incremental improvement. Generative- or double-loop learning is thinking which challenges the dominant logic or assumptions that guide decision making within an organisation from the lowest level of operation to Chief Executive Officer (CEO's) office. Therefore, it is incremental and transformational. Generative learning contrasts with adaptive learning; adaptive learning seeks improvements within the mental constraints of the prevailing assumptions about how an organisation currently does or should conduct business (Dodge, 1991; Duffy, 2000).

Generative learning, unlike adaptive learning, requires new ways of looking at the world. Generative learning requires seeing the systems that control events. When we fail to grasp the systemic source of problems, we are left to 'push on' symptoms rather than eliminate underlying causes. Without systemic thinking, the best we can ever do is adaptive learning. The secret of the learning organisation is to find the leadership, institutional arrangements, and cultural elements that result in generative learning as a continuous process.

Creating Learning Healthcare Organisations

Integral to creating a learning organisation is the need to foster KM technologies and enable knowledge workers. The process centric perspective of KM serves to underscore theoretically how important it is to foster organisational learning through the incorporation of KM tools and technologies as well as fostering human expertise so that superior decision making will ensue. What remains to be discussed is how healthcare organisations should effect such a transformation. As discussed in previous research, critical to any successful KM initiative is the development of KMI.

Implementing KMI Elements

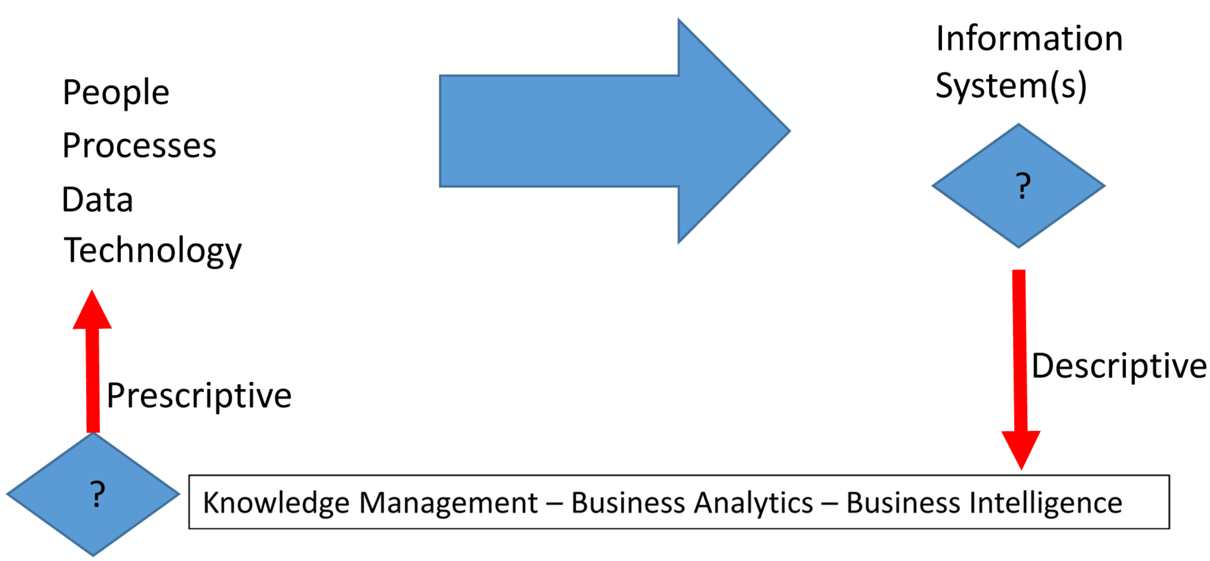
Traditionally, healthcare organisations in the US have structured around treatment protocols and care delivery (Starr, 1982). However, to incorporate KMI elements, described above in Table 1, into a typical healthcare organisation does not require a major physical overhaul rather the judicious implementation of key technologies and the incorporation of new techniques and activities that are enabled by these technologies

The Intelligence Continuum (Wickramasinghe & Schaffer, 2006) is a representation of the collection of key tools, techniques and processes of today's knowledge economy; i.e. including but not limited to data mining, business intelligence/analytics and knowledge management. Taken together they represent a very powerful system for refining the data raw material stored in data marts and/or data warehouses and thereby maximizing the value and utility of these data assets for any organization. The first component is a generic information system which generates data that is then captured in a data repository. In order to maximize the value of the data and use it to improve processes, the techniques and tools of data mining, business intelligence and analytics and knowledge management must be applied to the data warehouse. Once applied, the results become part of the data set that are reintroduced into the system and combined with the other inputs of people, processes, and technology to develop an improvement continuum. Thus, the Intelligence Continuum includes the generation of data, the analysis of these data to provide a "diagnosis" and the reintroduction into the cycle as a "prescriptive" solution (Figure 2).

In today's context of escalating costs in healthcare, managed care in the US, regulations and a technology and health information savvy patient, the healthcare industry can no longer be complacent regarding embracing key processes and techniques to enable better, more effective and efficient practice management. The proliferation of databases in every quadrant of healthcare practice and research is evident in the large number of isolated claims databases, registries, electronic medical record data warehouses, disease surveillance systems, and other ad hoc research database systems 20. Not only does the number of databases grow daily, but even more importantly, so does the amount of data within them. Pattern-identification tasks such as detecting associations between certain risk factors and outcomes, ascertaining trends in healthcare utilization, or discovering new models of disease in populations of individuals rapidly becomes daunting even to the most experienced healthcare researcher or manager (Wickramasinghe & Schaffer, 2006). Yet these tasks may hold the answers to many clinical issues such as treatment protocols or the identification across geographic areas of newly emerging pathogens and thus are important. Add to all of this the daily volumes of data generated and then accumulated from a healthcare organization administrative system, clearly then, the gap between data collection and data comprehension and analysis becomes even more problematic. Information technology (IT) tools coupled with new business approaches such as data mining, business intelligence/analytics and knowledge management should be embraced in an attempt to address such healthcare woes (Wickramasinghe & Schaffer, 2006). Figure 2 highlights important aspects of knowledge in essential healthcare operations (McCormick, 1999; Morrissey, 2002; Wickramasinghe, Geisler & Schaffer, 2005; Wickramasinghe et al., 2006).

The essential backbone for establishing the infrastructure for collaboration includes intranet and extranet capabilities and client/server technologies. With such an infrastructure it is then possible for various care givers to coordinate efforts, communicate and collaborate electronically and ultimately devise the most appropriate treatment protocols. In a spine clinic in the Midwest, such a collaboration infrastructure does exist and it provides neuro surgeons, neurologists and orthopaedic surgeons as well as the other key care givers for the back and neck patients to share their expertise and thereby develop superior treatment protocols (Wickramasinghe and Davison, 2004; Wickramasinghe et al., 2004). Other more medical specific systems like Picture Archiving Communication System (PACS) and many of the electronic medical record systems also facilitate such interactions between various healthcare professionals including radiologists and specialists so that more effective and efficient as well as superior diagnoses and treatments can ensue (Serb, 2002).

Figure 2. The impact of the intelligence continuum on the generic healthcare system



The essential technology element to support the organisational memory element is the database. Databases used in this capacity must be carefully structured so that superior treatment protocols and critical lessons, anomalies and key results can be stored, maintained and readily accessible when required. Not only does such a system support effective and efficient healthcare delivery but also provides a useful evidence base for fostering evidence based medicine. Currently, the largest well organised and easy to access, search and retrieve medical data and literature is MedLine (Dearness & Tomlin, 2001; Anagnostelis, 2002; Glanville, Wilson & Richardson, 2003).

Healthcare organisations are plentiful with knowledgeable experts. Thus, the essential input for this element already exists. However, healthcare organisations have also been negligent in maximising this asset at the institutional level. An example of an innovative and useful way to leverage the talents and expertise of the human asset of a healthcare organisation can be seen in the way the Cleveland Clinic[1] has developed there web-based second opinion system. By incorporating intranet and extranet capabilities as well as client/server technologies, this second opinion system enables patients from anywhere in the US, or even internationally, to consult one of the expert physicians for a second opinion on a primary diagnosis (Wickramasinghe, Geisler & Schaffer, 2005). The system enables the key data elements including lab and radiology results as well as patient's history and primary diagnosis to be presented to the physician so that he/she can readily render an insightful second opinion with the support of sophisticated decision support tools. This second opinion is then provided to the patient.

Knowledge is more precisely relevant and germane knowledge is critical for the correct and timely diagnosis and subsequent treatment of patients. The knowledge transfer network in most healthcare organisations has not dramatically changed (Wickramasinghe and Schaffer, 2005). It is possible to address this by incorporating a combination of technologies and several management techniques such as Total Quality Management (TQM) and business process redesign. By continuously evaluating and analysing the volumes of data and information generated through various healthcare processes it is possible to firstly diagnose potential problems either with particular processes or treatments, even identify errors and then simultaneously prescribe process redesign initiatives or superior treatments. These strategies have been applied to a Midwest hospital to redesign its operating theaters for orthopaedic surgery to great benefit of the institution and most importantly the patient (Wickramasinghe and Schaffer, 2005).

Within healthcare there is tremendous scope to incorporate the complete spectrum of intelligence technologies. These technologies such as neural networks could facilitate better detection of malignant tumours or potential cures for epidemics such as avian flu (Johns, 1997; Sharma et al., 2006). In addition, the suite of business intelligence tools can also enable better practice management techniques to ensue (Applebaum & Wohl, 2000). The key with respect to the implementation of any of the intelligence technologies is to ensure that its systematic use does in fact support superior access, quality and value.

Many healthcare organisations currently have some of KMI elements in place to a greater or lesser extent. However, this is not sufficient for them to be learning healthcare organisations. Learning healthcare organisations must not only have all these elements in place they must support continuous improvement and learning by ensuring that new knowledge gained in the current state is applied in the future state so that the extant knowledge base always increases with germane and relevant knowledge, decision making is then supported by the 'best available' knowledge and thereby better healthcare delivery ensues.

CONCLUSION

To date the information age has been leaving healthcare behind. Healthcare can no longer allow this situation to continue and it is imperative that an intelligent healthcare system is developed that leverages of the tools, technologies and strategies of the knowledge economy. To effect such a transformation, requires changes at both the individual but more importantly the institutional level. Changes at the institutional level must be substantive. What is required is the creation of learning healthcare organisations which are flexible, focus on the effective and efficient management of their knowledge assets, foster organisational learning strategies so that superior access, quality and value; i.e. the value proposition for any health system, can in fact be realised. As eluded to in this chapter, to create learning healthcare organisations, requires the establishment of a robust KMI that support human and technical organisational assets, the incorporation of a process centric perspective of knowledge creation and the fostering of organisational learning strategies. Without such a commitment, healthcare organisations can never become learning healthcare organisations and the required change to the existing and out dated healthcare system will be incremental at the best, analogous to rearranging the deck chairs on the titanic.

Currently, healthcare is facing a major challenge to be cost effective and efficient and yet provide quality care. Without making the transformation to learning healthcare organisations, and thereby, creating pertinent information and germane knowledge and then applying this knowledge to enable superior decision making and facilitate continuous improvement, it will never be possible for healthcare to address this present dilemma. As has been evidenced in the business environment, the only sustainable solution lies in embracing the tools and techniques of becoming a learning organisation. The development of learning healthcare organisations should be an imperative as healthcare organisations automate medical record systems such as with the adoption of EMR (electronic medical record) solutions and the incorporation of more digital solutions; hence more research in this area is clearly needed.

REFERENCES

Adriaans, P., & Zantinge, D. (1996). *Data Mining*. New York, NY: Addison-Wesley.

Alavi, M., & Leidner, D. (2001). Review: knowledge management and knowledge management systems: conceptual foundations and research issues. *Management Information Systems Quarterly*, *25*(1), 107–136. doi:10.2307/3250961

Anagnostelis, B. (2002). *A guide to healthcare resources on the internet*. Academic Press.

Applebaum, S. H., & Wohl, L. (2000). Transformation or change: Some prescriptions for health care organizations. *Managing Service Quality*, *10*(5), 279–298. doi:10.1108/09604520010345768

Argote, L. (1999). *Organizational Learning: Creating, Retaining and Transferring Knowledge*. Berlin: Springer.

Argyris, C. (1982). *Reasoning, Learning and Action: Individual and Organizational*. San Francisco: Jossy-Bass, Inc.

Argyris, C., & Schon, D. (1978). *Organizational Learning: a Theory of Action Perspective*. Reading: Addison-Wesley Publishing Co.

Award, E., & Ghaziri, H. (2004). *Knowledge Management*. Upper Saddle River, NJ: Prentice Hall.

Becerra-Fernandez, I., & Sabherwal, R. (2001). Organizational knowledge management: A contingency perspective. *Journal of Management Information Systems*, *18*(1), 23–55. doi:10.1080/07421222.2001.11045676

Bendoly, E. (2003). Theory and support for process frameworks of knowledge discovery and data mining from ERP systems. *Information & Management*, *40*(7), 639–647. doi:10.1016/S0378-7206(02)00093-9

Boland, R. Jr, & Tenkasi, R. (1995). Perspective making perspective taking. *Organization Science*, *6*(4), 350–372. doi:10.1287/orsc.6.4.350

Boyd, J. R. (1987). In Patterns of Conflict. Retrieved from Essence of Winning and Losing: http://www.d-n-i.net

Boyd, J. R. (2002). Destruction and Creation. In *R Coram 'Boyd' Little*. New York: Brown & Co.

Bush, G. (2004). State of the Union Address. *The White House*. Available at http://www.whitehouse.gov/news/release/2004/01/20040120-7.html

Cabena, P., Hadjinian, P., Stadler, R., Verhees, J., & Zanasi, A. (1988). *Discovering Data Mining from Concept to Implementation*. Upper Saddle River, NJ: Prentice Hall.

Choi, B., & Lee, H. (2003). An empirical investigation of KM styles and their effect on corporate performance. *Information & Management*, *40*(5), 403–417. doi:10.1016/S0378-7206(02)00060-5

Chung, M., & Gray, P. (1999). Special section: Data mining. *Journal of Management Information Systems*, *16*(1), 11–16. doi:10.1080/07421222.1999.11518231

Croasdell, D. C. (2001). IT's role in organizational memory and learning. *Information Systems Management*, *18*(1), 8–11. doi:10.1201/1078/43194.18.1.20010101/31260.2

Davenport, T., & Grover, V. (2001). Knowledge management. *Journal of Management Information Systems*, *18*(1), 3–4. doi:10.1080/07421222.2001.11045674

Davenport, T., & Prusak, L. (1998). *Working Knowledge*. Cambridge, MA: Harvard Business School Press.

Davenport, T. H., Jarvenpaa, S. L., & Beers, M. C. (1996). Improving knowledge work processes. *Sloan Management Review*, *37*, 53–65.

Davenport, T. H., & Prusak, L. (1997). *Working Knowledge: How Organizations Manage What They Know*. Cambridge, MA: Harvard Business School Press.

Dearness, K. L., & Tomlin, A. (2001). Development of the national electronic library for mental health: Providing evidence-based information for all. *Health Information and Libraries Journal*, *18*(3), 167–174. doi:10.1046/j.0265-6647.2001.00344.x PMID:11780750

Dodge, B. (1991). *Learning in an Organizational Setting: the Public Service Context*. Study prepared for the Canadian Centre for Management Development.

Duffy, J. (2000). The KM technology infrastructure. *Information Management Journal*, *34*, 62–66.

Duffy, J. (2001). The tools and technologies needed for knowledge management. *Information Management Journal*, *35*, 64–67.

Ellinger, A. D., Watkins, K. E., & Bostrom, R. P. (1999). Managers as facilitators of learning in learning organizations. *Human Resource Development Quarterly*, *10*(2), 105–125. doi:10.1002/hrdq.3920100203

Fayyad, U., Piatetsky-Shapiro, G., & Smyth, P. (1996). From data mining to knowledge discovery: an overview. In U. Fayyad, G. Piatetsky-Shapiro, & P. S. Uthurusamy (Eds.), *Advances in Knowledge Discovery and Data Mining*. Menlo Park, CA: AAAI Press/The MIT Press.

Ganguly, A., Mostashari, A., & Mansouri, M. (2012). *Measuring Knowledge Management/Knowledge Sharing KM/KS Efficiency and Effectiveness in Enterprise Networks*. Dynamic Models for Knowledge-Driven Organizations.

Glanville, J., Wilson, P., & Richardson, R. (2003). Accessing the online evidence: A guide to key sources of research information on clinical and cost effectiveness. *Quality & Safety in Health Care*, *12*(>3), 229–231. doi:10.1136/qhc.12.3.229 PMID:12792016

Gupta, J. N. D., Sharma, S. K., & Hsu, J. (2003). An Overview of Knowledge Management. In *Creating Knowledge based Organization*. Idea Group Publishing.

Hammond, C. (2001). The intelligent enterprise. *InfoWorld*, *23*, 45–46.

Holsapple, C., & Joshi, K. (2002). Knowledge manipulation activities: Results of a Delphi study. *Information & Management*, *39*(6), 477–419. doi:10.1016/S0378-7206(01)00109-4

Holt, G. D., Love, P. E. D., & Li, H. (2000). The learning organization: Toward a paradigm for mutually beneficial strategic construction alliances. *International Journal of Project Management*, *18*(6), 415–421. doi:10.1016/S0263-7863(99)00066-6

Huber, G. (1991). Organization science organizational learning: The contributing processes and the literatures. *Organization Science*, *2*(1), 88–115. doi:10.1287/orsc.2.1.88

Johns, P. M. (1997). Integrating information systems and health care. *Logistics Information Management*, *10*(4), 140–145. doi:10.1108/09576059710187555

Kapp, K. M. (1999). Transforming your manufacturing organization into a learning organization. *Hospital Materiel Management Quarterly*, *20*, 46–54. PMID:10387780

Levine, L. (2001). Integrating knowledge and processes in a learning organization. *Information Systems Management*, *18*(1), 21–33. doi:10.1201/1078/43194.18.1.20010101/31262.4

Maier, R., & Lehner, F. (2000). Perspectives on Knowledge Management Systems Theoretical Framework and Design of an Empirical Study. *Proceedings of the 8th European Conference on Information Systems (ECIS)*.

March, J. (1981). Decisions in organizations and theories of choice. In A. Van der Ven & W. Joyce (Eds.), *Perspectives on Organization Design and Behavior*. New York: Wiley.

Markic, M. (2005). Innovation processes and quality development. *Int. J. Innovation and Learning*, *2*(3), 246–260. doi:10.1504/IJIL.2005.006368

Markus, L. (2001). Toward a theory of knowledge reuse: Types of knowledge reuse situations and factors in reuse success. *Journal of Management Information Systems*, *18*(1), 57–93. doi:10.1080/07421222.2001.11045671

McCormick, J. (1999). Wireless hospitals: New wave in healthcare technology. *Health Management Technology*, *20*, 12–13. PMID:10538649

Morrissey, J. (2000). 'Internet dominates providers' line of sight'. *Modern Healthcare, Chicago*, *30*, 72–92. PMID:11066427

Morrissey, J. (2001). Wanting more from information technology. *Modern Healthcare, Chicago*, *31*, 66–84. PMID:11216221

Morrissey, J. (2002). High on tech, low on budget. *Modern Healthcare*, *32*, 57–72. PMID:11859552

National Coalition on Healthcare. (2004). *Building a Better Health: Specifications for Reform*. Author.

Nevis, E.C., DiBella, A.J., & Gould, J.M. (1997). *Understanding organizations as learning systems*. Cambridge, MA: MIT. Available at http://learning.mit.edu:80/res/wp/learning_sys.html

Newell, S., Robertson, M., Scarbrough, H., & Swan, J. (2002). *Managing Knowledge Work*. New York: Palgrave.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science*, *5*(1), 14–37. doi:10.1287/orsc.5.1.14

Nonaka, I., & Nishiguchi, T. (2001). *Knowledge Emergence*. Oxford, UK: Oxford University Press.

Popper, M., & Lipshitz, R. (2000). Organizational learning: Mechanisms, culture, and feasibility. *Management Learning*, *31*(2), 181–196. doi:10.1177/1350507600312003

Schultze, U., & Leidner, D. (2002). Studying knowledge management in information systems research: Discourses and theoretical assumptions. *Management Information Systems Quarterly*, *26*(3), 212–242. doi:10.2307/4132331

Senge, P. M. (1990). The leader's new work: Building learning organizations. *Sloan Management Review*, 7–23.

Senge, P. M. (1994). *The Fifth Discipline: the Art and Practice of the Learning Organization*. New York: Currency, Doubleday.

Serb, C. (2002). Health care at your fingertips? *Hospitals & Health Networks*, *76*, 44–46. PMID:12035573

Sharma, S., Gupta, J., & Wickramasinghe, N. (2005). A framework for building a learning organization in the 21st century. *Int. J. Innovation and Learning*, *2*(3), 261–273. doi:10.1504/IJIL.2005.006369

Sharma, S., Xu, B., Ahmed, N., & Wickramasinghe, N. (2006). Electronic healthcare: Issues and challenges. *International Journal of Electronic Healthcare*, *2*(1), 50–65. doi:10.1504/IJEH.2006.008693 PMID:18048234

Simon, N. J. (1999). The learning organization. *Competitive Intelligence Magazine*, *2*, 40–42.

Starr, P. (1982). The Social Transformation of American Medicine Basic Books. Boston: Academic Press.

Thorne, K., & Smith, M. (2000). Competitive advantage in world class organizations. *Management Accounting*, *78*, 22–26.

Von Lubitz, D., & Wickramasinghe, N. (2006). Creating germane knowledge in dynamic environments. *International Journal of Innovation and Learning*, *3*(3), 326–347. doi:10.1504/IJIL.2006.009226

Wickramasinghe, N. (2003). Do we practise what we preach: Are knowledge management systems in practice truly reflective of knowledge management systems in theory? *Business Process Management Journal*, *9*(3), 295–316. doi:10.1108/14637150310477902

Wickramasinghe, N. (2006). Knowledge creation: A meta-framework. *International Journal of Innovation and Learning*, *3*(5), 558–573. doi:10.1504/IJIL.2006.010489

Wickramasinghe, N. (2006). Fostering knowledge assets in healthcare with the KMI model. *International Journal of Management and Enterprise Development*, *4*(1), 52–65. doi:10.1504/IJMED.2007.011455

Wickramasinghe, N., Bloomendal, H., de Bruin, A., & Krabbendam, K. (2004). Enabling innovative healthcare delivery through the use of the focused factory model: The case of the spine clinic of the future. *Int. J. Innovation and Learning*, *2*(1), 90–110. doi:10.1504/IJIL.2005.006086

Wickramasinghe, N., & Davison, G. (2004). Making explicit the implicit knowledge assets in healthcare. *Health Care Management Science*, *7*(3), 185–196. doi:10.1023/B:HCMS.0000039381.02400.49 PMID:15648561

Wickramasinghe, N., Fadlalla, A., Geisler, E., & Schaffer, J. (2005). A framework for assessing e-health preparedness. *International Journal of Electronic Healthcare*, *1*(3), 316–334. doi:10.1504/IJEH.2005.006478 PMID:18048213

Wickramasinghe, N., & Lichtenstein, S. (2006). Supporting knowledge creation with e-mail. *International Journal of Innovation and Learning*, *3*(4), 416–426. doi:10.1504/IJIL.2006.009565

Wickramasinghe, N., & Mills, G. (2001). MARS: The electronic medical record system the core of the Kaiser galaxy. *Health Information Systems and Informatics*, *1*, 68–81. doi:10.4018/jhisi.2006100106

Wickramasinghe, N., Misra, S., Jenkins, A., & Vogel, D. R. (2006). The competitive forces facing e-health. *International Journal of Healthcare Information Systems and Informatics*, *1*(4), 68–81. doi:10.4018/jhisi.2006100106

Wickramasinghe, N., & Schaffer, J. (2006). Creating Knowledge Driven Healthcare Processes With The Intelligence Continuum. *International Journal of Electronic Healthcare*, *2*(2), 164–174. doi:10.1504/IJEH.2006.008830 PMID:18048242

Wickramasinghe, N., & von Lubitz, D. (2007). Knowledge-based Enterprise: Theories and Fundamentals. IDEA Group.

ENDNOTE

[1] www.ccf.org

Chapter 2
WhatsApp Peer Coaching Lessons for eHealth

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ABSTRACT

WhatsApp was evaluated as a peer coach group support tool in a healthy lifestyle intervention with 15 young professionals. These individuals were time-constrained professionals, so two design challenges were to create enough attractiveness and quality in the peer group interactions. There were three main health domains: food, physical activity, and mental energy. As a result of the 12 week pilot, there were 127 WhatsApp peer coaching inputs. The variety of inputs was better than in a previous pilot; peer coaching quality improved; plus there was more continuity following the initial two weeks. Community building remained a challenge, especially in the longer run. Two design solutions seemed to work: pre-designed coach-inputs across health domains, plus the instructions for a health advocate from the group, per health domain. Based on the results, the authors hypothesize that user needs in the first five weeks were well supported but that user support needs seemed to change after the initial five weeks, which impacted the perceived added value from the WhatsApp group.

INTRODUCTION

Previously (Simons 2018, 2019, 2019b), we started researching the added value of social and affective group support in health interventions. In many models, like the HAPA (Health Action Process Approach) model (Schwarzer, 2008; Lippke, 2009; Wiedeman, 2011) and i-change model (De Vries, 1998), as well as in the design of eHealth solutions (Simons 2010), health behaviour improvements appear to revolve

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around setting goals and achieving them. But patient groups (Simons 2016, 2017, 2019b) and professionals (Simons 2012, 2013, 2017b) appeared to have other support motivators as well, which are less functional in nature. One can think of social motivators (like connecting with each other, sharing experiences or showing your best) and affective motivators (like pride, having fun, encouragement or compliments), as also seen in various social media contexts (Khan, 2017; Bitter, 2014; McQuail, 2010; Park, 2009)

As a practical challenge, the diversity across healthy lifestyle groups being coached is large. From patient groups that tend to be relatively ICT-illiterate or even have an ICT-aversion, to highly educated but time-constrained groups of young professionals in a work setting. Thus, a WhatsApp group was chosen as support tool, being an omnipresent technology, which is low-tech, low-threshold and has social media benefits for affective and social support (Schulz, 2014). This study focusses on results from a healthy lifestyle group of young professionals.

In a previous pilot with this target group, several challenges came up (Simons 2018, 2019). First of all, their inputs rapidly declined: 63% of their inputs in the first two weeks and only 14% during the next three weeks (totalling 77% of inputs in the first five weeks). Hence, the eHealth Law of Attrition (Eysenbach, 2005) applied, which states that the majority (80-90%) of initial eHealth tool usage is likely to be lost after several moments of usage, often within a period of several weeks. Second, although we knew that the majority of them had priorities on the topic of mental energy and performance, there were virtually no inputs/responses given on this topic. So this topic was largely neglected in their WhatsApp group interactions. Third, there were two enthusiastic participants who initially became advocates for the topics of food and exercise respectively, but they felt unsupported by responses from the rest of the group. Hence their inputs and motivation to contribute declined over time. The degree of participation is an important challenge; in other social media settings over 90% of users only consume, but do not participate in the sense of providing responses or inputs (Nonnecke, 1999).

Still, peer support and peer coaching have a lot of promise. In section 3 we discuss how we adopted several suggestions from the previous study into the WhatsApp group pilot, in order to improve the quality of the peer coach WhatsApp group. The aim of this pilot is to answer the following research question.

Research Question:

- Can we raise the quality of peer coaching for health with a WhatsApp group?

Sub-question 1.: Can we stimulate WhatsApp attractiveness as indicated by *inputs & user involvement*, using affective and social motivators (like in social media uses)?

Sub-question 2.: Can we stimulate peer coaching *quality* for the users?

THEORY

In this section we use social media research and we discuss peer coaching literature to develop our framework for evaluating the design goal achievement in our pilot. Hence, our theory framework addresses two topics. On the one hand, social and affective support that the WhatsApp group may add to the other health support that exists in the eSupported health program. On the other hand, it is important to review what determines the quality of peer coaching. Overall, this paper has a design focus, following a persuasive technology approach (Fogg, 2002, 2009; Ghorai, 2014; Hamari, 2014) in order to stimulate healthy behaviours.

Table 1. Service design goals for WhatsApp group user inputs and involvement

1. Develop Health Habits	2. Peer Coaching on:	3. Social Support Motives
A. Showing my best and celebrating progress. B. Learning how health behaviours can work for me.	A. Healthy foods. B. Physical activity. C. Mental energy.	A. Asking/giving practical support. B. Asking/giving affective support. C. Fun and humour.

Interesting article overviews in the field of *social media* are provided by Kamel Boulos (2016) on WhatsApp use studies for health, by Regmi (2017) on mobile app and WhatsApp uses focusing on smoking cessation, and by Kulyk (2014) focusing on apps using social, functional and affective cues for healthy lifestyle coaching and serious games. One of the more promising studies (Cheung, 2015) showed that WhatsApp group support was more effective than Facebook or a control condition for stimulating smoking cessation. However, another study (Muntaner-Mas, 2017) showed that WhatsApp support was less effective than face to face coaching. This latter finding is rather relevant for our study, since face to face coaching (plus various eSupport tools) are the base line condition in our current study, where we seek to find additional support value for participants by adding a WhatsApp group to the overall support portfolio. A second limitation from existing studies for our research question is that generally the relative contributions of the functional versus the affective/social support value remain implicit and unclear (Lehto, 2013; Ricciardi, 2014). A third limitation from existing studies is that they largely focus on health support from professional moderators or coaches. In this study we have an additional goal, inspired by resilience literature (see below): to foster peer coaching.

Previously, we explained our three design goals, see Table 1, for stimulating WhatsApp group user activity and we discussed the foundations from social media literature like the Uses and Gratification Theory of social media and others (Simons, 2018, 2019; McQuail, 2010; Khan, 2017). Our first design goal with this user group is to stimulate development of long term health habits, via motivators like for example ‘showing my best’. The second goal addresses the health domains (healthy foods, physical activity and mental energy) for which advocacy and peer inputs are invited. The third design goal concerns the motivators for social support and social interaction.

The second strand of research for this paper is concerned with *quality of peer coaching via social media*. We start from general literature on coaching and then move to issues that are more specific for peer coaching and for social media enabled coaching (instead of face to face expert coaching).

Table 2 shows a general themes from coaching literature (Beckers, 2016; de Haan 2013; Sonesh, 2015; Vandaveer, 2016; Zwart, 2009): that the entire ‘coaching chain’ should be in good working order. This goes from 1.) Coachee readiness and motivation, via 2.) Relationship quality, to 3.) Coach inputs quality. This framework is also the overall coaching quality frameworks we will use for evaluating our study outcomes on the second research question: regarding quality of peer coaching. Each of these three main elements has several sub-elements. We have used Table 2 to include different sub-elements as found in literature.

In Table 3 we highlight some of the differences between expert coaching, provided via one-on-one face to face meetings, and peer coaching via a WhatsApp group. The opportunities and risks for each of the coaching options are explicitly connected to coaching success factors from literature. In this study, the participants will experience both. One the one hand they have individual meetings with a professional health coach, addressing their individual goals, plans, actions and progress. On the other hand they are

Table 2. Coaching quality framework

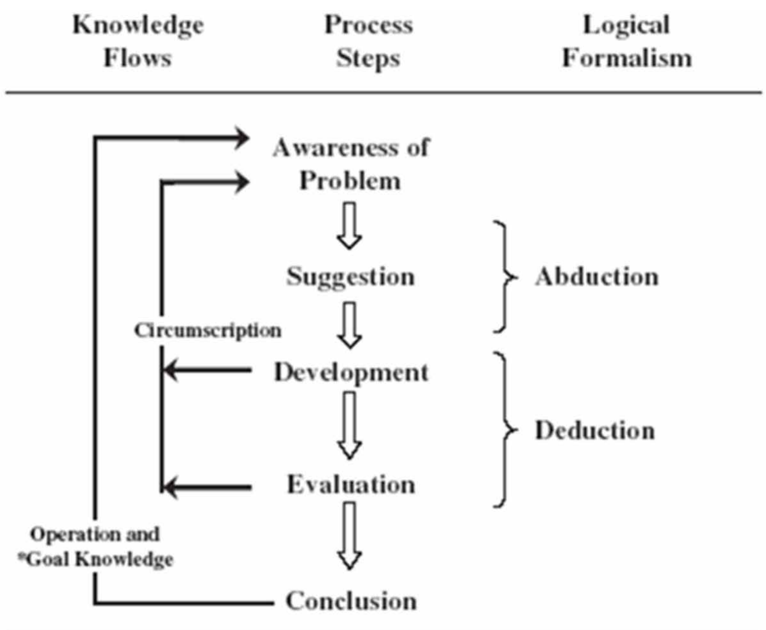
1. Coachee Readiness & Motivation
Intrinsically motivated coachee (Zwart, 2009) with commitment (Jowett, 2017) to self-initiate goals and tasks (Gessnitzer, 2015) and experiment (Zwart, 2009) toward achieving successes (Parker, 2015), insights (Beckers, 2016) and internalized skills (Parker, 2015). Self-efficacy (de Haan, 2013) is also important in coachee readiness (Vandaveer, 2016).
2. Relationship Quality
Important are mutual commitment (Sonesh, 2015) and closeness (Jowett, 2017), as well as complementarity in mutual leadership (Laios, 2003) and cooperation (Jowett, 2017). In peer coaching it is beneficial to have mutual learning (Parker, 2015), sharing experiences (Darwin 2009), supporting each other in choosing and attaining goals (Parker, 2015) and mild 'pressure' to experiment (Zwart, 2009). Finally, a safe environment is important (Zwart, 2009) to discuss and deepen insights (Sonesh, 2015) and learnings (Grant, 2017).
3. Coach Inputs Quality
The quality of the coach and her inputs are important (Vandaveer, 2016), including the range of techniques (de Haan, 2013), leadership (Laios, 2003) expertise (Swarbrick, 2016), scoping/selecting of main goals (Grant, 2017), deepening of insights/skills (Zwart, 2009, Sonesh, 2015) and supporting goal-attainment (Swarbrick, 2016).

Table 3. Comparison between expert coaching and peer coaching

	Expert Coaching, Face to Face	**Peer Coaching, WhatsApp Group**
Opportunities	+ Richer communication; more cues (Simons 2010b). + Spend time on coachee needs, motivation (Zwart, 2009) and commitment (Jowett, 2017). + Quality of coach inputs (Vandaveer, 2016). + Relationship quality: management of roles, goals and expectations (de Haan, 2013). + Digging deeper, reframing situations and insights (Sonesh, 2015)	+ Presence/Always on. Low thresholds to ask. Frequent contact (Simons 2018). + Many inspiration & trigger moments (Fogg, 2009). + Similarity of peers: empathy and understanding of situation and goals (Swarbrick, 2016). + Sharing experiences with likeminded peers (Darwin, 2009). + Mutual learning (Parker, 2015). + Motivate to experiment: 'If she can, I can' (Zwart. 2009).
Risks	- Expensive. Thresholds; also to ask questions (Simons, 2010). - In-frequent contact. Missing the daily practical issues and needs (Gessnitzer, 2015). - Takes time and effort to bridge gaps coach & coachee (Grant 2017).	- Less explicit goals and commitment (coachee and coach; Beckers, 2016). - Less time, attention, leadership; loss of priority over time (Laios, 2003). - Some inputs incorrect or low quality (Vandaveer, 2016). - Only 'easy' inputs. No 'deeper' conversations (Sonesh, 2015). - Relationship & trust building limited (Zwart, 2009).

in the WhatsApp peer coach group. Thus, the interesting question is if we can use the WhatsApp peer coach opportunities to create added value and to mitigate some of the risks via our study design and intervention design. These are discussed in the next section.

Figure 1. Design cycle knowledge via design iterations and evaluations (Vaishnavi, 2004)



METHODS, STUDY DESIGN, INTERVENTION

In this section we first discuss our design research approach and explorative pilot study. Next, we discuss how the WhatsApp group peer coach intervention fits in the overall health intervention that is offered. Regarding our design research approach, we follow the design cycle of Vaishnavi & Kuechler (2004): from problem awareness and solution suggestion to development, evaluation and conclusion, see Figure 1.

Our research method follows three steps: a) As ‘awareness’ and ‘suggestion’ steps from the ‘abduction phase’: Formulate possible social and affective WhatsApp user contribution motives, plus peer coach motives, that suit the design goals of the WhatsApp pilot. b) As ‘development’ and ‘evaluation’ steps: Adding the WhatsApp group support pilot to existing eSupported health program, plus fostering peer coaching by including predesigned coach inputs and instructing three peer coaches for their explicit health advocate roles. Next, as evaluation: quantitatively based on numbers of user inputs per design goal, plus qualitatively, based on user feedback (deduction step of Vaishnavi and Kuechler: section 4). c) As ‘conclusion’ step several design lessons are drawn, for practice and theory, see section 5.

In November 2018, a group of 18 employees from academia started with an eSupported healthy lifestyle program. On their start day, 15 of them volunteered to participate in the WhatsApp group support pilot, after reading the pilot study information and signing consent forms. They were a highly international group of scientists (from China, Netherlands, Hungary, Greece, Iran, USA, Jemen) from different disciplines at the Delft University of Technology: Postdocs, tenure trackers, assistant professors and the majority were PhD candidates. A first important characteristic of this group is that they are very time-constrained. They experience a high work load (as confirmed with intake surveys) and only want to spend time on (health- or other) activities if they are deemed useful for their performance as professionals. Secondly, the majority of them are young professionals, in their first or second job, and relatively unexperienced in managing work-life balance or ensuring healthy choices. It is not uncommon in this group to observe unhealthy belief/behaviour patterns like: 'I am not productive enough -> I will skip my breaks -> I lack energy -> I need more sugar.' Or sacrificing sleep, or exercise, or socializing, for the sake of working longer hours. Or other unhealthy 'corporate athlete' (Loehr, 2001) patterns. Thirdly, 80% of participants had a Mental Health score (RAND-SF8, Ware, 1998) below the overall Dutch average (for all age groups combined), even though their average age was below 35 years old. Thus a 20% Mental Health score below average would have been more appropriate instead of 80%.

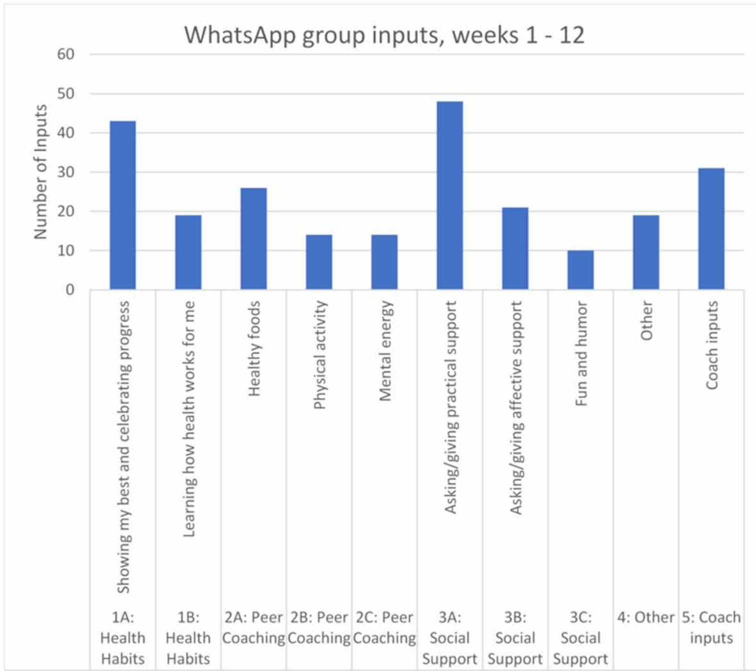
During the pilot of twelve weeks, all WhatsApp user inputs are Simonsymized, counted and clustered based on their contributions to the design goals. Two of the authors conducted the clustering independently and then discussed results in order to reach unanimous scores. Besides the user inputs analysis, subjective user evaluations are collected. We asked them to evaluate WhatsApp group contributions to the design goals (5-point Likert scale, plus explanations, extracted during telephone interviews).

The WhatsApp group support pilot is added to an existing eSupported health program, which combines coach sessions with electronic dashboarding and self-management (Simons 2010b), plus electronic health tips and a digital health quiz game. Key functionalities are (Simons 2010, 2014, 2015):

- A personal online health dashboard with graphs of progress towards adherence targets on the various health behaviours.
- Automated feedback on lifestyle aspects where positive scores have been achieved (nutrition, physical activity, stress management or an overall score).
- (Tele)coaching by a health coach, generating online coach reports on progress towards adherence targets in the personal dashboard;
- Options to ask questions to the coach: via messaging within the dashboard or via email.
- Online schedule indicating upcoming events: group sessions, individual coach sessions (when and where), physical measurements, surveys;
- A micro-learning Health Quiz accessible via smartphone, mail and/or web.
- Reading materials in the mail.
- Weekly tips via email on health, motivation and self-management.
- Besides individual coaching, group sessions are also used in order to stimulate group support, mutual inspiration and encouragement, plus peer education.

The WhatsApp group peer coach setup included two new elements, compared to the previous pilot (Simons 2018, 2019). First, in order to increase quality, extend the breadth of inputs to include the topic of mental energy and to trigger learning plus user participation, we added weekly, predesigned coach inputs (which can be automated in the future). They covered all health domain and including links to online information sources that provided additional depth and insights. Second, we explicitly invited three participants for a role as advocate (for each of the three health domains) and instructed them on their role and tasks for providing their own inputs, responding to reactions from others, plus contributing to domains which were not 'their own'.

Figure 2. WhatsApp user & coach inputs in 12 weeks, on the service design goals



RESULTS

In this section we discuss the results of the twelve weeks pilot from November 2018 to January 2019. Besides the WhatsApp group activity, participant activities in the rest of the eSupported health program were: a full day workshop at the start, intake interview and questionnaire, using the Health Quiz and other eTools, follow up workshop at one month (2 hours) plus three individual health coach sessions in the first two months after the start workshop. These participant activities were conducted alongside their busy jobs.

With this group of n=15 participants, 127 inputs in total were collected in the 12 weeks, of which 31 coach inputs (who were part of the WhatsApp group to help the group along) and 96 participant inputs. Some inputs qualified for more than one goal, hence the sum of scores are higher, see Figure 2 and 3.

The first cluster, 'Showing my best and celebrating', of the first design goal (fostering health identity and literacy) received relatively many inputs (n=41). 'Learning how health works for me' received n=19 inputs. Regarding the second design goal (peer coaching and advocacy), the three clusters ('Healthy foods', 'Physical activity' and 'Mental Energy') received n=26, n=14 and n=14 inputs respectively. Hence the 'Mental energy' domain inputs are better represented than in the previous pilot (Simons 2018, 2019). The third design goal of social support received respectively: n=48 practical support inputs, n=21 affective support inputs, plus n=10 fun inputs. This suggests a tentative 'yes' on our three social and affective design goals for the WhatsApp group inputs. The '4. Other' category (n=19) contains n=9 remarks on eTools and materials, plus it contains n=5 remarks from the start week, most notably thanks for the start workshop on health and vitality.

Figure 3. WhatsApp inputs per week (Christmas holidays in week 8 and 9)

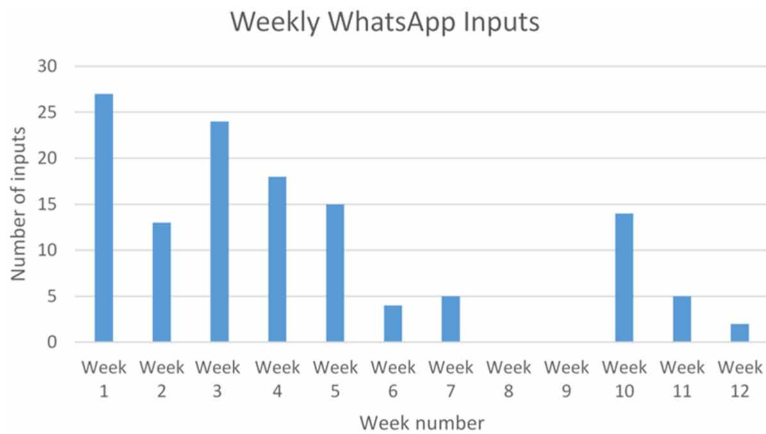


Figure 4. WhatsApp input distribution across participants

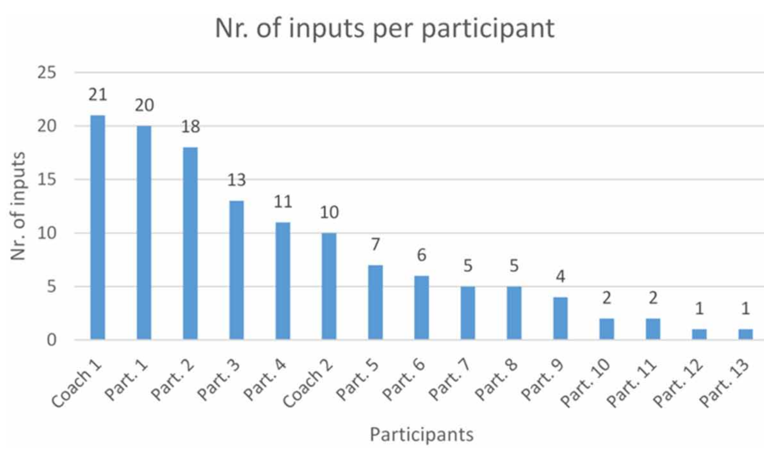
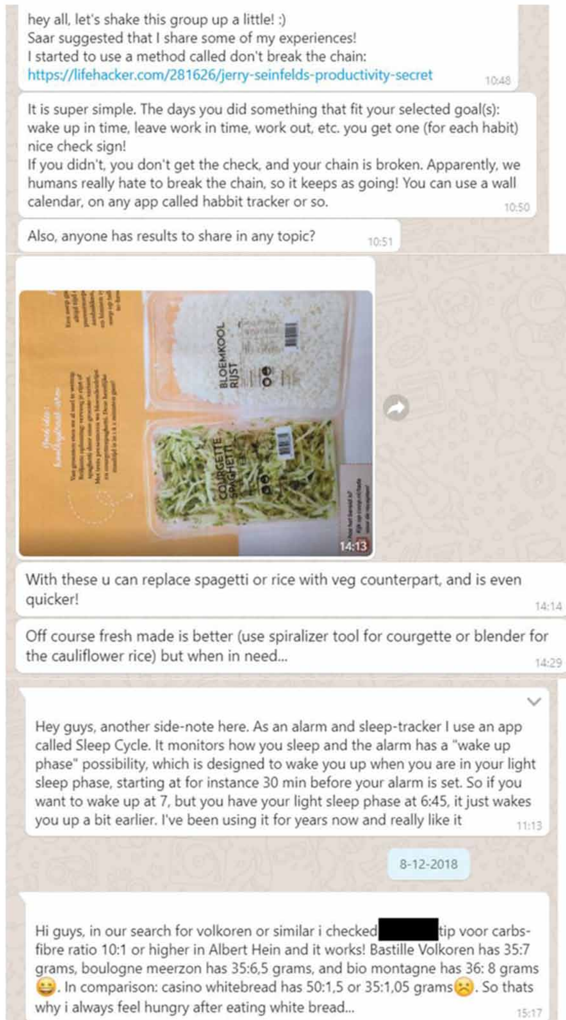


Figure 3 shows the inputs per week. Across the first five weeks, the inputs were relatively well distributed: n= 27, 13, 24, 18 and 15 inputs respectively. (Which is quite different from the previous pilot group (Simons, 2018, 2019), which started more enthusiastically with n=52 inputs in the first week, but dropping rapidly after that: week 2 until 5 had n= 29, 4, 11 and 3 inputs respectively.) Still, from week 6 on the inputs per week are much lower. This was partly due to the Christmas holiday of two weeks (week 8 and 9), but see the discussion in section 5 for an additional hypothesis on changing support needs over time.

Figure 4 displays the distribution of inputs across participants. As often with social media inputs, the distribution is skewed (Nonnecke, 1999), but it is less skewed than our previous study (Simons 2018, 2019). Two participants provided only one input and two did not provide any inputs at all (not displayed in Figure). Participants 1, 2 and 6 were the peer advocates for mental energy, foods and physical activity, respectively. Together with coach 1 and 2 (the professional coaches for the group) they provided many

Figure 5. WhatsApp input examples (Simonsymized)



of the inputs. Still, it is nice to see that participants 3, 4 and 5 were also relatively active, and even more so than one of the explicit 'advocate role' participants. Participants 7, 8 and 9 also had input levels (n=5 or n=4 inputs) similar to participant 6, the advocate for physical activity.

To illustrate the types of inputs provided, see Figure 5. The first example addresses the topic of 'How do I repetitively build a chain of positive health behaviours?' and shows an interaction with one of the coaches who suggests sharing a certain positive example with the group. The second example is an easy option from the supermarket for healthy eating, brought by one of the peer advocates. The third example shows advice from two different users (on different dates): one on better sleeping and one on shopping for bread with good fiber content in one of the prominent Dutch supermarket chains.

The final set of study results stem from the user evaluations, see Table 4. Two participants in the user evaluation explicitly didn't like social media very much. They also indicated to have given limited time and attention to the WhatsApp group. A first overall finding is that our users vary widely in their preferences and opinions, which is similar to users' responses to other health eTools as well (Simons

Table 4. User evaluations (5-pnt Likert: strongly disagree (1) - strongly agree (5). **>3 = Bold***)*

User Evaluation Questions (n=6)	Average (3 = neutral)
1. 'Helped me develop my *health habits*?' - Three disagree: didn't follow the group much & 'I'm more of a loner.' - One agrees, because of the info and the coach articles shared.	2.3
2. 'I am glad with the *peer support*?' - Three disagree, not much peer support needed, nor felt. - Two agree: nice group effects before Xmas; rapid answers to questions.	2.7
3. 'Helped me with *group advice plus encouragements*?' - One disagrees: 'I didn't follow the group much.' - Four agree: nice articles, inspiration and food suggestions, answers.	**3.7**
4. 'Helped me by *sharing* our examples?' - Two disagree: 'the others were not close to me' and sometimes no group activity. - Two agree: inspiration, hearing others are doing similar things. Handy reference.	2.7
5. 'I found the *coach* inputs useful?' - Four agree (no disagrees), due to the quality of the suggested tips and info-links (& easy for future reference).	**4.2**
6. 'I found the three *peer coach advocates* useful?' - Two disagree: not so relevant for me and not always a lot of activity. - Three agree: content sharing was useful, but participation fluctuated.	3.0
7. 'I feel WhatsApp helped *community* forming in our group?' - Two disagree: we didn't know each other at start and did not become close. - Three agree: especially in the beginning it was a place to help each other.	3.0
8. 'The WhatsApp group adds *value*?' - One disagrees: 'Not for me'. - Two agree. The rest are ambivalent: 'More (extended) activity would have been nice.' The information, photos and examples were initially much appreciated: more 'present' and 'engaging' triggers than (Internet) Apps or meetings.	**3.3**

2019b). Not everybody likes the same support tools, hence it is wise to offer a portfolio of tools, in order to help users with other preferences via other tools. A second finding is that two features stick out on the positive side: a) the coach inputs were widely liked for their relevance, usefulness and the quality of the information provided, b) all the encouragements and advice, especially initially, were liked by all but one participants. Third, the lowest score (2.3) is given for question 1, 'helped me develop my health habits', even though the quantitative analysis from Figure 2 shows many inputs there. We assume that these 'showing my best' inputs are perceived more as encouragements and social interaction than as aiding in developing health habits. Fourth, all other questions (on peer support, sharing examples, advocates, community forming and value added) get ambivalent scores, with about equal positive and negative responses. In general, options are more positive about the first weeks than about the final weeks of the pilot.

Table 5. Evaluation of WhatsApp peer coaching success factors (author opinions)

Quality of WhatsApp Group Peer Coaching:	Evaluation:
1. Coachee Readiness & Motivation	+ / -
Large variation: Some participants are quite motivated (Zwart, 2009) to use WhatsApp for peer support and coaching, others are not.	
See text for our hypothesis regarding the motivation change after 5 weeks: from 'inspiration and know-how (Beckers, 2016) on foods, exercise and mental energy' to 'personal life implementation details' (Parker, 2015).	
2. Relationship Quality	- (some +)
Downside: Limited commitment and closeness (Jowett, 2017) in the peer to peer relations, compared to real coach relationships. Although some are more committed to using WhatsApp for mutual learning (Parker, 2015, Zwart, 2009) and building social bonds (Vandaveer, 2016).	
Positive: Similar co-orientation (Jowett, 2017), mutual learning & discovering similar things (Parker, 2015), plus complementarity in know-how. Also: social and affective sharing of experiences (Darwin, 2009) even though this is not so deep: limited (re)interpretation of situations or life lessons via the WhatsApp group (Sonesh, 2015).	
3. Coach Inputs Quality	+
The quality of the predesigned expert coach inputs was valued by all users (Swarbrick, 2016). Also using 'instructed peer advocates' for each health domain increased quality and persistence of useful inputs: from the peer coaches and the other participants: no online 'lurking' (Nonnecke, 1999).	
Inputs on broader range of topics, including mental energy (better than previous pilot (Simons 2018, 2019, de Haan, 2013).	
Improved participation before 'attrition' (Eysenbach, 2005) started: five weeks instead of two weeks of steady inputs and mutual learning (Parker, 2015) and sharing (Darwin, 2009).	

DISCUSSION

This section discusses limitations and implications for practice and theory. Limitations of this study are the small scale (n=15), plus the short term nature of the results (twelve weeks). Usage and contribution patterns declined after the initial five weeks, but we had no user evaluation moment in the first month. So even though we hypothesize on the basis of quantitative inputs plus user evaluations after the end of the pilot that user needs in the first weeks may differ from those in the last weeks, this is hard to conclude in hindsight. At our moment of user evaluation, several participants were abroad or otherwise unavailable, so the user evaluation is only based on n=6 respondents. Given the small scale of the pilot, we are also not able to correct for cultural differences in the group. Also, theory testing is out of the scope of this explorative study. Finally, the added value that participants perceive, is an added value relative to the existing eSupported health coaching, which makes users' added value perceptions harder to objectify.

As a first implication for practice, it is nice to conclude that this WhatsApp group pilot generated higher degrees of participation than many other social media settings (often more large-scale and 'feeling' more Simonsymous like on Youtube) with their 90% passive viewers (Nonnecke, 1999; Sun, 2014; Khan, 2017). This is likely due to the relatively high 'presence' and 'engagement' attributes of WhatsApp, as reported back by our participants.

As a second implication for practice, we see some important differences when comparing this pilot group with the previous one (Simons, 2018, 2019). There are always differences between groups and this pilot group was initially a bit more reserved and more functional in their WhatsApp group behaviours. Hence, only n=27 inputs were provided in the first week (versus n=52 in the previous pilot). Also, 50% of participant inputs across all weeks were practical support inputs (n=48 from n=96 participant inputs, see also Figure 2). Although more research is needed to confirm this tentative finding, our predesigned coach inputs plus 'peer-advocate-instructions' do seem to help to trigger participant inputs, at least for the first five weeks. As a third implication for practice, it seems to help when peer advocates are instructed on their roles: not just for their inputs, but also for managing their expectations regarding the limited reciprocity that is to be expected in terms of the inputs that others will send in return.

In Table 5 we evaluated the quality of peer coaching, based on the user evaluation, their WhatsApp inputs, plus the interpretations from the expert coaches that were coaching the participants in parallel to their WhatsApp group activities. Overall, regarding the first coaching success factor, we observed a large of variation in the group, regarding their motivation for WhatsApp use, as well as their degree of commitment, inputs and relationship forming with the other coaches. As observed more often, user preference seem to vary a lot for almost every eTool used (Simons, 2015, 2017). Coachee readiness also varied a lot across participants in this group. The second success factor, relationship quality, showed some positive forms of mutual learning and complementarity (Parker, 2015; Jowett, 2017), but over time the relationship did not deepen enough to give users a feeling of community: the fact that the users were not otherwise in contact with each other was mentioned as a limitation. The third success factor of coach inputs quality was valued positively by most users, plus the period of active participation and appreciation from the users was extended to five weeks (compared to the two weeks of active involvement which illustrated the 'eHealth law of attrition' (Eysenbach, 2005) in the previous pilot (Simons 2018; 2019)).

Finally, we would like to *hypothesize*, based on our qualitative observations, that the self-learning and *coach needs of these type of groups change after about a month*. Their initial needs in the first month appear to focus on inspiration, experimentation and know-how. But during the next two months, the challenges (and coaching needs) reside in questions of how to structurally implement health behaviours in one's personal life and schedules. Then the deepening discussions and reflections (as can be done with the expert coaches) may appear more valuable to many of the participants (Sonesh, 2015).

CONCLUSION

The main conclusions from this pilot study are fourfold. First, social and affective motivators from social media literature were relevant for this user group and generated interactions beyond the functional level of finding practical health behaviour answers. Second, both our measures to improve peer group coaching quality (using pre-designed coach inputs across health domains, plus 'peer-advocate-instructions') did appear to help raise peer coaching quality. Third, key coaching quality factors (like quality of relationships, coach inputs and coachee readiness) were confirmed in this social media peer coaching setting. Fourth, the combined quantitative and qualitative data have lead us to hypothesize that the self-learning and self-management needs of this group change after about a month (entering a new learning phase). This requires a) more frequent user evaluation moments in the next pilot study for research these possible differences and b) exploring other design solutions for longer term support.

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REFERENCES

Beckers, J., Dolmans, D., & Van Merriënboer, J. (2016). e-Portfolios enhancing students' self-directed learning: A systematic review of influencing factors. *Australasian Journal of Educational Technology*, *32*(2).

Bitter, S., Grabner-Kräuter, S., & Breitenecker, R. J. (2014). Customer engagement behaviour in online social networks–the Facebook perspective. *International Journal of Networking and Virtual Organisations*, *14*(1-2), 197–220. doi:10.1504/IJNVO.2014.065088

Cheung, Y. T. D., Chan, C. H. H., Lai, C. K. J., Chan, W. F. V., Wang, M. P., Li, H. C. W., ... Lam, T.-H. (2015). Using WhatsApp and Facebook online social groups for smoking relapse prevention for recent quitters: A pilot pragmatic cluster randomized controlled trial. *Journal of Medical Internet Research*, *17*(10), e238. doi:10.2196/jmir.4829 PMID:26494159

Darwin, A., & Palmer, E. (2009). Mentoring circles in higher education. *Higher Education Research & Development*, *28*(2), 125–136. doi:10.1080/07294360902725017

De Haan, E., Duckworth, A., Birch, D., & Jones, C. (2013). Executive coaching outcome research: The contribution of common factors such as relationship, personality match, and self-efficacy. *Consulting Psychology Journal: Practice and Research*, *65*(1), 40–57. doi:10.1037/a0031635

De Vries, H., Kremers, S. P. J., Smeets, T., Brug, J., & Eijmael, K. (2008). The effectiveness of tailored feedback and action plans in an intervention addressing multiple health behaviors. *American Journal of Health Promotion*, *22*(6), 417–425. doi:10.4278/ajhp.22.6.417 PMID:18677882

Eysenbach, G. (2005). The law of attrition. *Journal of Medical Internet Research*, *7*(1), e11. doi:10.2196/jmir.7.1.e11 PMID:15829473

Fogg, B. J. (2002, Dec.). Persuasive technology: Using computers to change what we think and do. *Ubiquity*, 5.

Fogg, B. J. (2009). A behavior model for persuasive design. *Proceedings of the 4th international conference on persuasive technology*. 10.1145/1541948.1541999

Fuhrman, J. (2005). *Eat to live: the revolutionary formula for fast and sustained weight loss*. New York: Little, Brown and Company.

Gessnitzer, S., & Kauffeld, S. (2015). The working alliance in coaching: Why behavior is the key to success. *The Journal of Applied Behavioral Science*, *51*(2), 177–197. doi:10.1177/0021886315576407

Ghorai, K., Jahan, S., Ray, P., & Chylinski, M. (2014). mHealth for behaviour change: Role of a smartphone-based multi-intervention service for hypertension and diabetes in Bangladesh. *International Journal of Biomedical Engineering and Technology*, *16*(2), 135–155. doi:10.1504/IJBET.2014.065655

Grant, A. M. (2017). The third 'generation'of workplace coaching: creating a culture of quality conversations. *Coaching: An International Journal of Theory*. *Research and Practice*, *10*(1), 37–53.

Hamari, J., Koivisto, J., & Pakkanen, T. (2014, May). Do persuasive technologies persuade?-a review of empirical studies. *International conference on persuasive technology*, 118-136. 10.1007/978-3-319-07127-5_11

Jowett, S. (2017). Coaching effectiveness: The coach–athlete relationship at its heart. *Current Opinion in Psychology*, *16*, 154–158. doi:10.1016/j.copsyc.2017.05.006 PMID:28813341

Kamel Boulos, M. N., Giustini, D. M., & Wheeler, S. (2016). Instagram and WhatsApp in health and healthcare: An overview. *Future Internet*, *8*(3), 37. doi:10.3390/fi8030037

Khan, M. L. (2017). Social media engagement: What motivates user participation and consumption on YouTube? *Computers in Human Behavior*, *66*, 236–247. doi:10.1016/j.chb.2016.09.024

Kulyk, O., op den Akker, R., Klaassen, R., & van Gemert-Pijnen, L. (2014). Personalized Virtual Coaching for Lifestyle Support: Principles for Design and Evaluation. *International Journal on Advances in Life Sciences*, *6*(3-4), 300–309.

Laios, A., Theodorakis, N., & Gargalianos, D. (2003). Leadership and power: Two important factors for effective coaching. *International Sports Journal*, *7*(1), 150–154.

Lehto, T., Oinas-Kukkonen, H., Pätiälä, T., & Saarelma, O. (2013). Virtual health coaching for consumers: a persuasive systems design perspective. *International Journal of Networking and Virtual Organisations 4, 13*(1), 24-41.

Lippke, S., Wiedemann, A. U., Ziegelmann, J. P., Reuter, T., & Schwarzer, R. (2009). Self-efficacy moderates the mediation of intentions into behavior via plans. *American Journal of Health Behavior*, *33*(5), 521–529. doi:10.5993/AJHB.33.5.5 PMID:19296742

Loehr, J., & Schwartz, T. (2001). The making of a corporate athlete. *Harvard Business Review*, *79*(1), 120–129. PMID:11189456

McQuail, D. (2010). *McQuail's mass communication theory*. London: Sage.

Muntaner-Mas, A., Vidal-Conti, J., Borràs, P. A., Ortega, F. B., & Palou, P. (2017). Effects of a Whatsapp-delivered physical activity intervention to enhance health-related physical fitness components and cardiovascular disease risk factors in older adults. *The Journal of Sports Medicine and Physical Fitness*, *57*(1-2), 90–102. PMID:26364690

Nonnecke, B., & Preece, J. (1999). Shedding light on lurkers in online communities. Ethnographic Studies in Real and Virtual Environments: Inhabited Information Spaces and Connected Communities, 123-128.

Paffenbarger, R. S., & Olsen, E. (1996). *Lifefit: An Effective exercise program for optimal health and a longer life*. Champaign, IL: Human Kinectics.

Park, N., Kee, K. F., & Valenzuela, S. (2009). Being immersed in social networking environment: Facebook groups, uses and gratifications, and social outcomes. *Cyberpsychology & Behavior*, *12*(6), 729–733. doi:10.1089/cpb.2009.0003 PMID:19619037

Parker, P., Wasserman, I., Kram, K. E., & Hall, D. T. (2015). A relational communication approach to peer coaching. *The Journal of Applied Behavioral Science*, *51*(2), 231–252. doi:10.1177/0021886315573270

Prochaska, J. O., & Velicer, W. F. (1997). The transtheoretical model of health behavior change. *American Journal of Health Promotion*, *12*(1), 38–48. doi:10.4278/0890-1171-12.1.38 PMID:10170434

Regmi, K., Kassim, N., Ahmad, N., & Tuah, N. A. A. (2017). Effectiveness of mobile apps for smoking cessation: A review. *Tob. Prevent. Cessat.*, *3*, 1–11.

Reiss, S. (2004). Multifaceted nature of intrinsic motivation: The theory of 16 basic desires. *Review of General Psychology*, *8*(3), 179–193. doi:10.1037/1089-2680.8.3.179

Ricciardi, F., Rossignoli, C., & De Marco, M. (2013). Participatory networks for place safety and livability: organisational success factors. *International Journal of Networking and Virtual Organisations 4, 13*(1), 42-65.

Schulz, J. (2014). Technology solutions in chronic disease management: The role of 'Social Media'. *International Journal of Biomedical Engineering and Technology*, *15*(4), 291–304. doi:10.1504/IJBET.2014.064819

Schwarzer, R., Richert, J., Kreausukon, P., Remme, L., Wiedemann, A. U., & Reuter, T. (2010). Translating intentions into nutrition behaviors via planning requires self-efficacy: Evidence from Thailand and Germany. *International Journal of Psychology*, *45*(4), 260–268. doi:10.1080/00207591003674479 PMID:22044011

Seligman, M. E. P. (2012). *Flourish: A visionary new understanding of happiness and well-being*. New York: Simon and Schuster.

Simons, L. P. A., Foerster, F., Bruck, P. A., Motiwalla, L., & Jonker, C. M. (2015). Microlearning mApp Raises Health Competence: Hybrid Service Design. *Health and Technology*, *5*, 35–43. doi:10.100712553-015-0095-1

Simons, L. P. A., Hafkamp, M. P. J., Bodegom, D., Dumaij, A., & Jonker, C. M. (2017b). Improving Employee Health; Lessons from an RCT. *Int. J. Networking and Virtual Organisations*, *17*(4), 341–353.

Simons, L. P. A., & Hampe, J. F. (2010). Exploring e/mHealth Potential for Health Improvement; A Design Analysis for Future e/mHealth Impact. Paper presented at the 23rd Bled eConference. Bled, Slovenia, from www.bledconference.org. Accessed 20-6-2018.

Simons, L. P. A., & Hampe, J. F. (2010b). Service Experience Design for Healthy Living Support; Comparing an In-House with an eHealth Solution. Paper presented at the 23rd Bled eConference. Bled, Slovenia, from www.bledconference.org. Accessed 20-6-2018.

Simons, L. P. A., Hampe, J. F., & Guldemond, N. A. (2012). Designing Healthy Consumption Support: Mobile application use added to (e)Coach Solution. Paper presented at the 25th Bled eConference. Bled, Slovenia, from www.bledconference.org. Accessed 20-6-2018.

Simons, L. P. A., Hampe, J. F., & Guldemond, N. A. (2013). Designing Healthy Living Support: Mobile applications added to hybrid (e)Coach Solution. *Health and Technology*, *3*(1), 1–11.

Simons, L. P. A., Hampe, J. F., & Guldemond, N. A. (2014). ICT supported healthy lifestyle interventions: Design Lessons. *Electronic Markets*, *24*, 179–192. doi:10.100712525-014-0157-7

Simons, L. P. A., Pijl, M., Verhoef, J., Lamb, H. J., van Ommen, B., Gerritsen, B., . . . Jonker, C. M. (2016). Intensive Lifestyle (e)Support to Reverse Diabetes-2. Paper *presented at the 29th Bled eConference*. Bled, Slovenia, from http://aisel.aisnet.org/cgi/viewcontent.cgi?article=1023&context=bled2016 & www.bledconference.org. Accessed 20-6-2018.

Simons, L. P. A., Pijl, M., Verhoef, J., Lamb, H. J., van Ommen, B., Gerritsen, B., . . . Jonker, C. M. (2017). Diabetes Lifestyle (e)Coaching 50 Weeks Follow Up; Technology Acceptance & e-Relationships, pp. 545-560, *presented at the 30th Bled eConference*. Bled, Slovenia, Proceedings retrieval from www.bledconference.org. Accessed 20-6-2018. ISBN 978-961-286-043-1, DOI: https://doi.org/doi:10.18690/978-961-286-043-1

Simons, L. P. A., Pijl, M., Verhoef, J., Lamb, H. J., van Ommen, B., Gerritsen, B., ... Jonker, C. M. (2019b). (Accepted). e-Health Diabetes; 50 Weeks Evaluation. [DOI will follow]. *International Journal of Biomedical Engineering and Technology*.

Simons, L. P. A., van den Heuvel, A. C., & Jonker, C. M. (2018). eHealth WhatsApp Group for Social Support; Preliminary Results, pp. 225-237, *presented at the 31st Bled eConference*. Bled, Slovenia, Proceedings retrieval from www.bledconference.org. Accessed 20-6-2018. ISBN-13: 978-961-286-170-4, DOI: https://doi.org/ doi:10.18690/978-961-286-170-4

Simons, L. P. A., van den Heuvel, A. C., & Jonker, C. M. (2019). (Accepted). eHealth WhatsApp for social support: Design lessons. [DOI will follow]. *Int. J. Networking and Virtual Organisations*.

Sonesh, S. C., Coultas, C. W., Marlow, S. L., Lacerenza, C. N., Reyes, D., & Salas, E. (2015). Coaching in the wild: Identifying factors that lead to success. *Consulting Psychology Journal: Practice and Research*, *67*(3), 189–217. doi:10.1037/cpb0000042

Southwick, S. M., & Charney, D. S. (2012). *Resilience: The science of mastering life's greatest challenges*. Cambridge University Press. doi:10.1017/CBO9781139013857

Sun, N., Rau, P. P. L., & Ma, L. (2014). Understanding lurkers in online communities: A literature review. *Computers in Human Behavior*, *38*, 110–117. doi:10.1016/j.chb.2014.05.022

Swarbrick, M., Gill, K. J., & Pratt, C. W. (2016). Impact of peer delivered wellness coaching. *Psychiatric Rehabilitation Journal*, *39*(3), 234–238. doi:10.1037/prj0000187 PMID:27054901

Thom, D. H., Ghorob, A., Hessler, D., De Vore, D., Chen, E., & Bodenheimer, T. A. (2013). Impact of peer health coaching on glycemic control in low-income patients with diabetes: A randomized controlled trial. *Annals of Family Medicine*, *11*(2), 137–144. doi:10.1370/afm.1443 PMID:23508600

Vaishnavi, V., & Kuechler, W. (2004). *Design Research in Information Systems*. Retrieved from http://desrist.org/design-research-in-information-systems

Vandaveer, V. V., Lowman, R. L., Pearlman, K., & Brannick, J. P. (2016). A practice analysis of coaching psychology: Toward a foundational competency model. *Consulting Psychology Journal: Practice and Research*, *68*(2), 118–142. doi:10.1037/cpb0000057

Ware, J. E. Jr, & Gandek, B. (1998). Overview of the SF-36 health survey and the international quality of life assessment (IQOLA) project. *Journal of Clinical Epidemiology*, *51*(11), 903–912. doi:10.1016/S0895-4356(98)00081-X PMID:9817107

Wiedemann, A. U., Lippke, S., Reuter, T., Ziegelmann, J. P., & Schwarzer, R. (2011). How planning facilitates behaviour change: Additive and interactive effects of a randomized controlled trial. *European Journal of Social Psychology*, *41*(1), 42–51. doi:10.1002/ejsp.724

Zwart, R. C., Wubbels, T., Bergen, T., & Bolhuis, S. (2009). Which characteristics of a reciprocal peer coaching context affect teacher learning as perceived by teachers and their students? *Journal of Teacher Education*, *60*(3), 243–257. doi:10.1177/0022487109336968

Chapter 3
Public Reporting on Health and Social Care Services

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ABSTRACT

The growth of the healthcare sector has led to innovative ways to cater to consumers' needs, with some of the rich, developed countries at the forefront. An in-depth understanding of them enables a successfully implemented and useful system for consumers. Public reporting is developed mainly for and around consumers. In this chapter, the authors take a general look at public reporting on health and social care services. They examine the existing reporting systems and the issues they encounter. There are significant benefits of public reporting on health and social care services, but we currently do not know the limits of such reporting. Citizens need such information services when deciding from there to acquire health and social care services for themselves or their families and relatives. Service providers need these information services for benchmarking purposes and for the development of their service offerings.

INTRODUCTION

Over the years, we have observed several changes in the healthcare sector, which have been beneficial to all stakeholders involved. Developed nations are in the forefront of these advancements in healthcare, for instance, the use of technology in healthcare delivery at all levels. These advances in medicine and healthcare delivery have imposed a new type of demand for the availability of accurate and processed information in healthcare. It has also started the conversation on the patient's role in the effective delivery of healthcare. What is the patient's potential role in healthcare delivery? Can the patient be considered a consumer? What is consumer health informatics?

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Eysenbach (2000) defines consumer health informatics as "*the branch of medical informatics that analyses consumer's need for information; studies and implements methods of making information accessible to consumers; and models and integrates consumers' preferences into medical information systems*" (p. 1713). Most industries are consumer driven, meaning that consumers have enough knowledge to make informed choices about products and services. Consumers use information technology to gain access to information that directly influences their decisions. Information systems are gradually becoming integral parts of modern healthcare services and policies in developed nations. Clearly, consumers will need and demand an unprecedented ability to access information and participate in their own healthcare. Consumers should have the choice and be able to judge the advantages and the disadvantages of all possible courses of action in relation to their health and according to their values, beliefs, preferences, and personal circumstances.

Over the past few years, we have witnessed the emergence and the growth of health tourism, electronic patient records, telemedicine, and web medicine. Information availability and use is an integral aspect of all these new additions to healthcare delivery. Public reporting on health and social care services is rooted in the availability of information. Access to insights on data and information is possible and in abundance now. It has become a catalyst of change in healthcare and social care delivery, wherein consumers have become the nucleus.

Various healthcare services and facilities are available to patients. The issue is how patients are choosing their healthcare and social care service providers. Researchers have conducted various studies on how patients make their health and social care service choices. It has been found that people make decisions in a fast and uncontrolled manner, without decision-making processes, and based on their experiences (Kumpunen, Trigg, & Rodrigues, 2014). Therefore, the health and social care services available to them have not been under serious scrutiny. This may affect the quality of provided services. These are the various reasons why public reporting on health and social care services is necessary. For public reporting to be useful to patients, there is the need for more than one care provider available per service (Kumpunen et al., 2014). Patients need to know about the availability of more health and social care service options.

The outcomes of public reporting on health and social care services are improved performance by providers, better quality of care, informed users, informed healthcare and social care choices for users, and hospital process improvements (Behrendt & Groene, 2016; Cacace et al., 2017; Maurer et al., 2016; Werner & Bradlow, 2010; Werner et al., 2009). However, public reporting has some negative aspects. Healthcare providers have the incentive to select patients for challenging healthcare treatments, as has been the case in the United States (US) (Behrendt & Groene, 2016; Cutler, Huckman, & Landrum, 2004; Narins, Dozier, Ling, & Zareba, 2005). Other challenges are accessibility, structuring, and presentation of information, as well as lack of prior experience. Based on existing literature and implemented systems, public reporting is used in measuring and comparing transparency, safety, quality, success rates, mortality rates, waiting times, health plans, and so on.

Studies have shown that the style of presenting information and access to information are important in reporting health and social care services. Data presentation enables the use of reported information. For public reporting to be successful, access to and use of information are of paramount importance. Data are gathered from all the various sources, analyzed, and published for consumers. How do consumers gain access to the published information or even understand what they read? The issue of access and understanding is another important element of public reporting that needs to be addressed. Readability, assimilation, and comprehension of information materials and the users' health literacy levels can create barriers to the usage of information, even when it has been accessed (Gilmour, 2007). It is necessary to provide consumers with all the essential tools to make the best healthcare choices. This consumer-driven approach means supporting consumers with the most useful information to make informed choices as much as possible.

The expectations for public reporting are vast and go beyond just the consumers. In this article, we introduce public reporting on health and social care services, as well as the benefits and the issues attached to it.

Literature Review

Public reporting systems have been of great interest to many countries. It is necessary to meet the many demands of improved health services and healthcare delivery. A good amount of research on public reporting has been undertaken. According to the World Health Organization (2008), a health information system *"collects data from the health sector and other relevant sectors, analyses the data and ensures their overall quality, relevance and timeliness, and converts data into information for health-related decision- making*" (p. 2). In simple terms, this means the integration of information technology or different technologies into healthcare. This has become a necessity for almost all the fundamental reasons why many companies in other industries implement information systems. The benefits of healthcare information systems outweigh their negative impacts if implemented correctly. According to Hoyt et al. (2012), the goals of healthcare information systems are improving communication, continuity, quality of care, patient outcomes, clinical productivity, and return on investment; reducing medical errors and duplication of tests; standardizing medical care provided by individuals and organizations, accelerating access to care; protecting privacy; and ensuring security. A successful healthcare information system is one that is used correctly and supported by all the key players (doctors, patients, clinicians, nurses, support staff, public health, governments, medical educators, insurance companies, hospitals, medical researchers, and technology vendors) for which it was built.

Over the years, no in-depth definition of information has been published. The very specific definitions available are found in dictionaries. *Oxford Dictionary* defines information as "facts provided or learned about something or someone." McCreadie and Rice (1999) conceptualize information as a commodity, data in the environment, representation of knowledge, and part of the communication process. It has become an essential part of everyday life. The importance of information has been shown in almost every industry and continues to grow. The growth of the use of information has led to consumers' information dependency.

Public reporting in healthcare is growing in several European countries. Its goals are to increase choices for patients, improve healthcare services, and enhance transparency in healthcare delivery. Cacace et al. (2017) define the availability of healthcare market information for patients *"as the reporting of performance related information to the general public and about non-anonymous, identifiable professionals and providers using systematically gathered comparative data*" (p. 1). Public reporting is intended to enable and support informed choices by patients. This is a consumer-driven approach as patients are considered consumers, and meeting their needs is paramount in the health and social care delivery system.

The efficacy of the use of public reporting depends on several factors: data presentation, information quality and integrity, collection of information from patients, platform for information presentation, and consideration of various customer groups (Hibbard & Peters, 2003). Hibbard, Stockard, and Tusler (2003) report that making hospital performance information public causes improvements in general and in the reported areas in particular. Public reporting has also enabled patients to make informed choices about healthcare selection and health plans (Kelaher, Prang, Sabanovic, & Dunt, 2018). The benefits of public reporting for users are not limited to healthcare services' performance improvement. Elliot et al. (2015) also report the improvement in patients' hospital care after the release of performance reports on hospitals. This improvement is mainly observed in hospitals with low scores in published reports. Werner and Bradlow (2010) also report process improvements in hospitals with low baseline performance yet find that high-performing hospitals are unaffected by public reporting. Thus, underperforming hospitals tend to benefit more from public reporting. According to Marshall, Shekelle, Davies, and Smith (2003), in the US states that have implemented public reporting, it has had an impact on the quality of care. However, some physicians do not see the type of impact generated by public reporting, which will continue to have an effect on patient choices due to the credibility of the data (Marshall et al., 2003). One issue is certain; public reporting is here to stay and will demand a lot more research work.

Public reports are disseminated in different forms to consumers. From the existing literature and reporting systems, published information is made accessible to consumers through websites, report cards, newspapers, and scorecards (Hibbard et al., 2003; Narins et al., 2005). With these available communication media, it is important to present the information in an understandable way that consumers can efficiently use. During a report's designing stage, it is essential to pay attention to the presentation style, which should be well suited for the type of information to be published. Hibbard and Sofaer (2010) state that to understand comparative data, consumers must go through a large amount of information, select relevant factors, weigh them, and put them together to make a decision. This is tedious work for users when deciding on which health service to patronize. This hinders the use of the published report. Following their studies on presenting quality information to consumers, Peters, Dieckmann, Dixon, Hibbard, and Mertz (2007) conclude that in a presentation, "less is more." Based on the cited literature and the experiences with implemented public reporting systems, the style of presenting information is critical to the success of any form of public reporting. Kasiske et al. (2019) stated that some level of improvement of the presentation of data in the public reporting platform of transplant program performance in the Unites States improved the engagement of patients and indicates the need for continuous improvements of the presentation of data on such platforms.

According to Lagu et al. (2019) publishing of data on health and social care services will continue as there is great deal of interest in public reporting by consumers. The positive effect of public reporting spreads across the various activities and processes in health and social care services as is shown in the reduction of prescribing of antipsychotic drugs in nursing homes (Ivers et al., 2019). This is a further indication of changes for improvement that public reporting invokes in health and social care facilities.

SELECTION AND CHANGE PATHWAYS

According to Cacace, Ettelt, Brereton, Pedersen, and Nolte (2011), quality measurement and public reporting improve healthcare and social service care via two pathways of change: improvement through selection and improvement through change. Improvement through selection occurs when users make their choices based on the comparative information available to them (Berwick et al., 2003). The reported comparative information enables the users to make better healthcare choices. Berwick et al. (2003) further explain that for users to make choices for improved healthcare, they identify the outcomes that are relevant to them, learn the different performance levels of surgeons, and choose their surgeons. The selection of quality healthcare and social service care solely depends on the consumer.

Improvement through change is the pathway where healthcare providers improve their services based on the published comparative data (Berwick et al., 2003). For example, a hospital can improve the care given to patients after surgery to reduce post-surgery infections. This type of improvement comes from the hospital, thus improving the quality of care received by users. The user is the main beneficiary of the two pathways of change as both lead to improved quality of healthcare services.

In 2005, Hibbard et al. introduced an additional pathway—improvement through reputation. One of the effects of public reporting is the exposure of poor-performing health and social care service providers. This suggests that high-performing providers acquire a good reputation among customers, whereas poor- performing providers suffer from a bad reputation. A bad reputation means less patronage by users and the general public, which also leads to less market share. Their company reputation compels providers to improve their services. The combination of all the pathways results in improvements in all aspects of health and social care service delivery.

THE NEED FOR ESTABLISHED INDICATORS

A key issue in public reporting is finding indicators that describe health and social care service offerings in a good way. As everywhere, health and social care services have a cost/benefit ratio. Thus, in addition to service quality information, cost information should be included. Health and social care services often have client queues, so the waiting time might also be an important topic to report. For all indicators, up-to-date information is clearly needed. A major problem in public reporting is that service reports and assessments tend to be rather old.

It is typical to differentiate among outcomes, processes, and structure information (Cacace et al., 2011). Typical outcome indicators would be mortality and morbidity after healthcare operations, as well as return to care after specific time intervals, such as 10, 30, or 90 days. In social services, a typical outcome indicator could be staying out of criminality for a problem teenager. Process indicators are typical in standardization and certificates and accreditation, even in healthcare. A process indicator could determine if a hospital has check lists in surgical operations or if a pharmacy can offer automated drug-dispensing services. In social care, for example, periodical checks on different aspects of a client's life would be process indicators. Structure indicators include issues such as the number of beds in a hospital, availability of different access services, hours of service, and service availability in different languages. A typical example of structure information is about the qualifications of health and social care personnel.

Public reporting is primarily intended for a large audience, consisting of laypersons. Therefore, extremely professional terms of coding systems that are abundant in healthcare and are not publicly available should not be used. With quantitative information, care must be taken to frame the information at the right time and place, for example, how many surgical operations, in which hospital ward, and in which time frame. Healthcare indicators involving clinical and non-clinical professionals in healthcare and social care of course need specific reports, but that is not part of public reporting.

Metadata constitute an important part of indicators (Darius, Boucneau, De Greef, De Feber, & Froeschl, 1993). With each indicator, proper descriptions of its meaning, data collection methods, possible use scenarios, used scales, and so on should be included. Indicators most likely have relationships among themselves, and when integrated, primary indicators form advanced indicators. To provide an understanding of this, a conceptual model of the indicators is needed, and if manageable in size, it should also be provided to the public.

WHO IS RESPONSIBLE FOR PUBLIC REPORTING

Public reporting is by definition, public, as well as free for anyone. Providing public reporting can hardly be a (good) business. Thus, public reporting is typically a responsibility of public authorities. Another group of public reporters comprises market makers in healthcare and social care. For example, insurance companies need and collect a lot of data on health and social care service providers and thus have a natural reserve of meaningful information that they might want to publish and extend into public reporting.

An individual service provider can publish information on its services and achievements, but that is not public reporting in the sense of allowing comparisons among different service providers. Service providers' own reports are often created to be marketing materials, ignoring the poor aspects of their services.

DATA COLLECTION FOR PUBLIC REPORTING

Data collection for health and social care public reporting is difficult without a proper infrastructure. As stated above, the data collection should be undertaken in the framework of a well-defined and meticulously designed conceptual model or schema.

Data collection and reporting impose a huge burden on health and social care institutions. Public reporting should not add too much to their burden. Public reporting is often based on data that are otherwise already collected, typically by government authorities. These data are then further elaborated to contain meaningful information for the public audience. Care must be taken that valuable information is not lost in this elaboration process. Even painful and disconcerting issues belong to public reporting.

Data manipulation and embellishment unfortunately belong to data collection in health and social care, as in any other sector of life. For this reason, data should be double checked if possible, missing information should be reacted on immediately, and sanctions should be implemented against sloppy or misleading reporting.

Big data make a great promise for public reporting. Big data are often born naturally, and a combination of different data elements can bring highly valuable insights into the studied health and social services. In the case of big data, the speed of reporting can be accelerated if the data are made available.

CHANNELS FOR PUBLISHING PUBLIC REPORTING

The Internet is currently the dominant channel for the publication of any information; the same is true for public reporting. The Internet is about the only channel that allows for interactive data search. However, the needs of the audience that has no Internet access should also be catered to (Benigeri & Pluye, 2003).

Different printed versions of data are needed, to be distributed in libraries and other public places. Summary information can also be published in traditional media, such as newspapers and magazines. These are also good channels to increase awareness about public reporting.

Different language versions of public reporting are needed. In addition to reporting in domestic languages, countries should respond to the needs of adventurous visitors, such as immigrants and tourists. This also means reporting in English as the only option. Special needs of people with vision impairments must of course be taken into account. In every case, the text used should be clear and not complicated.

In addition to sporadic and singular data, public reporting should be able to provide trend data. Are issues improving or deteriorating? In the beginning of public reporting, trend data are of course impossible to deliver.

Data visualization is a key element in public reporting. Here again, it is important to remember that visualization must be done with honesty and an eye for details—a figure can depict a thousand words, but it can also tell lies of a thousand words.

Examples of Public Reporting Systems

Several European countries have already implemented reporting systems in their healthcare. Public reporting has been implemented in the United Kingdom (UK) (nhs.uk), the Netherlands (kiesbeter, "Make better choices"), Germany (weisse-liste.de, 'White List'), and Denmark (sundhed.dk). The US has a number of reporting systems. Rechel et al. (2016) report that several high-income countries, namely Australia, Canada, England, France, Germany, Netherlands, New Zealand, Norway, Sweden, Switzerland, and the US, have a public reporting platform for quality, waiting times, and patient experience. Public reporting is consistently growing in Europe. Public reporting activities started in the Eastern European countries (e.g., Bulgaria, the Czech Republic, Romania, Slovakia, Slovenia) in 2004 after they joined the European Union (EU) (Cacace et al., 2017). The majority of the EU countries have some sort of public reporting system. In Sweden's decentralized healthcare system, public reporting varies among regional units; the same applies to the Italian public reporting system (Ciani, Tarricone, & Torbica, 2012; Guénette, Belzile, & Hjertqvist, 2017). Germany and the Netherlands have several reporting systems for the hospital sector and GP specialists (Bernd et al., 2016).

The UK has made significant strides in its public reporting system. It is one of the few countries with initiatives for the hospital sector, combining these with financial incentives and providing composite ratings of providers' performance. It also reports the overall rating for general practice. In terms of long-term care, the UK reports the overall rating of each provider. Unsurprisingly, the UK has gone far with public reporting; its reporting on hospital performance goes as far back as 1980 (Marshall et al., 2003). In addition to the government platform for public reporting in the UK, some independent organizations publish hospital performance online (Marshall et al., 2003).

Public reporting has also been undertaken in the US since the 1980s. The US is one of the pioneers, and its first major public report was published in 1993. Both private and government organizations carry out public reporting in the country. The National Committee for Quality Assurance is a nonprofit organization that reports and evaluates healthcare delivery and quality in the US. A couple of other private organizations in the US are the Leapfrog Group and the Pacific Business Group on Health. Healthgrades is a for-profit company that handles reporting and comparative information on various healthcare delivery facilities. The US government is heavily involved in public reporting on health and social care services. According to Burstin, Leatherman, and Goldmann (2016), the development of quality measures should be the focus of attention of public reporting in the US. For further improvements in the healthcare system, an extensive use of data and information is needed (Burstin et al., 2016). In 2011, *Consumer Reports*, one of the top 10 magazines circulated in the US, published an 11-page feature article on the state of cardiac care in the US to better educate consumers about their various options in this service. Having extensive work in public reporting on health for many years, the US is one of the global leaders of public reporting. Ferlie and Shortell (2001) report that some states, such as New York, Massachusetts, Pennsylvania, and California, initiated selective public reporting on treatment outcomes as one of the tools for improving the quality of healthcare.

Germany is one of the leading European countries in public reporting. According to Emmert, Sander, Esslinger, Maryschok, and Schöffski (2012), Germany has an extensive number of websites related to reporting on healthcare. Some of the most relevant and most used public reporting sites are Jameda (www.jameda.de), Docinsider (www.docinsider.de), Imedo (www.imedo.de), and Die Arztempfehlung (www.die-arztempfehlung.com). Consumers in Germany actively use these websites and other public reporting media. In Germany, the focus magazines release information lists of the best hospitals for treatment and diagnosis (Bernd et al., 2016). More criteria should be added to these websites for a broader range of information on which to base decisions (Emmert et al., 2012). With all the reporting platforms in Germany, some patients still base their choices on experience (Werner & Geraedts, 2017), specifically the type of experience they have had at healthcare and social service centers. Their decisions are based on their knowledge of the healthcare facilities, not on the published reports.

Public reporting has been implemented in Canada because of the need for increased transparency and accountability (Morris & Zelmer, 2005). Canada is divided into provinces, many of which have their individual public reporting systems in health and social care services. Examples of public reporting initiatives in Canada are British Columbia's reports on health authorities' performance agreements, focused reporting initiatives on specific areas of care, and balanced scorecards on particular health and social care service organizations, such as hospitals in Ontario. This shows a wide variety of public reporting systems that already exist. The Canadian healthcare system is decentralized and has a good experience in the use of health and social care services' public reporting systems.

Specific issues with public reporting are observed in most countries that have adopted it. Most countries will need to build on what the US and the UK have accomplished. They have attained success with the reporting system.

Benefits and Downsides of Public Reporting Systems

The advantages of any information system are determined by the benefits derived by its users and the ease of use. The existing literature on public reporting systems strongly suggests that many benefits are associated with such systems. Several studies show that the public reporting system increases healthcare providers' motivation to improve care (e.g., Hibbard et al., 2003). Liu, Tang, Wang, and Zhang (2017) also emphasize that the public reporting system has become an essential quality improvement tool in most countries that have adopted it. According to Cacace et al. (2017), public reporting systems increase the effectiveness of care; patient safety and delivery become patient centered. The major benefit is the possibility for patients to make informed choices and better voice their preferences in healthcare delivery (Cacace et al., 2017; Hibbard et al., 2003; Hoyt et al., 2012; Marshall et al., 2003). James et al. (2012) state that public reporting allows customers or patients to compare healthcare services with their costs before decisions are made. Clearly, public reporting offers several benefits for all stakeholders in the healthcare delivery system, especially for patients.

Transparency has been a recurring benefit of public reporting in health and social care services in various research works on public reporting in various countries. Government healthcare organizations are usually expected to show transparency in the use of public resources and in the provision of quality care to the public, as well as to governments and stakeholders that want detailed information on the quality of care and services provided (Morris & Zelmer, 2005). Public reporting is one route to demonstrate this transparency. The target audience of transparency comprises governments and regulatory bodies (Morris & Zelmer, 2005). Germany developed Weisseliste to increase the transparency of provider performance in 2008 (Kumpunen, 2014). Campanella et al. (2016) also state that public reporting makes providers acknowledge the need for transparency and accountability. Cacace et al. (2011) report that in Denmark, many of the reporting systems are intended to increase transparency and the right to choose a provider. Transparency is normally the objective in publicly funded systems.

Research shows that consumer choice is one of the intended benefits of public reporting on health and social care services. Consumer choice improves consumer decision making in the selection of a health and social care provider. Kumpunen et al. (2014) argue that for patients and users to make choices, there needs to be a market of healthcare providers available per the various services, and users should perceive them as such. A pool of health and social care service providers from which to make choices is needed. For public reporting to achieve this aim, it demands reporting on various healthcare providers in a province or in a country. According to Morris and Zelmer (2005), consumers would be expected to make their choices based on high-performing healthcare and social care providers. This also leads to poor-performing organizations improving their services to be able to compete and be chosen by consumers. Consumer choice can be hindered by the lack of skill to interpret the information available to make the best possible choice.

Improvement in the quality and the efficiency of services and processes is another one of the main benefits and an intended outcome of public reporting on health and social care services. Such improvement due to public reporting occurs through three pathways that are caused by consumer choice of providers (Berwick et al., 2003; Cacace et al., 2011; Hibbard et al., 2005). As mentioned, the three pathways are improvement through selection, improvement through change, and improvement through reputation. These compel providers to improve if they are consumer centric. Morris and Zelmer (2005) state that comparative public reporting gives providers information to identify and examine their quality improvement projects.

Morris and Zelmer (2005) argue that the cited various benefits of comparative public reporting on health and social care services are as many as the different types of reports that are produced and made available to consumers. The benefits mentioned here are the main ones cited by a number of leading research studies on this topic.

Public reporting systems have several issues, including information quality, accessibility, lack of trust, and careful selection of patients to treat to keep scores high (Cacace et al., 2017; Hibbard et al., 2003; Hoyt et al., 2012; Marshall et al., 2003). Information quality is a major concern of both consumers and other stakeholders involved. According to Kelaher et al. (2018), the efficiency of public reporting strongly depends on the quality of the information that is publicly available to patients. Important aspects are quality in terms of information accuracy and objectivity, believability, the reputation of the information source, and the consistency and the presentation of the information. Leonardi, McGory, and Ko (2007) state that accessibility is important to the success of public reporting. Patients need to access the information available to them to be able to use it. This significant issue needs a critical examination due to different demographics of the patients who will use the information. The Internet is one of the best ways to access publicly reported information on healthcare delivery, but inequity in Internet access is an issue (Gilmour, 2006).

Werner and Asch (2005) find that patients do not trust the information that is made available to them with a public reporting system. Instead, they trust information from friends and family members, whom they consider more credible than a website or a report card. This issue affects the usage of the various healthcare delivery reporting systems.

One of the greatest issues and concerns about a public reporting system is that it might actually have an effect on the treatment of patients. Leatherman and McCarthy (1999) state that healthcare providers may turn away very sick patients just to keep their published scores high. This defeats the purpose of the public reporting system. Narins et al. (2005) report that a good score does not necessarily mean improved service or quality service as some health providers are turning away sicker patients who need surgery, for example. Published information on the performance of surgeons and healthcare providers may change referrals of sicker patients for treatment and reduce surgeons' willingness to operate on these patients (Cutler et al., 2004; Dehmer et al., 2014). This issue might lead to devastating outcomes for patients. As a result, quality healthcare delivery suffers and defeats one of the fundamental purposes of improved quality of patient care.

Public reporting is a necessity for healthcare improvement and lower prices, as well as a catalyst for turning healthcare delivery into a consumer-centered one. The benefits strengthen the need for public reporting systems. The issues also show that a lot more work should be done to gain the full benefits of public reporting systems.

BAD RECEPTION OF PUBLIC REPORTING

One concerning issue of public reporting is the poor reception observed in the low utilization grade. Doering and Maarse (2014) report that general practitioners do not help patients utilize publicly available information to make choices concerning secondary healthcare. This is because of general practitioners' common perception of public reporting. The majority of them question the quality of the available information (Doering & Maarse, 2014). Therefore, such information does not form the basis of their secondary healthcare recommendations to patients. If general practitioners will recommend published information on healthcare to patients, the reception rate by patients will increase dramatically.

There is a considerable lack of understanding of what published reporting and its importance are to users by users. According to Marshall (2002), consumers do not understand the need for and the usefulness of published reports, which is also due to the lack of confidence in such reports. They will rather stick to health service providers that they are used to. These are relationships they have developed over time, and a published report is perceived as a threat to these long-standing relationships between users and providers.

The lack of involvement of all relevant stakeholders impedes the reception of public reporting on health and social care services. Cacace et al. (2017) state that when implementing reporting systems, including all stakeholders is essential for success. In software engineering, the users are actively involved in building and implementing the system that they will use, which facilitates the process and is beneficial to them. All stakeholders should be involved in building and implementing public health and social care service reporting systems.

Currently, public reporting does not actively engage users. It is a medium of communication and a unidirectional communication platform. The pressing question is how to make users actively involved. The inclusion of user reviews is one of the proven ways to do so. This has been implemented in the tourism public reporting systems and in other industries. The inclusion of customer reviews in public reporting in health and social care services is not currently practiced. Customer reviews offer an active way of encouraging users' active involvement in public reporting other than just the passive usage of the reports.

After the usage of public reports, it will be very useful to know what the users think about them. It will be beneficial to the groups and the organizations developing the reports to know the users' views on the presentation style, as well as the relevance and the easy assimilation of the information, and get answers on its quality. Customer reviews represent the voice of the customers.

A customer review is defined as a form of product or service information produced by the user based on personal experience of that product or service (Chen & Xie, 2008). The information is used by potential customers to make informed choices regarding products and services. Customer reviews are integrated into the majority of online shopping platforms (e.g., Amazon, eBay, ebookers). On these platforms, customers base their purchasing decisions on other customers' reviews. They find the reviews more reliable and trustworthy. Customer reviews have been successfully implemented in customer-centric industries.

A successful public reporting system in health and social care services requires understanding and closely catering to customer demands and needs. Several ways to obtain customer reviews about public reporting systems in health and social care services include user interviews, focus groups, usability tests, and follow-up surveys through phone calls and customer feedback. According to Maurer and Schaich (2011), a customer review is also used as a complaint management tool. This is an example of customer reviews' usefulness to producers and business owners. For a public reporting system in health and social care services to be fully beneficial to users, the inclusion of customer or user reviews is a necessity. Such inclusion is also required for the continuous development of public reporting systems.

IMPROVING THE RECEPTION AND THE USE OF PUBLIC REPORTING

For users to enjoy the benefits of the public reporting system of health and social care services, they need to be able to use the various reports. Consumers' adoption and effective use of reports are affected by several factors, including presentation of information, incentives for engagement, engagement of the public, advertisement, reduction of the cognitive burden for users, and test reports involving consumers during development. To maximize the use of the reports, they need to engage and motivate users to explore and use the reports, deepen consumers' understanding of quality and quality measurements, and legitimize the reports' credibility (Sofaer & Hibbard, 2010).

Presentation of Information

The style of presenting information either enhances the assimilation and the use of the information or hinders it (Faber, Bosch, Wollersheim, Leatherman, & Grol, 2009; Hibbard, Slovic, Peters, & Finucane, 2002). It is important to make reports easy for consumers to understand and use. During the development of the reports, it is essential to consider how the information will be presented. The data can be presented in plain text, visualized, or interactive. To present information in plain text for users, it is essential to do so in the least broken form for usability by users representing various demographics. The information will have to be presented in the simplest form to be understood. The use of visual cues from studies and experiments has been shown as one of the most effective ways of presenting information and communicating with consumers (Hibbard et al., 2002).

User Engagement

To achieve consumers' proper use of public reports, it is essential that reports be developed to actively engage the public. For public reporting organizations to achieve this type of engagement by the public, it is necessary for public reports to meet the criteria of understandability, accessibility, relevance, and trust in sponsoring organizations (Marshall et al., 2004). It is important for consumers to understand the ins and outs of the public reports they use. There should be an understanding of what the intended purposes of the reports are and who the beneficiaries are. According to Marshall et al. (2004), consumers may not understand quality indicators and may be surprised and overwhelmed by the amount of information to which they are exposed in the published reports.

Enhanced accessibility of the reports is important to maximize the use of publicly published reports on health and social care services. Marshall et al. (2004) also state that reports should be organized properly so that consumers can select the information they want, when they want it, and in the format with which they are most comfortable. This means that during the development of the reports, content experts should work with both report designers and users. A user perspective is needed for designing a report that will be of use to consumers. Accessibility also includes the proper use of evaluation cues, fonts, colors, headings, and bulleted lists (Marshall et al., 2004).

The quality of published public reports is an essential enabler for their use. The quality of the reports can be improved by personalizing them to meet user requirements (Marshall et al., 2004). This leads to users' in-depth understanding of the reports (Hibbard & Sofaer, 2010). This enables users to turn directly to the specific information they are looking for to make their decisions on which health provider or service they want.

Advertisement of Public Reporting

Ackerberg (2001) states that advertisements should affect both experienced and non-experienced users. In either case, users are informed about the product or the service being advertised. Consumers of published public reports on health and social care services should be targeted by the organizations producing the reports and bombarded constantly with information about the need for and the use of public reporting through every advertisement channel. The various advertisement channels reach a wide range of users from all demographics. Marshall et al. (2004) report that the television media will be involved in the advertisement of public reporting if visuals of patients and health professionals could be provided. This imposes more demands on organizations producing public reports. An advertisement has always been one of the proven and most effective ways of reaching consumers in most industries. It has improved consumers' decision making; has affected brand, product, and service switching and repeated purchases of products and services (Deighton, Henderson, & Neslin, 1994); and has the potential of influencing the way that public reporting is perceived and used by consumers. Advertisements should be used for the intentional popularization of public reporting on health and social care services. Thus, it is essential to engage all consumers through all the available advertisement channels (radio, newspapers, magazines, and television). Users' education about the quality of healthcare and increased awareness of the benefits and the use of public reporting can be achieved through the advertisement channels.

Reduction of the Cognitive Burden of Users

Users' understanding of the published public information is paramount for the successful use of public reports. Reducing the cognitive burden of users aims to enable them to understand the presented information, regardless of their social and educational status (Cacace et al., 2017), by decreasing the complexity of the presented data. Reports in other industries have evolved, from complex figures and statistical tables to more interactive tools that allow easy searching, filtering, and accessible formats (Sandmeyer & Fraser, 2016). Hibbard and Sofaer (2010) also suggest that to make it easy for consumers to understand and use the comparative published public reports, it is necessary to reduce the cognitive burden by summarizing, interpreting, highlighting meaning, and reducing the options. Consumers should be provided with guidance and support on how to use the published reports. The ability to read, assimilate, and make decisions are processes that need to be simplified in a way that will still capture the attention of users of all social standing.

Testing the Reports Before They are Published

Report development should be an iterative activity. Consumers and designers should work hand in hand to produce reports. Reports should be tested with consumers before they are published, particularly their language, format, and structure (Sofaer & Hibbard, 2010). The test can be performed through consumer interviews, surveys, and consumer reviews.

PUBLIC REPORTING IN OTHER INDUSTRIES

Other industries have successfully implemented public reporting systems for many years. These systems are being developed constantly to satisfy customer needs. Amazon is currently one of the most successful companies in online shopping. It has implemented a very good public reporting system that continuously and actively engages users. Customer reviews on Amazon are about the services provided and the products sold on the webstore. Reviews on Amazon can be classified according to the goods being purchased to receive the maximum feedback on which other consumers can base their purchasing decisions (Mudambi & Schuff, 2010). Kandemirli (2018) states that Amazon has leveraged innovative technology to provide advantages that are based on more knowledge of their customers, which leads to customer satisfaction.

The tourism industry has also been very successful in public reporting and has many types of public reporting platforms. The tourism industry comprises different services, including accommodations, transportation, tourist sites, and many more services. Each of these services either has its own public reporting platform or an integrated platform of two or more services, which includes customer reviews or feedback. For instance, a tourist looking for comparative information on accommodations can visit booking.com. This public reporting platform allows users to filter their search for information by property theme, star ratings, distance from a city center, enjoyable things to do, 24-hour reception, beach access, property type, landmarks, review scores, facilities, room facilities, district, facilities for guests with disabilities, hotel and hostel chains, and room accessibility. The medium of communication is the Internet. This is an example of a highly developed, mature, up-to-date, and customer-centric public reporting system.

ICT has enabled the evolution of the tourism industry by providing new tools for management, marketing, and interactivity between customers and tourism enterprises (Buhalus & Connor, 2005). According to Buhalis and Amaranggana (2015), transforming tourism into smart tourism is a necessity. Smart tourism means enhanced access to real-time information, personalized services, and an advanced feedback loop (Buhalis & Amaranggana, 2015). This demonstrates the continuous development of the tourism industry based on a customer-centric approach to business. Advanced technologies, such as big data, the Internet of Things, machine learning, and artificial intelligence, have been integrated into reporting platforms to meet the evolving demands of users from the public reporting platforms. The tourism industry has been undergoing continuous and consistent development, where some of the best reporting systems are found. Examples of other public reporting platforms in the tourism industry are TripAdvisor, Uber, Airbnb, and Expedia.

Public reporting in health and social care services is still developing. Reporting platforms in the tourism industry can serve as templates for building and implementing the health and social care services' own platforms.

Challenges and Alternatives in Implementing Public Reporting

Despite the potential opportunities for public reporting, a number of challenges could prevent the realization of the benefits and the full potential of some of the challenges, for example, the following:

1. Presentation of information.
2. Accessibility.
3. Structuring of information.
4. Lack of prior experience by adopting countries and users.

Presentation of Information

One of the most significant challenges of public reporting is the presentation of information. Accessing and understanding the information to be able to use it is the main point of public reporting and publishing. The lack of a proper presentation of information to patients might lead to the lack of usage of the platform. An optimal presentation of a published public report is required for patient engagement (Liu et al., 2017). According to Geraedts et al. (2011), presentation styles should reduce the cognitive burden for users. Structuring the information in the simplest and most direct form and omitting unnecessary information constitute the best possible way of presentation to users. Consumer types have to be considered when publishing information for the public. Providers of public reporting on healthcare services and delivery should ensure that the true message is not lost in the volume of available data. Hibbard and Sofaer (2010) state that information should be made easy for use by consumers. They further outline the things to do when designing a report:

1. Reduce the cognitive burden by summarizing, interpreting, highlighting meaning, and narrowing options.
2. Reduce the cognitive burden by helping to bring the information together into a choice.

Accessibility

Accessibility is a challenge in public reporting in healthcare because of the various communication media available to patients. Published information is practically useless if consumers have no good and easy way to access it. Based on this issue, accessibility should be one of the focal points of public reporting during the planning, designing, and implementation stages. The web is one of the most common and most used media for access to information by both users and providers. The usage of the web as a medium of communication poses several challenges. Leonardi et al. (2007) report that with the accessibility of websites, three criteria should be considered, which are cost, the need for signing up, and ease of use. These criteria drastically affect the usage of the reporting websites. This will continue to be a challenge in public reporting. The cost incurred by a consumer in using a public website will affect the user's interest and attitude towards the website. The process of signing up to use a website will also affect the user's interest in the website. Lastly, the ease of use will play a vital role in patients' and consumers' patronage of a website.

Structuring of Information

The challenges of presenting and structuring the information are connected. The main issue with both challenges is how to communicate insightful information to customers and patients. A key challenge is how to structure the information that will satisfy customers or patients with different demographic characteristics including age, gender, economic status, social status, and literacy level. In addition to the patients' demographic characteristics, health literacy has to be also considered when structuring the information to be released to the public. Gilmour (2007) states that health literacy is essential in making informed choices regarding health services. Faber et al. (2008) report that out of six studies that tested presentation formats, the context of the information, risk messages, and easy-to-read layout styles lead to positive results in terms of the users' proper use of the published information. Structuring of information sets multilayered challenges for public reporting. Hibbard and Sofaer (2010) outline practical design solutions, such as:

1. Present the overall definition of quality.
2. Define the elements of quality and use them as report categories.
3. Include information on the sponsor and the methods.

Du, Zhang, and Tang (2016) report that some stakeholders in the health and social care services worry about the quality of work that is put into designing the report.

Lack of Prior Experience by Adopting Countries and Users

Countries with some prior experiences with public reporting in healthcare might have little challenges in designing and implementing a new public reporting system. Countries with no prior experience will face more challenges in designing, building, and implementing a new public reporting system in healthcare.

Research Opportunities in Public Reporting

Public reporting has the potential to be a quality improvement agent. Patients in the future will demand more quality services and the accountability of health and social care service providers. Public reporting enables customers to take a good look into providers and other stakeholders and influence how services should be delivered to them.

Despite the tremendous growth of public reporting, there is still more to be done. Some aspects remain unclear and uncertain. The research opportunities in public reporting are vast and necessary for further development of the system. Key topics have been unexplored or under-explored during this research work. Below is a list of topics that should be studied:

1. Health and social care service providers' attitudes toward public reporting.
2. Benefits of public reporting to health and social care service providers.
3. Quality of the data presented in public reports on health and social care services.
4. Role of information systems in public reporting.
5. Big data and public reporting on health and social care services.
6. Standard of public reporting on health and social care services.
7. Design and implementation of health and social care services' public reporting platforms.
8. The authorities responsible for reporting healthcare and social care quality.

Further research needs to be done on the above list of topics for in-depth knowledge of the various elements of public reporting. This will enable improved designs and implemented systems of public reporting.

CONCLUSIONS

Successful and useful public reporting systems in health and social care services require considerable investments. This review of public reporting systems in general has found some common benefits and issues in countries that have implemented health and social care services' reporting systems. Public reporting is a mix of healthcare, policies, technologies, standards, and information systems. The successful implementation and use of public reporting leads to benefits for consumers since it is a consumer-driven system. The issues of public reporting are all resolvable with time since it is still a developing idea, system, and concept worldwide. The idea of public reporting is new in some parts of the world. Developed countries have taken the lead and will provide the blueprints for other countries that will implement public reporting in the future. The benefits are too great for countries not to adopt it.

Public reporting also allows physicians to examine their own practice, such as how they are doing. It encourages providers to connect with others, with the goal of development. To get the most from public reporting, providers have to be actively involved in it. Providers of healthcare and social services are important for the success of any healthcare reporting system. One of the strongest benefits of public reporting is making providers more attentive to consumers, as well as coming to the table to examine their own performance and seeking opportunities for improvement. Public reporting is a feedback mechanism for providers, enhancing the relationship between providers and consumers.

In addition to the three channel pathways mentioned earlier, we believe that the inclusion of customer or user reviews is another channel pathway for improvement in quality and performance. Based on research, customer reviews have affected products and services, both positively and negatively. The improvement impact of customer or user reviews on public reporting takes three forms. Customer reviews constitute a system by which users can give their take on the reports they have used. Based on these reviews, the reports will be improved according to the users' specific needs. Improved reports enhance their reception and usage. This also leads to users' choices that will influence health and social care service providers, resulting in the improvement of their services. There is a connection between all three channels and the proposed review channels of improvements.

More measures need to be taken to increase the popularity of public reporting on health and social care services to the public. Similar to the case of any new product or service, there are commercials and advertisements to inform the public about them. The lack of advertisement of public reporting should be addressed. Thus, there is the need for intensive campaigning in the various countries that have adopted public reporting in their health and social care services. To enhance the reception of public reporting systems, there ought to be a deliberate move to make users aware of these various reporting systems and what they are about.

Public reporting on health and social care services is equally important and useful to the providers as it is to the consumers. The growth of public reporting on health and social care services is inevitable as we are heading more toward the consumer-driven approach in almost every industry.

REFERENCES

Behrendt, K., & Groene, O. (2016). Mechanisms and effects of public reporting of surgeon outcomes: A systematic review of the literature. *Health Policy (Amsterdam)*, *120*(10), 1151–1161. doi:10.1016/j.healthpol.2016.08.003 PMID:27638232

Benigeri, M., & Pluye, P. (2003). Shortcomings of health information on the Internet. *Health Promotion International*, *18*(4), 381–386. doi:10.1093/heapro/dag409 PMID:14695369

Berwick, D. M. (2003). Disseminating innovations in health care. *Journal of the American Medical Association*, *289*(15), 1969–1975. doi:10.1001/jama.289.15.1969 PMID:12697800

Buhalis, D., & Amaranggana, A. (2015). Smart tourism destinations enhancing tourism experience through personalisation of services. In *Information and communication technologies in tourism 2015* (pp. 377–389). Cham: Springer. doi:10.1007/978-3-319-14343-9_28

Burstin, H., Leatherman, S., & Goldmann, D. (2016). The evolution of healthcare quality measurement in the United States. *Journal of Internal Medicine*, *279*(2), 154–159. doi:10.1111/joim.12471 PMID:26785953

Cacace, M., Ettelt, S., Brereton, L., Pedersen, J. S., & Nolte, E. (2011). How health systems make available information on service providers: Experience in seven countries. *Rand Health Quarterly, 1*.

Cacace, M., & Geraedt, M. (2017). Public reporting as a quality strategy. *European Journal of Public Health, 27*(suppl_3).

Campanella, P., Vukovic, V., Parente, P., Sulejmani, A., Ricciardi, W., & Specchia, M. L. (2016). The impact of public reporting on clinical outcomes: A systematic review and meta-analysis. *BMC Health Services Research*, *16*(1), 296. doi:10.118612913-016-1543-y PMID:27448999

Chen, Y., & Xie, J. (2008). Online consumer review: Word-of-mouth as a new element of marketing communication mix. *Management Science*, *54*(3), 477–491. doi:10.1287/mnsc.1070.0810

Ciani, O., Tarricone, R., & Torbica, A. (2012). Diffusion and use of health technology assessment in policy making: What lessons for decentralised healthcare systems? *Health Policy (Amsterdam)*, *108*(2–3), 194–202. doi:10.1016/j.healthpol.2012.09.017 PMID:23093020

Cutler, D. M., Huckman, R. S., & Landrum, M. B. (2004). The role of information in medical markets: An analysis of publicly reported outcomes in cardiac surgery. *The American Economic Review*, *94*(2), 342–346. doi:10.1257/0002828041301993 PMID:29068186

Darius, P., Boucneau, M., De Greef, P., De Feber, E., & Froeschl, K. (1993). Modelling metadata. *Statistical Journal of the United Nations Economic Commission for Europe*, *10*, 171–179.

de Cruppé, W., & Geraedts, M. (2017). Hospital choice in Germany from the patient's perspective: A cross-sectional study. *BMC Health Services Research*, *17*(1), 720–720. doi:10.118612913-017-2712-3 PMID:29132430

Dehmer, G. J., Drozda, J. P. Jr, Brindis, R. G., Masoudi, F. A., Rumsfeld, J. S., Slattery, L. E., & Oetgen, W. J. (2014). Public reporting of clinical quality data: An update for cardiovascular specialists. *Journal of the American College of Cardiology*, *63*(13), 1239–1245. doi:10.1016/j.jacc.2013.11.050 PMID:24509280

Deighton, J., Henderson, C. M., & Neslin, S. A. (1994). The effects of advertising on brand switching and repeat purchasing. *JMR, Journal of Marketing Research*, *31*(1), 28–43. doi:10.1177/002224379403100103

Doering, N., & Maarse, H. (2015). The use of publicly available quality information when choosing a hospital or health-care provider: The role of the GP. *Health Expectations*, *18*(6), 2174–2182. doi:10.1111/hex.12187 PMID:24673801

Du, X., Zhang, X., & Tang, Y. (2016). General practitioners' perceptions of public reporting of institution and individual medicine prescribing data. *BMC Health Services Research*, *16*(1), 641–641. doi:10.118612913-016-1893-5 PMID:27829429

Elliott, M. N., Cohea, C. W., Lehrman, W. G., Goldstein, E. H., Cleary, P. D., Giordano, L. A., ... Zaslavsky, A. M. (2015). Accelerating improvement and narrowing gaps: Trends in patients' experiences with hospital care reflected in HCAHPS public reporting. *Health Services Research*, *50*(6), 1850–1867. doi:10.1111/1475-6773.12305 PMID:25854292

Emmert, M., Sander, U., Esslinger, A. S., Maryschok, M., & Schöffski, O. (2012). Public reporting in Germany: The content of physician rating websites. *Methods of Information in Medicine*, *51*(02), 112–120. doi:10.3414/ME11-01-0045 PMID:22101427

Eysenbach, G. (2000). Consumer health informatics. *BMJ (Clinical Research Ed.)*, *320*(7251), 1713–1716. doi:10.1136/bmj.320.7251.1713 PMID:10864552

Faber, M., Bosch, M., Wollersheim, H., Leatherman, S., & Grol, R. (2009). Public reporting in health care: How do consumers use quality-of-care information?: A systematic review. *Medical Care*, *47*(1), 1–8. doi:10.1097/MLR.0b013e3181808bb5 PMID:19106724

Ferlie, E. B., & Shortell, S. M. (2001). Improving the quality of health care in the United Kingdom and the United States: A framework for change. *The Milbank Quarterly*, *79*(2), 281–315. doi:10.1111/1468-0009.00206 PMID:11439467

Geraedts, M., Hermeling, P., & de Cruppé, W. (2012). Communicating quality of care information to physicians: A study of eight presentation formats. *Patient Education and Counseling*, *87*(3), 375–382. doi:10.1016/j.pec.2011.11.005 PMID:22177585

Gilmour, J. A. (2007). Reducing disparities in the access and use of Internet health information. A discussion paper. *International Journal of Nursing Studies*, *44*(7), 1270–1278. doi:10.1016/j.ijnurstu.2006.05.007 PMID:16828775

Guénette, J., Belzile, G., & Hjertqvist, J. (2017). *Health care in Sweden: Decentralized, autonomous, competitive, and universal*. MEI.

Hibbard, J., & Sofaer, S. (2010). *Best practices in public reporting no. 1: How to effectively present health care performance data to consumers*. Rockville, MD: Agency for Healthcare Research and Quality.

Hibbard, J. H., & Peters, E. (2003). Supporting informed consumer health care decisions: Data presentation approaches that facilitate the use of information in choice. *Annual Review of Public Health*, *24*(1), 413–433. doi:10.1146/annurev.publhealth.24.100901.141005 PMID:12428034

Hibbard, J. H., Slovic, P., Peters, E., & Finucane, M. L. (2002). Strategies for reporting health plan performance information to consumers: Evidence from controlled studies. *Health Services Research*, *37*(2), 291–313. doi:10.1111/1475-6773.024 PMID:12035995

Hibbard, J. H., Stockard, J., & Tusler, M. (2003). Does publicizing hospital performance stimulate quality improvement efforts? *Health Affairs*, *22*(2), 84–94. doi:10.1377/hlthaff.22.2.84 PMID:12674410

Hoyt, R. E., & Yoshihashi, A. K. (2014). *Health informatics: Practical guide for healthcare and information technology professionals*. Academic Press.

Ivers, N. M., Taljaard, M., Giannakeas, V., Reis, C., Williams, E., & Bronskill, S. (2019). Public reporting of antipsychotic prescribing in nursing homes: Population-based interrupted time series analyses. *BMJ Quality & Safety*, *28*(2), 121–131. doi:10.1136/bmjqs-2018-007840 PMID:30061102

Kandemirli, B. (2018). What makes a helpful online review? A study of customer reviews on Amazon.com. *Research Gate*, 185–200.

Kasiske, B. L., Wey, A., Salkowski, N., Zaun, D., Schaffhausen, C. R., Israni, A. K., & Snyder, J. J. (2019). Seeking new answers to old questions about public reporting of transplant program performance in the United States. *American Journal of Transplantation*, *19*(2), 317–323. doi:10.1111/ajt.15051 PMID:30074680

Kelaher, M., Prang, K. H., Sabanovic, H., & Dunt, D. (2018). The impact of public performance reporting on health plan selection and switching: A systematic review and meta-analysis. *Health Policy (Amsterdam)*. PMID:30340906

Kumpunen, S., Trigg, L., & Rodrigues, R. (2014). *Public reporting in health and long-term care to facilitate provider choice*. Academic Press.

Lagu, T., Norton, C. M., Russo, L. M., Priya, A., Goff, S. L., & Lindenauer, P. K. (2019). Reporting of Patient Experience Data on Health Systems' Websites and Commercial Physician-Rating Websites: Mixed-Methods Analysis. *Journal of Medical Internet Research*, *21*(3), e12007. doi:10.2196/12007 PMID:30916654

Leatherman, S., & McCarthy, D. (1999). Public disclosure of health care performance reports: Experience, evidence and issues for policy. *International Journal for Quality in Health Care*, *11*(2), 93–98. doi:10.1093/intqhc/11.2.93 PMID:10442837

Leonardi, M. J., McGory, M. L., & Ko, C. Y. (2007). Publicly available hospital comparison web sites: Determination of useful, valid, and appropriate information for comparing surgical quality. *Archives of Surgery*, *142*(9), 863–869. doi:10.1001/archsurg.142.9.863 PMID:17875841

Liu, C., Tang, Y., Wang, D., & Zhang, X. (2017). The effect of public reporting presentation on patients' decision making: An experimental survey in Yunan Province, China. *Medicine*, *96*(24), e7203. doi:10.1097/MD.0000000000007203 PMID:28614266

Marshall, M. N., Hiscock, J., & Sibbald, B. (2002). Attitudes to the public release of comparative information on the quality of general practice care: Qualitative study. *BMJ (Clinical Research Ed.)*, *325*(7375), 1278. doi:10.1136/bmj.325.7375.1278 PMID:12458248

Marshall, M. N., Shekelle, P. G., Davies, H. T., & Smith, P. C. (2003). Public reporting on quality in the United States and the United Kingdom. *Health Affairs*, *22*(3), 134–148. doi:10.1377/hlthaff.22.3.134 PMID:12757278

Maurer, C., & Schaich, S. (2011). *Online customer reviews used as complaint management tool*. Enter. doi:10.1007/978-3-7091-0503-0_40

Maurer, M., Firminger, K., Dardess, P., Ikeler, K., Sofaer, S., & Carman, K. L. (2016). Understanding consumer perceptions and awareness of hospital-based maternity care quality measures. *Health Services Research*, *51*, 1188–1211. doi:10.1111/1475-6773.12472 PMID:26927831

McCreadie, M., & Rice, R. E. (1999). Trends in analyzing access to information. Part I: Cross-disciplinary conceptualizations of access. *Information Processing & Management*, *35*(1), 45–76. doi:10.1016/S0306-4573(98)00037-5

Morris, K., & Zelmer, J. (2005). *Public reporting of performance measures in health care*. Ottawa: Canadian Policy Research Networks.

Mudambi, S. M., & Schuff, D. (2010). What makes a helpful review? A study of customer reviews on Amazon. com. *Management Information Systems Quarterly*, *34*(1), 185–200. doi:10.2307/20721420

Narins, C. R., Dozier, A. M., Ling, F. S., & Zareba, W. (2005). The influence of public reporting of outcome data on medical decision making by physicians. *Archives of Internal Medicine*, *165*(1), 83–87. doi:10.1001/archinte.165.1.83 PMID:15642879

Peters, E., Dieckmann, N., Dixon, A., Hibbard, J. H., & Mertz, C. K. (2007). Less is more in presenting quality information to consumers. *Medical Care Research and Review: MCRR*, *64*(2), 169–190. doi:10.1177/10775587070640020301 PMID:17406019

Rechel, B., McKee, M., Haas, M., Marchildon, G. P., Bousquet, F., Blümel, M., ... Anell, A. (2016). Public reporting on quality, waiting times and patient experience in 11 high-income countries. *Health Policy (Amsterdam)*, *120*(4), 377–383. doi:10.1016/j.healthpol.2016.02.008 PMID:26964783

Sandmeyer, B., & Fraser, I. (2016). New evidence on what works in effective public reporting. *Health Services Research*, *51*, 1159–1166. doi:10.1111/1475-6773.12502 PMID:27120996

Sofaer, S., & Hibbard, J. (2010). *Best practices in public reporting no. 2: Maximizing consumer understanding of public comparative quality reports: Effective use of explanatory information*. Rockville, MD: Agency for Healthcare Research and Quality.

Werner, R. M., & Asch, D. A. (2005). The unintended consequences of publicly reporting quality information. *Journal of the American Medical Association*, *293*(10), 1239–1244. doi:10.1001/jama.293.10.1239 PMID:15755946

Werner, R. M., & Bradlow, E. T. (2010). Public reporting on hospital process improvements is linked to better patient outcomes. *Health Affairs*, *29*(7), 1319–1324. doi:10.1377/hlthaff.2008.0770 PMID:20606180

Werner, R. M., Konetzka, R. T., Stuart, E. A., Norton, E. C., Polsky, D., & Park, J. (2009). Impact of public reporting on quality of postacute care. *Health Services Research*, *44*(4), 1169–1187. doi:10.1111/j.1475-6773.2009.00967.x PMID:19490160

World Health Organization. (2008). *Health information systems*. Retrieved July 5, 2019 from <http://www.who.int/healthinfo/statisticstoolkit_hss/EN_PDF_Toolkit_HSS_InformationSystems.pdf> <https://publicreporting.sts.org/sites/default/files/files/Consumer%20Reports%20and%20STS%20Public%20Reporting.pdf>

Chapter 4
Proposal for Pervasive Elderly Care:
A Case Study With Next of Kin

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ABSTRACT

This chapter reports how interaction between family members and caregivers as perceived by family members could be improved via context-aware, imperceptible internet of things (IoT)-based solutions. The qualitative study focused on investigating experiences of the family members and the communication between caretakers in sheltered accommodation. Interviews including both open and closed questions revealed that there is high need for improving the communication, adding to the sparse earlier knowledge. The study revealed that the family members were willing to adopt an application to improve the communication that currently was experienced as too limited and vague. The results provide a fruitful base for further actions to improve communication between family members and professional caretakers.

INTRODUCTION

The purpose of our study was to investigate how family members of the elderly experience the potential use of assistive technology in sheltered accommodation when interacting with caretakers. The motivation for this study arose from earlier studies that revealed a lack of or slender interaction between caretakers and family members of elderly care centre residents.

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The numbers of elderly are increasing globally, and the growth is expected to continue (Medjahed et al., 2011). The supportive role of family members in assisting their elderly is important and may lead to reduced costs down the line (Bolin et al., 2008). Along with ageing, the need for assistance and care increases, and the elderly are moving to accommodation that can offer more support than at private homes (Hainstock et al., 2017). However, the rising number of ageing occupants also means an increased need for care and resources from the caregivers (Alam et al., 2012).

Guiding family members is one of the duties of nurses. Family members bring meaning, continuity and importance to the lives of the elderly. It is important to encourage and support relatives to interact with the elderly and nursing staff (Andersen, 1995; Doty, 1986). The current study investigated the possibilities of state-of-the-art technology to support interaction between caretakers and visiting family members and other next of kin of the occupants. The research problem was compressed into a research question: How do next of kin of the elderly living in sheltered accommodation consider using assistive technology when communicating with personnel who take care of the elderly? To answer the research question, methods of qualitative research were applied in a home (dubbed Comfort in this paper) offering sheltered accommodation for elderly. Qualitative interviews were carried out in Comfort, and eight persons representing the next of kin participated in the study.

By identifying the family members' worries during their visit, it was hoped the bottlenecks resulting from the care work can be reduced, enabling family members to participate in different stages of the care. In addition, there already are devices that provide intelligent surveillance technology to help elderly people live in safety while providing energy efficiency, comfort and automation (Wong et al., 2017).

However, the question remains: Are family members willing to apply assistive technology to ease information sharing and reduce uncertainty related to the wellbeing of their elderly?

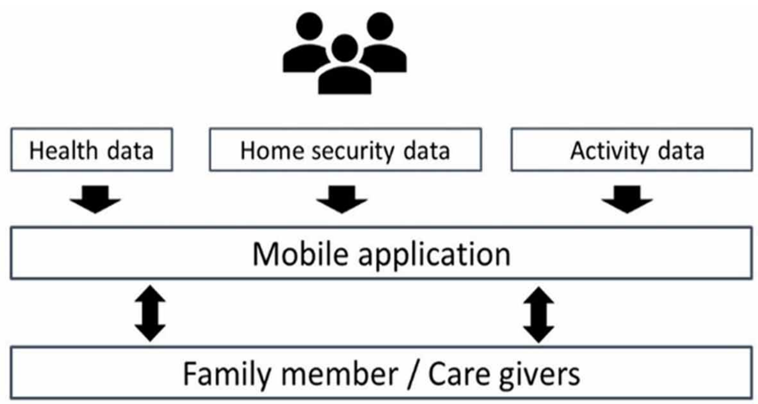
BACKGROUND

Elderly in Sheltered Accommodation

The proportion of aging populations is growing worldwide, and explosive growth is expected to continue (Medjahed et al., 2011). When supporting the elderly to maintain their independence and quality of life, the role of family is crucial. However, the next of kin can experience too heavy a burden in caring for their elderly and continuing their lives (Hainstock et al., 2017). Sheltered accommodation and treatment costs are rising, and illness is more prominent, requiring additional resources for nursing staff (Alam et al., 2012). Studies show that the life of the elderly is more meaningful in nursing homes than in an institutional care facility (Nikmat et al., 2015; Tuominen et al., 2016). In the nursing home, the elderly can have their own rooms and live in their own apartments surrounded by their own belongings. Nursing staff is available 24/7 (Coelho et al., 2015); however, with an increasing number of residents, so does the workload of nursing staff increase, thus weakening the premise of better care of patients, mostly due to efficiency bottlenecks (Huttunen et al., 2018). Intelligent care systems provide many opportunities to overcome such challenges, and elderly well-being, health and functional ability have been shown to improve with wearable sensors and personal area networks (PAN) (Wong et al., 2017).

It is natural for the nursing staff to recognise the limitations of older people's ability to perform daily tasks, thus empowering them to provide high-quality care for the elderly. Guiding and providing information to family members are among the duties of a nurse, and the role of the family in service

Figure 1. Data flow of mobile applications



systems is also very important. Studies show that it is important to encourage and support relatives to interact with the elderly and nursing staff (Andersen, 1995; Doty, 1986).

Technology in Sheltered Accommodation

Over the last few decades, technological advances have been made in solutions for intelligent homes, providing a remote monitoring system useful for healthcare. The devices provide surveillance technology to help elderly people live in safety and provide energy efficiency, comfort and automation (Wong et al., 2017). Safe housing has been studied previously, in a case where an intelligent control environment was built in the home of elderly persons. Such technology was placed in each room of the home to monitor the movement of users in the rooms and, if necessary, an alarm can be triggered remotely (Freitas et al., 2015; Klakegg et al., 2017).

The elderly could be supervised by a remote system that collects information about health, activity and safety of the person. Automatically collected data gathers valuable information about their behaviour and potentially their needs to enable prompt decisions and plans for future actions. Devices exported to the home of the elderly should not compromise patient safety and therefore must be as discreet as possible and work under everyday living conditions (Klakegg et al., 2017; Nygård & Starkhammar, 2007).

Figure 1 illustrates how data can flow between several actors, such as care personnel in the sheltered accommodation and next of kin at their homes who are involved in the communication related to elderly persons' health-related data (Klakegg et al., 2017).

The role of digitalisation will be more visible in future in the form of unobtrusive body area networks (BAN) and PAN sensors in rooms to be applied in healthcare when the requirements of treatment grow worldwide. Sensor networks work together through a wireless network and can identify and achieve numerous opportunities to track and understand the lived phenomena of people (Krishnamachari, 2015; Atzori et al., 2010).

Figure 2: Smart home device for elderly

Healthcare Sensors in Sheltered Accommodation

Internet of things (IoT) refers to devices and items that communicate between each other and are located around us, ubiquitously (Atzori, 2010). IoT consists of sensors, net connections and information management. Sensors located in devices are energy efficient, identifiable and safe and include net technology (Gubbi et al., 2013).

Figures 2, 3 and 4 illustrate unobtrusive BAN and PAN sensors positioned in sheltered accommodation for the elderly. Figure 2 shows a microwave oven and hotplate secured by a separate switch on the wall, a tablet to allow distant connection between the user and caretaker, a camera on the windowsill, and a scale to measure body weight – all connected via IoT.

Sensors attached to the body or clothing form a network in the body area (BAN). The purpose of the body sensors is to measure heart rate, daily rest, sleep quality, activity, mood and stress levels (Figure 3).

Sensors attached to a person should be easy to use and unobtrusive so that their existence does not affect the everyday life of the patient or elderly. Movement must also be possible unobstructed (Cavallari et al., 2014). Sensors attached to the environment form a PAN where sensors are located close to the object. Sensors are placed in the home to various devices such as home appliances, bed, walls or smartphones. PAN sensors can measure, for example, movement, sound, air pressure, temperature, humidity and light. Sensors are used to gather required information about the environment of the elderly (Huttunen et al., 2017).

Figure 3: Wrist sensors

The use of information technology and telecommunications in healthcare provides advanced solutions for nursing staff. In addition, patients can take advantage of technology to support their own care and at the same time increase interaction between their relatives and the nursing staff. Figure 4 illustrates wearable medical measures such as blood pressure meter, clinical thermometer, measure to monitor oxygen concentration and measure to monitor blood sugar level.

Intelligent systems are intended to enhance access to care, to develop nursing workflows and to reduce bottlenecks that occur in nursing. By first identifying nursing processes, the quality of healthcare services can be improved (Faertes, 2015; Huttunen et al., 2017).

Pervasive healthcare is considered to be one of the solutions to support the future of high-quality care. Healthcare should be available to anyone, anywhere, anytime. The purpose of pervasive healthcare is to eliminate time and place limitations in healthcare. The definition includes short-term and long-term prevention, maintenance and patient controls. Medical equipment that monitors patients' vital functions,

Figure 4: Wearable medical measures

movements, quality of life and activity are provided to support patients' care at home or at sheltered housing (Varshney, 2005; Huttunen & Halonen, 2018).

Healthcare professionals are encouraged to use more and more handheld devices to obtain patient information. In elderly care, relatives can receive information about the client's status, reminders about treatment and medication changes or write prescriptions electronically. Healthcare staff rarely have training in intelligent applications, so patients and their relatives should be trained in hospitals in the use of the information and communications technology (ICT)-enabled applications (Varshney, 2005). Handheld devices and personal digital assistants (PDAs) can also detect and monitor patients' vital functions and send alarm messages to hospitals, ambulances or patients' relatives for emergency services. Alarm messages can also support patients' own care, leading to early detection of symptoms and timely taking of medication (Varshney, 2005; Huttunen & Halonen, 2018).

RESEARCH APPROACH

Our study focused on understanding a limited group of people in their real environment (see Myers & Avison, 2002; Larsson & Sjöblom, 2010). In the study, qualitative theme-based and open interviews and observation were applied.

The study was carried out among visiting next of kin of people who were being cared for at Comfort. The empirical material was collected in two phases. In the first phase, the participants were asked to fill out a semi-structured questionnaire that consisted of 19 questions. The questions included three main questions and their sub-questions. The main questions were about the background information of the informants, care activities in Comfort and using smart technology that could transfer information about the health status of the occupants to their next of kin. In the second phase, a face-to-face interview was carried out, guided by the information from the semi-structured questionnaires.

Table 1. Family members as visitors

Frequency of Visiting Comfort	Age	Kinship	Distance to Home
Daily	85	Spouse	1km
A few times per week	60	Daughter	3km
A few times per week	56	Son	2km
Once a week	58	Daughter	10km
Once a week	69	Son	3km
A few times per month	64	Son	110km
A few times per month	47	Son	2km
A few times per month	46	Other relative	230km

The interviews, which lasted from 45 minutes to 90 minutes, were completed in two days. In total, eight family members were interviewed in March 2018. The questions in the questionnaires allowed freedom for the informants to describe their experiences about the interaction between them and the caretakers.

The interviews were transcribed, and the questionnaires were analysed with the help of content analysis (see Myers, 1997). Earlier studies were also noted in the analysis phase. The questionnaire included both open and closed questions, and they were answered by numerals, words or 'yes/no' responses. Eight people participated in both questionnaires and interviews, all of whom were appropriate for the research.

The background information was sorted based on sex, age, relationship with the occupant, distance of home, frequency and duration of stay in Comfort, length of care, frequency of change of care staff during occupancy and whether the next of kin experienced any lack of information related to the care given in Comfort.

Related to participating in the giving of care in Comfort, the resources of the family members were classified. In addition, the ways of participating in care, how personnel encourage participating in care and which tasks in care the informant would like more information about were analysed. Further, the preparedness of the family members to apply smart technology in interacting with care personnel were analysed, mirroring it with earlier research.

FINDINGS

Our eight participants consisted of five men and three women. They were three sons, three daughters, one living partner and one other relative. Their age varied between 46 and 85 years, and their homes were situated at the distance from 1 to 230 km. The informants were also asked how often they visited their elderly (see Table 1).

Table 1 reveals that one of the relatives visited the elderly every day, two a few times a week and another two persons once a week. Families that visited often lived near, but the respondents who lived far away visited only a few times a month, except one son who despite the short distance visited a few times per month.

Most of the respondents felt that the information was not always delivered to the family quickly enough and that the information was not explicit enough. Some nurses provided information without asking, but most nurses responded only *'I don't know'* when information was requested because they were not named as personal nurses for those elderly. Some relatives also felt that nurses gave loose answers. One of the respondents stated there was a flaw in the information flow between nurses and relatives in the service unit. One of them was very annoyed as the nurses did not note any informed observations about the elderly, who had a urinary tract infection and subsequently had to be treated in hospital.

Eight respondents stated that they didn't get enough information about the care related to their elderly. Most of them also experienced that information is not transferred quickly enough and that the information is inconsistent and changing. In general, the family members felt that the nurses give somewhat vague reports about the daily tasks of their elderly. One of the family members gave a thorough opinion about the issues related to communication between the caregivers and family members as follows:

During my visits there has never been a nurse at work who could have known about the wellbeing of my next of kin and if it has changed in a way or other during the past month. When I visit, I ask the nurse on shift how my uncle is. The nurse is not able or cannot say other but what has happened during her shift. If there had been a responsible nurse on shift, she could tell accurately because a trained nurse must be aware of all the clients and their wellbeing. For instance, the influence of medication, injections, starting new medication, results of laboratory tests and their effect on the wellbeing of the client. In addition, the nurse should be responsible for recording all changes in health status, medication and prescriptions and healthcare actions according to the health reports and examinations and the vital functions of the client.

Also, the family members were asked for their opinions about their resources to participate in the care in Comfort. Most of them were ready to help the elderly in Comfort as a support for the nurses. They reported that they can offer a lot of support by helping their elderly in getting dressed, going out, discussing, giving information about happenings outside of Comfort, taking care of tasks, listening, comforting, calming and cheering up the elderly and participating in the physician's visit together with the care personnel. We also asked how much the family members had been involved in planning and evaluating the care of their relative before the client arrives in the sheltered accommodation and during the housing. Most of the respondents had been involved in the planning of their elderly person's care, but a few of them had not been able to be give input on the treatment planning. *'I haven't participated due to the long distance. It could have been possible with a video call, but it was not available in the service room at that time.'* One person mentioned in the interview that he was involved in a health meeting where they went through his relative's health, hobbies, interests and background information. These biographical items were written on a card where the nurses can check client information. One person also mentioned that she was involved in planning care at the beginning, but afterwards did not get enough information about her relative. *'We did a care plan with the nursing assistant when we arrived to Comfort. After that, perhaps little evaluation took place, but not collectively.'*

Eight of the informants suggested that the smart application should not automatically report about the status of the elderly, daily activities and prescriptions. Rather, the nurse should forward the information to the family member via the application and, in case of need, the family member can contact the elderly via the application. The application should also have a direct messaging functionality to inform the care personnel.

After receiving the background information, the interviewers asked if the respondent was willing to use intelligent technology for interaction between nursing staff and relatives. All eight respondents informed that they desired day-to-day communication through intelligent technology. Relatives would quickly know about changes in health and overall health. The smartphone application would replace the notebook where a family member writes while visiting his or her relative. The answer would be in real time. Family members living far away would get more information and would then be more aware of their elderly's behaviour and change in health status, and the flow of information would be facilitated. The respondents did not find it necessary to get information updates daily. However, one family member considered the smartphone application as a communication tool, defining it as *'Seeing the daily report, current medicines and doses. Despite the long distance I could experience that the distance is not that long and that I am better informed about how my uncle manages.'*

Discussion

This study focused on the family members of elderly living in a sheltered accommodation called Comfort and their willingness to use assistive healthcare if offered by a mobile phone application designed for caregivers.

In Comfort, each client had an individual treatment plan, which supported high-quality care in sheltered accommodation and at the same time acted as a tool for nursing staff. The treatment plans were collaborated with the care unit, occupants and relatives. The need for care of the occupant, the goal of the treatment, the implementation of the treatment and the means were recorded in the treatment plan (see Russello et al., 2008; Schenk et al., 2013).

Guiding family members was one of the nursing staff tasks, and the role of the family was very important. An active role of family members (elderly's spouse, a child or other relative) in the care of the elderly brings substance, continuity and importance to the lives of the elderly. It is important to encourage and support relatives to interact with the elderly and nursing staff (Andersen, 1995; Doty, 1986).

The current study showed that family members *need support for elderly care*. They are *unsure of what's happening* in the nursing home, and they want intelligent technology to support communication. The family members would like *to know that the nurses at the sheltered accommodation can, if necessary, quickly provide topical information* through phone apps to family members.

Family members should also *be offered an opportunity to ask questions about the elderly* from the nursing staff. Intelligent systems allow information sharing between several stakeholders, such as medical staff and nursing staff (Freitas et al., 2015; Klakegg et al., 2017). Our study proposes that the means of pervasive systems are used to inform family members about the status of the elderly.

By adding technology to support nurses' workflows, it is possible to reduce bottlenecks from nursing work and to increase patient safety in sheltered accommodation (Huttunen et al., 2018). Our study assumes that there are *family members who have resources to support care of the elderly and can thus reduce the care work* of nursing staff. The interaction between nursing staff and family members should be enhanced by using intelligent technology to allow *prompt informing when necessary*.

Available intelligent solutions have been developed to provide remote monitoring systems for healthcare. The devices provide intelligent technology for surveillance of the elderly in housing security, comfort and automation (Wong et al., 2017). Current knowledge and technology already enable pervasive systems (Medjahed et al., 2011; Faertes, 2015; Klakegg et al., 2017). Healthcare mobile devices enable more efficient patient care, and sensors can be used to allow collecting and evaluating physiological data from the elderly (Cavallari et al., 2014).

The current study proposes that the communication between nurses and the family members should be enabled and improved via a mobile device, which could *facilitate and increase the awareness of family members about the care and status of their relatives* in sheltered accommodation. The application should inform about *facilities in use, safety of the elderly, e.g. risk of falling when standing up, duration of living in Comfort and mood of the elderly*.

CONCLUSION

To conclude, the family members strongly wanted to apply assistive technology to ease and reduce uncertainty related to the wellbeing of their elderly. Fixed and wearable sensors offer practical means to collect physical, mental and social information about the wellbeing of people. The fixed sensors collect accurate information about the location and safety of the participants. Sensor-based data can be transferred to the mobile application to be used by the care personnel, who can share information with the family members when appropriate.

By identifying the worries and troubles raised by family members when they visit sheltered accommodation, one can reduce the bottlenecks from communication between family members and nursing staff. With the help of applications, the nursing staff can include the occupants' relatives in different stages of the care to bring the nursing staff and family members closer to the elderly's everyday care during the service life. In case of unexpected issues, the family could be informed about any incidents. However, the family members also pointed out that the final decisions should be made by them, not automatically by 'the computer software'.

There are many kinds of sensors on the market that can improve people's lives. There are sensors both inside the body and wearables but also set in the environment (Klakegg et al., 2017). In Comfort, sensor information could facilitate communication between the patient and the nursing staff, as well as between relatives and caregivers.

In healthcare, the use of technical aids is seen as a key means of facilitating interaction between nursing staff, patients/clients and their relatives. Pervasive healthcare is largely based on the use of technical aids and the continuous availability of healthcare to the patient. The goal of pervasive healthcare is to turn healthcare from doctor-centred care to patient-centred care. Pervasive healthcare aims to guide patients/clients to prevent the emergence of acute illnesses and to respond more quickly to their own care (Varshney, 2005; Klakegg et al., 2017; Huttunen & Halonen, 2018). In our study, the nursing staff benefits from continuous automated data collection for a single patient, and in the current study also all family members were willing to accept new technology in caring activities for their elderly. With automation it will be possible to help and respond faster to changes in patient status.

Automation can help improve access to care (Wong et al., 2017), but the technology and security of sensors need to be improved continuously to allow patients/clients to safely use sensors to identify diseases and change lifestyles. In future, the security of tools developed for communication between nursing staff, patients and relatives to improve communication should also be investigated in order not to compromise privacy.

So far, there have been only few studies on communication between relatives and nursing staff to support elderly care. More research is needed in the future to find out how family members of the elderly experience the use of assistive technology in communication when interacting with caregivers in sheltered accommodation. The interaction should be enhanced by using intelligent technology as desired by the next of kin.

The next phase will focus on the application and communication that could extend between the relevant healthcare providers. The current study offers constructive observations and informative points to build a prototype for the mobile application.

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REFERENCES

Alam, M. R., Reaz, M. B. I., & Ali, M. A. M. (2012). A review of smart homes—Past, present, and future. *IEEE Transactions on Systems, Man and Cybernetics. Part C, Applications and Reviews*, *42*(6), 1190–1203. doi:10.1109/TSMCC.2012.2189204

Andersen, R.M. (1995). Revisiting the behavioral model and access to medical care: does it matter? *Journal of Health and Social Behavior*, 1–10. DOI: 11 doi:10.2307/2137284

Atzori, L., Iera, A., & Morabito, G. (2010). The internet of things: A survey. *Computer Networks*, *54*(15), 2787–2805. doi:10.1016/j.comnet.2010.05.01014

Bolin, K., Lindgren, B., & Lundborg, P. (2008). Your next of kin or your own career? Caring and working among the 50+ of Europe. *Journal of Health Economics*, *27*(3), 718–738. doi:10.1016/j.jhealeco.2007.10.004 PMID:18207265

Cavallari, R., Martelli, F., Rosini, R., Buratti, C., & Verdone, R. (2014). A survey on wireless body area networks: Technologies and design challenges. *IEEE Communications Surveys and Tutorials*, *16*(3), 1635–1657. doi:10.1109/SURV.2014.012214.00007

Choe, E., Lee, N., Lee, B., Pratt, W., & Kientz, J. (2014). Understanding quantified-selfers' practices in collecting and exploring personal data. *Proceedings of the 32nd Annual ACM Conference on Human Factors in Computing Systems (CHI '14)*, 1143–1152. 10.1145/2556288.2557372

Coelho, C., Coelho, D., & Wolf, M. (2015, December). An IoT smart home architecture for long-term care of people with special needs. In *IEEE 2nd World Forum on Internet of Things (WF-IoT)*, 2015 (pp. 626–627). IEEE. 10.1109/WF-IoT.2015.7389126

Doty, P. (1986). Family care of the elderly: The role of public policy. *The Milbank Quarterly*, *64*(1), 34–75. doi:10.2307/3350005 PMID:3084932

Faertes, D. (2015). Reliability of supply chains and business continuity management. *Procedia Computer Science*, *55*, 1400–1409. doi:10.1016/j.procs.2015.07.130

Freitas, D. J., Marcondes, T. B., Nakamura, L. H., & Meneguette, R. I. (2015, June). A health smart home system to report incidents for disabled people. In *International Conference on Distributed Computing in Sensor Systems (DCOSS)* (pp. 210–211). IEEE. 10.1109/DCOSS.2015.28

Gubbi, J., Buyya, R., Marusic, S., & Palaniswami, M. (2013). Internet of Things (IoT): A vision, architectural elements, and future directions. *Future Generation Computer Systems*, *29*(7), 1645–1660. doi:10.1016/j.future.2013.01.010

Hainstock, T., Cloutier, D., & Penning, M. (2017). From home to 'home': Mapping the caregiver journey in the transition from home care into residential care. *Journal of Aging Studies*, *43*, 32–39. doi:10.1016/j.jaging.2017.09.003 PMID:29173512

Huttunen, H.-L., & Halonen, R. (2018). Willingness to use smartphone application assistant to support migraine treatment. *BLED 2018 Proceedings*. Retrieved from https://aisel.aisnet.org/bled2018/15

Huttunen, H.-L., Halonen, R., & Ferreira, D. (2018, May). Identifying bottlenecks in work processes: Elderly care. In *2018 IEEE 6th International Conference on Serious Games and Applications for Health (SeGAH)* (pp. 1–8). IEEE. doi: 10.1109/SeGAH.2018.8401385

Huttunen, H.-L., Klakegg, S., Van Berkel, N., Visuri, A., Ferreira, D., & Halonen, R. (2017, December). Understanding elderly care: a field-study for designing future homes. In *Proceedings of the 19th International Conference on Information Integration and Web-based Applications & Services* (pp. 390–394). ACM. 10.1145/3151759.3151835

Kern, S. E., & Jaron, D. (2003). Healthcare Technology, Economics and Policy: An Evolving Balance. *IEEE Engineering in Medicine and Biology*, *1*(22), 16–19. doi:10.1109/MEMB.2003.1191444 PMID:12683057

Klakegg, S., van Berkel, N., Visuri, A., Huttunen, H.-L., Hosio, S., Luo, C., ... Ferreira, D. (2017, September). Designing a context-aware assistive infrastructure for elderly care. In *Proceedings of the 2017 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2017 ACM International Symposium on Wearable Computers* (pp. 563–568). 10.1145/3123024.3124403

Ko, J., Lu, C., Srivastava, M. B., Stankovic, J. A., Terzis, A., & Welsh, M. (2010). Wireless sensor networks for healthcare. *Proceedings of the IEEE*, *98*(11), 1947–1960. doi:10.1109/JPROC.2010.2065210

Krishnamachari, B. (2005). *Networking Wireless Sensors*. Cambridge University Press. doi:10.1017/CBO9780511541025

Larsson, S., & Sjöblom, Y. (2010). Perspectives on narrative methods in social work research. *International Journal of Social Welfare*, *19*(3), 272–280. doi:10.1111/j.1468-2397.2009.00672.x

Medjahed, H., Istrate, D., Boudy, J., Baldinger, J. L., & Dorizzi, B. (2011, June). A pervasive multi-sensor data fusion for smart home healthcare monitoring. In *IEEE International Conference on Fuzzy Systems (FUZZ)*, 2011 (pp. 1466–1473). 10.1109/FUZZY.2011.6007636

Myers, M. D. (1997). Qualitative research in information systems. *Management Information Systems Quarterly*, *21*(2), 241–242. doi:10.2307/249422

Myers, M. D., & Avison, D. (Eds.). (2002). *Qualitative research in information systems: a reader*. Sage. doi:10.4135/9781849209687

Nikmat, A. W., Hawthorne, G., & Al-Mashoor, S. H. (2015). The comparison of quality of life among people with mild dementia in nursing home and home care—A preliminary report. *Dementia (London)*, *14*(1), 114–125. doi:10.1177/1471301213494509 PMID:24339093

Nygård, L., & Starkhammar, S. (2007). The use of everyday technology by people with dementia living alone: Mapping out the difficulties. *Aging & Mental Health*, *11*(2), 144–155. doi:10.1080/13607860600844168 PMID:17453547

Rogoff, R. (1985). *U.S. Patent No. 4,538,616*. Washington, DC: U.S. Patent and Trademark Office.

Russello, G., Dong, C., & Dulay, N. (2008, June). Consent-based workflows for healthcare management. In *IEEE Workshop on Policies for Distributed Systems and Networks, 2008. POLICY 2008* (pp. 153–161). DOI: 10.1109/POLICY.2008.22

Schenk, L., Meyer, R., Behr, A., Kuhlmey, A., & Holzhausen, M. (2013). Quality of life in nursing homes: Results of a qualitative resident survey. *Quality of Life Research: An International Journal of Quality of Life Aspects of Treatment, Care and Rehabilitation*, *22*(10), 2929–2938. doi:10.100711136-013-0400-2 PMID:23595411

Tuominen, L., Leino-Kilpi, H., & Suhonen, R. (2016). Older people's experiences of their free will in nursing homes. *Nursing Ethics*, *23*(1), 22–35. doi:10.1177/0969733014557119 PMID:25488758

Varshney, U. (2005). Pervasive healthcare: Applications, challenges and wireless solutions. *Communications of the Association for Information Systems*, *16*, 3. doi:10.17705/1CAIS.01603

Weber, R. H. (2010). Internet of Things – New security and privacy challenges. *Computer Law & Security Review*, *26*(1), 23–30. doi:10.1016/j.clsr.2009.11.008

Wong, J. K. W., Leung, J., Skitmore, M., & Buys, L. (2017). Technical requirements of age-friendly smart home technologies in high-rise residential buildings: A system intelligence analytical approach. *Automation in Construction*, *73*, 12–19. doi:10.1016/j.autcon.2016.10.007

Chapter 5
Patient Portal Acceptance by the Elderly:
Explained by the Elaboration Likelihood Model and Social Heuristics

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ABSTRACT

The motivating factors that influence patient portal acceptance among the elderly are not well understood. Using the social heuristic theory, the elaboration likelihood model, and the unified theory of acceptance and use of technology, this study proposes a model that examines the persuasive mechanisms for the elderly to use patient portals. An empirical study involving 117 subjects in the United States was used to test the proposed model. Using the partial least squares method, social power, and imitate-the-successful social heuristics were found to significantly influence patient portal acceptance among the elderly. These findings indicate that older people invest less effort cognitively elaborating when presented with technology acceptance decisions and accept influence from their higher status peers from their network. Imitate-the-majority heuristics and central route processing were not found to be significant, implying that older people are more inclined to take advice from sources, which they find credible and invest less cognitive effort in evaluating the complex phenomena.

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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 connection (Krist et al., 2012; HealthIT.gov at https://www.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 use 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 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 in their social environment that 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. The study further scrutinizes these driving forces with complementing theories and empirically tests the proposed model. Data collected from the elderly in various social settings provides the basis of our empirical evidence that social forces significantly influence older patients' use behavior toward patient portals when information and understanding of the technology is limited (Goel et al., 2011).

BACKGROUND

This chapter examines three complementary theories that pertain to the individual decision-making process. The focus is on the *social aspect* of these theories and how they can be combined into a comprehensive model to empirically evaluate the precursors of behavioral intention to use patient portals by the elderly. The three models are: 1) Unified Theory of Acceptance and Use of Technology (UTAUT) Model, 2) Elaboration Likelihood Model (ELM), and 3) Social Heuristics Hypothesis (SHH).

Unified Theory of Acceptance and Use of Technology (UTAUT)

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).

Social Heuristic Hypothesis

Heuristics are simplified models of reality, which help reduce the complexity of the decision-making process by building on previous experiences (Tversky & Kahneman, 1975). SHH is a guiding principle to help make decisions when part of the available information is ignored and only a few relevant predictors are considered. Some relevant information for decision making is ignored due to limited cognitive ability to process all relevant information or due to lack of motivation (Chen, Duckworth, & Chaiken, 1999). It is particularly applicable in this research study considering that patient portals are complex applications and elderly patients tend to ignore the technical aspect and rely on other characteristics and recommendations from within their social environment. For example, if most actors in an older patient's social environment use and recommend the patient portal, the individual will conform even though not all aspects of the patient portal are understood. This type of social heuristic is called *imitate-the-majority* heuristic. Another type of social heuristic is the *imitate-the-successful.* The desire to consciously or unconsciously follow those who are more successful leads individuals to feel gratification due to the expectation that they will achieve a similar level of success. (Hertwig and Hoffrage, 2012; Pachur, Rieskamp, & Hertwig, 2005). In the context of this study, the elderly are likely to follow the example of those they respect and deem to be successful. One of the most pervasive social concepts is *social power,* due to its function within social heuristics for decision making (Keltner, Van Kleef, Chen et al., 2008). Social power is a result of a multitude of complex decision-influencing social factors such as formal/informal norms, social status, and resource/action dependencies (Castelfranchi, 2003). Those with higher social status, for example physicians, would likely have stronger influence on the elderly in the patient portal acceptance decision.

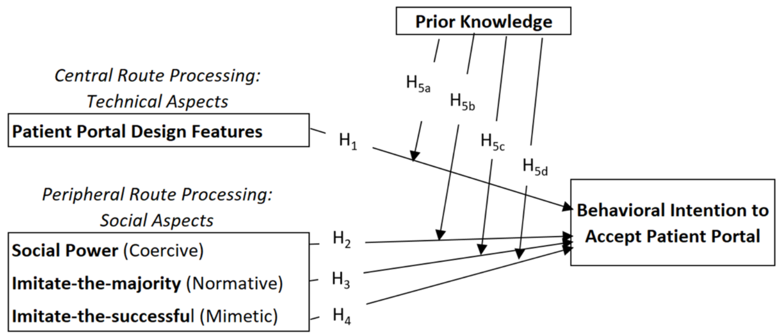
Elaboration Likelihood Model

ELM is concerned with the amount of cognitive efforts individuals are likely to invest when facing complex information for decision making (Petty & Cacioppo, 1979,1984). The goal is to understand the factors that influence the effort older patients are willing to invest into making a rational choice toward the acceptance of patient portals. The model is based on the premise that individuals can change their intention based on the source of information and the context in which it is presented (Petty & Cacioppo, 1986). Specifically, this model helps us understand how elderly users may choose to accept patient portals, even though they may have concerns, such as privacy or usability (Angst & Agarwal, 2009). Originally, this model was developed in the consumer behavior domain, and recently has been used to explain individuals' intention to respond to online advertisements (Flavian, 2010) and electronic health record acceptance (Angst & Agarwal, 2009).

When elderly individuals are presented with new information, such as patient portal details, cognitive elaboration is required to make the decision about acceptance (Petty & Cacioppo, 1986). Cognitive elaboration refers to supplementing one's pre-existing knowledge structure through the integration of new information (Anderson, 1983). New beliefs may be formed or previously established beliefs changed by the source and credibility of the new information (Petty & Wegener, 1999). Forming a belief as a response to the information is greatly dependent on the extent to which individuals elaborate on the new information, cognitively processing and giving consideration (Tam & Ho, 2005). Those who exhibit a high degree of elaboration will experience a *central route of persuasion*, while those who ignore the message content and exhibit a low degree of elaboration experience a *peripheral route of persuasion* (Petty & Cacioppo, 1986). The latter situation results in use behavior decisions based on simple criteria and cues such as the attractiveness of the person who conveys the information rather than the content itself. Nonexperts and those with no prior experience rely on the peripheral route of decision making and follow the social force rather than make a well-thought out and considered decision (Lord, Lee, * Sauer 1995; Petty & Cacioppo, 1981).

In the context of elderly patients facing the decision of patient portal acceptance, they will either consider the portal's design features or follow guidance from their respected peers. The former is expected by those with prior experience or having the cognitive ability to evaluate the portal for their needs. The

Figure 1. Conceptual Model



latter is likely followed by those elderly patients who ignore the design features and follow the advice or example of their peers from their social environment.

Hence, this study will empirically investigate the effect of social factors on patient portal use behavior by the elderly, and will expand the theory's applicability through theoretical and managerial implications.

INFLUENCES ON PATIENT PORTAL USE BY THE ELDERLY

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), SHH (Hertwig & Hoffrage, 2012), ELM (Petty & Cacioppo, 1984) 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). The Social Heuristic Hypothesis similarly groups the social influences on behavioral intention to accept the patient portal. The Elaboration Likelihood Model groups the social influences into central and peripheral route processing, where greater prior knowledge is expected to allow for greater elaboration (Alba & Hutchinson, 1987). This study empirically tests the model and examines which elaboration route older individuals favor when facing the decision to accept a patient portal. The moderating effect of prior knowledge of patient portals is also investigated.

MODEL COMPONENTS

Behavior Intention to Accept Patient Portal

An individual's behavioral intention refers to the individual's decision to perform a specific behavior in the future (Chatzoglu et al., 2009). For the purposes of this study, use behavior intention to accept patient portal is defined as the degree to which a user intends to regularly use the patient portal for the purposes for which 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.

Central Route

Patient Portal Design Features

System characteristics are a major consideration when individuals decide to adopt technology for long term use. The main technology acceptance models include system characteristics such as usability, usefulness, effort it takes to learn (Ajzen & Fishbein, 1980), and other advanced characteristics such as interconnectivity and connectedness (Liu, Wu, Sun, 2014). Such characteristics are considered to be difficult to evaluate for novice users and are often overlooked during an acceptance decision (Lin, Shih, & Sher, 2007). Therefore, it takes more effort and cognitive ability to evaluate the system characteristics of a patient portal, especially for elderly users. This evaluation process is also known as central route processing by ELM and refers to a higher degree of user involvement during the acceptance process, leading to the first hypothesis:

H1: Higher level of elaboration will positively influence behavioral intention to accept patient portals among the elderly.

Peripheral Route

Social Power / Coercive Pressure

Weber (1962) defines social power as "the probability that an actor within a social relationship is in the position of doing as he wills not withstanding resistance, independently over the basis on which this probability stands". Most definitions agree on the concept that individuals with high social power possess the potential to exert a force toward change in another person. In a social environment, such actors are usually superiors or someone having formal authority such as doctors over patients, or teachers over students.

Coercive pressure, the institutionalized form of social power, 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. Given its focus on patient portal acceptance, this study investigates the pressure that providers may put on patients to use patient portals. For example, physicians are powerful actors in the physician-patient relationship, and may informally pressure patients to access their portal for health-related communications in order to increase the effectiveness of care. Hence, it is hypothesized:H2: Higher degree of perceived social power will positively influence behavioral intention to accept patient portals among the elderly.

Imitate-the-Majority / Normative Pressure

Individuals with limited insight on information presented to them will more likely imitate the behavior of the majority of individuals in their reference group (Boyd & Richerson, 2005). For example, if more people are waiting for a service, then the more likely it is that uninformed agents will prefer that service (Raz & Ert, 2008). Very simple decision criteria are the driving factor in such situations. Elderly individuals may not have the cognitive ability to consider and process all relevant information to properly evaluate patient portals and are more likely to agree with its adoption even though they initially would not consider it. The peripheral route of persuasion is likely to change elderly individuals' minds about patient portals if they decide to follow the majority of their peers who choose to accept patient portals.

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:

H3: Higher degree of perceived imitate-the-majority social heuristic will positively influence behavioral intention to accept patient portals among the elderly.

Imitate-the-Successful / Mimetic Pressure

Individuals who rely on social heuristics may choose to follow the advice of a successful person in their reference group. Celebrity endorsements or media influence fall into this category as source credibility is often ignored under such social heuristic scenarios (Boyd et al., 2005).

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 to try using it. Therefore, it is hypothesized:

H4: Higher degree of perceived imitate-the-successful social heuristic will positively influence behavioral intention to accept patient portals among the elderly.

Moderating Effect of Prior Knowledge

Petty and Cacioppo (1979) empirically found that individuals with high involvement with an issue they were investigating used enhanced information processing in the central route. A higher degree of expertise or significant prior experience with the technology moderate the central route processing to behavioral intention in technology acceptance (Bhattacherjee & Sanford, 2006). The current investigation explores the degree to which prior knowledge moderates the relationship of patient portal design features (the central route, e.g. usability, interconnectedness, privacy, security… etc.) and social heuristics (the peripheral route) with our dependent variable of behavioral intention to accept patient portals among the elderly. The findings are expected to be in line with the literature that an elderly user's prior knowledge of patient portals will impact their behavioral intention to accept a patient portal and more likely consider the central route to evaluate patient portals. This expectation is reflected in the following hypotheses:

$H_{5a\text{-}d}$: Prior knowledge of patient portal will attenuate the relationship of patient portal design features (H5a), social power (H5b), imitate-the majority heuristic (H5c), and imitate-the-successful heuristic (H5d) with behavioral intention to accept patient portal among the elderly.

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. The moderator and system design feature items were adopted from Bhattacherjee & Sanford (2009), Khalfan (2004), Smith et al. (2007), and Dhillon & Blackhouse (2000). (Please see Appendix for the questionnaire items and indicators.)

Data Collection

Convenience and snowball sampling were 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 ANALYSIS AND RESULTS

Test of Measurement Model

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 3.2.8 for Windows 64 bit), the relationships between constructs (path coefficients) and the predictive power of the dependent variable – R-squared (Chin, 1998) is examined.

Common Method Bias

The study checked for common method bias, which occurs when the independent and dependent variables are collected from the same respondents at the same time (Podsakoff et al. 2003). The exploratory factor analysis on the items in the measurement model revealed four items with eigenvalues > 1.0 with 70.2% total variance accounted for. 38.7% variance was captured by the first factor, below the recommended 50% mark (Schriesheim, 1979).

Content and Construct Validity

The survey items were adopted from previous studies (see Appendix A), therefore content validity for these items' constructs have been ascertained. The multi-item constructs were assessed by confirmatory factor analysis, which is well suited for validated constructs (Gefen & Straub, 2005). The measurement items on their latent constructs exhibited significantly higher loading than on other constructs, and hence satisfies discriminant validity. The discriminant validity (inter-construct correlations) is also satisfied as the correlation between any constructs is lower than the square root of average variance extracted (AVE) shared by items in a construct (Fornell & Larcker, 1981) and exceeds the recommended 0.5 threshold.

Construct validity is the degree to which a test measures what it claims to measure for the reflective constructs. Cronbach's alpha values ranged from 0.631 for patient portal design features to 0.914 for imitate-the-successful constructs and fall within the acceptable range of > 0.5 (Rivard & Huff, 1988). The composite reliability is also greater than the recommended 0.5 (Forner & Larcker, 1981) for all constructs, and therefore the instrument exhibits satisfactory construct validity.

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).

Test of Structural Model

The study used Structural Equation Modeling (SEM) with component-based PLS software, which is an appropriate choice for this early stage of model development (Chin et al., 2003; Anderson & Gerbing, 1988).

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 (H_1) path coefficients from design features to behavioral intention to accept patient portal ($b=0.216$, $p<0.05$) and (H_2) from social power to behavioral intention to accept patient portal ($b = 0.174$, $p<0.01$) supported hypotheses 1 and 2 respectively, indicating that design features and social power have a significant effect on the behavioral intention to accept patient portals among the elderly. However, (H_3) imitate-the-majority showed no significant impact on behavioral intention to accept patient portals ($b=-0.039$, NS) and (H_4) imitate-the-successful had a borderline significance (0.186, $p=0.0546$) on behavioral intention to accept patient portals. Table 2. summarizes the hypotheses and their path coefficients along with t-statistics and moderating effects. Figure 2 displays the measurement model.

The research model explains 31% of the variance of social forces and technical design on behavioral intention to accept patient portals 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 patient portal design features familiar to only small number of elderly users. Our model 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= 0.143, -0.209, -0.195, 0.703 respectively for attitude toward self-health, gender, resident type, and technical affinity respectively.

DISCUSSION

This study empirically tested our proposed model to study the elderly individuals' elaboration route to patient portal acceptance with respect to prior knowledge of patient portal.

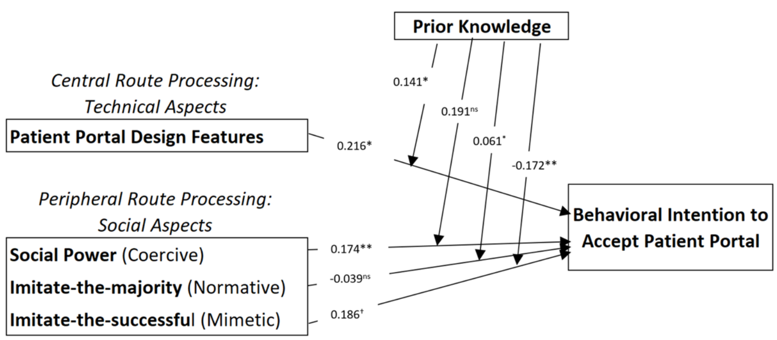
The study revealed findings that contribute to theory and practice. First, it extended understanding of the *social norm* construct of the commonly used UTAUT model. The additional granularity sheds light on the social force component as the strongest indicator of patient portal acceptance. In the context of this study it can be concluded that new technology acceptance is strongly encouraged by those with more informal authority over the elderly users. This authority usually comes from the healthcare provider and trusted family members based on the survey responses. This indicates the importance of proper guidance from these sources as the elderly are more likely to be influenced by their suggestions to accept patient portal. This provides additional insight on the role of physicians (Peck & Conner, 2011; Lipworth et al., 2013). The authors recommend that healthcare providers are formally trained and equipped with resources to guide the elderly in patient portal acceptance. Similarly, family members should understand the role they represent in the technology acceptance decision of their older family members and provide support and guidance as needed. This significant finding leads us to the recommendation that healthcare providers should consistently provide guidance via patient portal suggestions and equip providers with

Table 2. Structural model analysis results including prior knowledge (moderator)

Relational Path	Direct Path		Moderation of Prior Knowledge	
	B-coefficient	t-statistics (sig.)	B-coefficient	t-statistics (sig.)
H_1: Design Features → Behavioral Intention H_{5a}: Moderation effect of Prior Knowledge	0.216*	2.189	-0.141*	2.419
H_2: Social Power → Behavioral Intention H_{5b}: Moderation effect of Prior Knowledge	0.174**	3.194	0.191^{ns}	1.081
H_3: Imitate-the-majority → Behavioral Intention H_{5c}: Moderation effect of Prior Knowledge	-0.039^{ns}	-0.916	0.061**	2.619
H_4: Imitate-the-successful → Behavioral Intention H_{5d}: Moderation effect of Prior Knowledge	0.186†	1.941	-0.172**	2.637

** Significant at the 0.01 level; * significant at the 0.05 level; † significant at the 0.10 level; ns not significant. Two-tailed hypotheses

Figure 2. Measurement model
*** Significant at the 0.01 level; * significant at the 0.05 level; † significant at the 0.10 level; ns not significant. Two-tailed hypotheses*



audience-appropriate handouts and resources. Similarly, our findings suggest that family members need to realize the influencing power they have in their elderly relatives' patient portal adoption decisions, which is reflected in earlier literature (Lorenzen-Huber et al., 2011; Courtney et al., 2008)

Second, the non-significant path coefficient of *imitate-the-majority* to *behavioral intention to accept patient portal* indicates that elderly individuals are not concerned about what the majority of their peers do in terms of patient portal adoption. It may be due to the fact that there are many other variables impacting this decision, for example their previous experience with technology, specifically, with patient portals. The not strong yet statistically significant path coefficient of the moderating effect of prior knowledge suggests this conclusion. Elderly individuals respect their trusted and successful peers and follow their example (Bozan, Davey, Parker, 2017). However, our current study shows that having prior experience with a patient portal diminishes the significance of peers, in both the *imitate-the-majority* and *imitate-the-successful.* In fact, the significant and strong *negative* moderating effect of prior knowledge indicates that the more prior experience an elderly individual has, the less likely will they follow their successful peers' example in terms of patient portal adoption decision and avoid fads and bandwagon effects (Abrahamson, 1991; Abrahamson & Rosenkopf, 1993).

The impact of *patient portal design features* is statistically significant and exhibits strong positive correlation with *behavioral intention to accept patient portal.* The *prior knowledge* moderating effect also displays strong positive correlation. This indicates that the elderly find the patient portal design features important in their decisions to accept this technology. Having prior experience with patient portals encourages elderly individuals to elaborate more on the acceptance decision and consider all relevant information by taking the central route of elaboration.

The findings of our study highlight the importance of informal authority, the transparency of patient portal design features, and prior experience with patient portals. Those elderly individuals who prefer the peripheral route of elaboration will more likely follow the guidance of those who have informal authority over them such as caregivers, providers, and trusted and respected family members. Those elderly who further elaborate rely more on their prior experience and value the transparency of patient portal features such as confidentiality, integrity, auditability, interconnectivity, and security (Appendix A.). Having this information available would increase their understanding and the elderly would more likely intend to accept patient portals.

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, aside from previous experience with patient portals.

FUTURE RESEARCH AND 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 snowball 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 (69%) 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 the decision to adopt 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 to accept patient portals as the mediator between social factors and design features of the patient portal and actual portal use, similar to UTAUT. Since this study investigates social factors on a more granular level, one may wonder whether or not all three social heuristics are significant with the moderator or only with the intention to accept patient portal as the dependent variable.

CONCLUSION

This study examined the effect of social heuristics and patient portal design features on patient portal adoption intention among the elderly. The conceptual model was constructed on the social heuristics, elaboration likelihood model, and UTAUT. The predictive indicators were measured by considering prior knowledge and experience with patient portals as moderator. With the adoption intention of patient portals by the elderly serving as the dependent variable, this study empirically tested the strength of the effects of four independent variables, namely 1) patient portal design features, 2) social forces, 3) imitate-the-majority, and 4) imitate-the-successful.

This study serves to extend the literature on the patient portal acceptance decision by the elderly, which has not been previously investigated with respect to social heuristics and elaboration likelihood model. The application of these models along with UTAUT as the pillar of our model, accompanied by significant findings, adds to the growing literature on the adoption of information and communication technologies in healthcare by the elderly, specifically the patient portal. Additional factors have been identified for patient portal adoption by the elderly population, and promise to lead to future research that can reveal additional important guiding factors that may strengthen the predictive power of the model.

REFERENCES

Abrahamson, E. (1991). Managerial fads and fashions: The diffusion and rejection of innovations. *Academy of Management Review*, *16*(3), 586–612. doi:10.5465/amr.1991.4279484

Abrahamson, E., & Rosenkopf, L. (1993). Institutional and competitive bandwagons: Using mathematical modeling as a tool to explore innovation diffusion. *Academy of Management Review*, *18*(3), 487–517. doi:10.5465/amr.1993.9309035148

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179–211. doi:10.1016/0749-5978(91)90020-T

Ajzen, I., & Driver, B. L. (1991). Prediction of leisure participation from behavioural, normative, and control beliefs: An application of the theory of planned behavior. *Leisure Sciences*, *13*(3), 185–204. doi:10.1080/01490409109513137

Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior*. Englewood Cliffs, NJ: Prentice-Hall.

Alba, J. W., & Hutchinson, W. (1987). Dimensions of consumer expertise. *The Journal of Consumer Research*, *13*(4), 411–454. doi:10.1086/209080

Ancker, J. S., Barrón, Y., Rockoff, M. L., Hauser, D., Pichardo, M., Szerencsy, A., & Calman, N. (2011). Use of an electronic patient portal among disadvantaged populations. *Journal of General Internal Medicine*, *26*(10), 1117–1123. doi:10.100711606-011-1749-y PMID:21647748

Anderson, J. C., & Gerbing, D. W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin*, *103*(3), 411–423. doi:10.1037/0033-2909.103.3.411

Anderson, J. R. (1983). *The architecture of cognition*. Cambridge, MA: Harvard University Press.

Ang, S., & Cummings, L. L. (1997). Strategic response to institutional influences on information systems outsourcing. *Organization Science*, *8*(3), 235–256. doi:10.1287/orsc.8.3.235

Angst, C. M., & Agarwal, R. (2009). Adoption of electronic health records in the presence of privacy concerns: The elaboration likelihood model and individual persuasion. *Management Information Systems Quarterly*, *33*(2), 339–370. doi:10.2307/20650295

Barclay, D., Higgins, C., & Thomson, R. (1995). The partial least squares approach to causal modeling, personal computer adoption and use as an illustration. *Technology Studies*, *2*(2), 285–309.

Bennenbroek, F. T., Buunk, B. P., van der Zee, K. I., & Grol, B. (2002). Social comparison and patient information: What do cancer patients want? *Patient Education and Counseling*, *47*(1), 5–12. doi:10.1016/S0738-3991(02)00018-6 PMID:12023095

Bhattacherjee, A., & Sanford, C. (2006). Influence processes for information technology acceptance: An elaboration likelihood model. *Management Information Systems Quarterly*, *30*(4), 805–825. doi:10.2307/25148755

Bierman, A. S. (2012). Averting an impending storm: Can we reengineer health systems to meet the needs of aging populations? *PLoS Medicine*, *9*(7), e1001267. doi:10.1371/journal.pmed.1001267 PMID:22815655

Blumenthal, D., & Tavenner, M. (2010). The 'Meaningful Use' regulation for electronic health records. *The New England Journal of Medicine*, *363*(6), 501–504. doi:10.1056/NEJMp1006114 PMID:20647183

Botwinick, J. (1973). *Aging and behavior*. New York: Springer.

Boyd, R., & Richerson, P. J. (2005). *Solving the puzzle of human cooperation. Evolution and Culture*. Cambridge, MA: MIT Press.

Boynton, A. C., Zmud, R. W., & Jacobs, G. C. (1994). The influence of IT management practice on IT use in large organizations. *Management Information Systems Quarterly*, *18*(3), 299–318. doi:10.2307/249620

Bozan, K., Davey, B., & Parker, K. (2017). Social forces that influence health IT use behavior of the elderly. In N. Wickramasinghe (Ed.), *Handbook of research on healthcare administration*. Hershey, PA. doi:10.4018/978-1-5225-0920-2.ch021

Bozan, K., Davey, B., & Parker, K. R. (2015). Social influence on health IT adoption patterns of the elderly: An institutional theory based use behavior approach. *Procedia Computer Science*, *63*, 517–523. doi:10.1016/j.procs.2015.08.378

Carley, K. M., & Kaufer, D. S. (1993). Semantic connectivity: An approach for analyzing symbols in semantic networks. *Communication Theory*, *3*(3), 183–213. doi:10.1111/j.1468-2885.1993.tb00070.x

Castelfranchi, C. (2003). The micro–macro constitution of power. *Protosociology*, *18*, 208–268. doi:10.5840/protosociology200318/198

Cattan, M., White, M., Bond, J., & Learmouth, A. (2005). Preventing social isolation and loneliness among older people: A systematic review of health promotion interventions. *Ageing and Society*, *25*(1), 41–67. doi:10.1017/S0144686X04002594

Centers for Disease Control and Prevention (CDC). (2013). *The state of aging and health in America 2013*. Atlanta, GA: Centers for Disease Control and Prevention, US Dept of Health and Human Services. Available at: http://www.cdc.gov/features/agingandhealth/state_of_aging_and_health_in_america_2013.pdf

Chaffin, A. J., & Harlow, S. D. (2005). Cognitive learning applied to older adult learners and technology. *Educational Gerontology*, *3*(4), 301–329. doi:10.1080/03601270590916803

Chatzoglou, P. D., Sarigiannidis, L., Vraimaki, E., & Diamantidis, A. (2009). Investigating Greek employees' intention to use web-based training. *Computers & Education*, *53*(3), 877–889. doi:10.1016/j.compedu.2009.05.007

Chatzoglou, P. D., Sarigiannidis, L., Vraimaki, E., & Diamantidis, A. (2009). Investigating Greek employees' intention to use web-based training. *Computers & Education*, *53*(3), 877–889. doi:10.1016/j.compedu.2009.05.007

Chen, S., Duckworth, K., & Chaiken, S. (1999). Motivated heuristic and systematic processing. *Psychological Inquiry*, *10*(1), 44–49. doi:10.120715327965pli1001_6

Chin, W. W. (1998). Issues and opinion on structural equation modeling. *Management Information Systems Quarterly*, *22*(1), vii–xvi.

Chin, W. W., Marcolin, B. L., & Newsted, P. R. (2003). A partial least squares latent variable modeling approach for measuring interaction effects: Results from a Monte Carlo simulation study and an electronic-mail emotion/adoption study. *Information Systems Research*, *14*(2), 189–217. doi:10.1287/isre.14.2.189.16018

Chrischilles, E. A., Hourcade, J. P., Doucette, W., Eichmann, D., Gryzlak, B., Lorentzen, R., ... Levy, B. (2014). Personal health records: A randomized trial of effects on elder medication safety. *Journal of the American Medical Informatics Association*, *21*(4), 679–686. doi:10.1136/amiajnl-2013-002284 PMID:24326536

Courtney, K. L., Demiris, G., Rantz, M., & Skubic, M. (2008). Needing smart home technologies: The perspectives of older adults in continuing care retirement communities. *Informatics in Primary Care*, *16*, 195–201. PMID:19094406

Dabaj, F. (2009). The role of gender and age on students' perceptions towards online education case study: Sakarya University, Vocational High School. *The Turkish Online Journal of Educational Technology*, *8*(2), 120–123.

Delone, W. H. (1988). Determinants of success for computer usage in small business. *Management Information Systems Quarterly*, *12*(1), 51–61. doi:10.2307/248803

Dhillon, G., & Backhouse, J. (2000). Information system security management in the new millennium. *Communications of the ACM*, *43*(7), 125–128. doi:10.1145/341852.341877

DiMaggio, P. J., & Powell, W. W. (1983). The iron cage revisited: Institutional isomorphism in organizational fields. *American Sociological Review*, *48*, 147–160. doi:10.2307/2095101

Fishbein, M. (1980). A theory of reasoned action: Some applications and implications. In H. Howe, & M. Page (Eds.), *Nebraska Symposium on Motivation* (pp. 65-116). Lincoln, NE: University of Nebraska Press.

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention and behavior: An introduction to theory and research*. Reading, MA: Addison-Wesley.

Flavian Blanco, C., Gurrea Sarasa, R., & Orus Sanclemente, C. (2010). Effects of visual and textual information in online product presentations: Looking for the best combination in website design. *European Journal of Information Systems*, *19*(6), 668–686. doi:10.1057/ejis.2010.42

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *JMR, Journal of Marketing Research*, *18*(1), 39–50. doi:10.1177/002224378101800104

Gefen, D., & Straub, D. W. (2005). A practical guide to factorial validity using PLS-Graph: Tutorial and annotated example. *Communications of the Association for Information Systems*, *16*, 91–109. doi:10.17705/1CAIS.01605

Goel, M., Brown, T., Williams, A., Hasnain-Wynia, R., Thompson, J., & Baker, D. (2011). Disparities in enrollment and use of an electronic patient portal. *Journal of General Internal Medicine*, *26*(10), 1112–1116. doi:10.100711606-011-1728-3 PMID:21538166

Goldzweiq, C. L., Orshansky, G., Paiqe, N. M., Towfiqh, A. A., Haqqstrom, D. A., Miake-Lye, I., & ... . (2013). Electronic patient portals: evidence on health outcomes, satisfaction, efficiency, and attitudes: a systematic review. *Annals of Internal Medicine*, *159*(10), 677–687. doi:10.7326/0003-4819-159-10-201311190-00006 PMID:24247673

Harcourt, M., Lam, H., & Harcourt, S. (2005). Discriminatory practices in hiring: Institutional and rational economic perspectives. *International Journal of Human Resource Management*, *16*(11), 2113–2132. doi:10.1080/09585190500315125

Hertwig, R., & Hoffrage, U. (2012). Simple heuristics: The foundations of adaptive social behavior. *Simple Heuristics in a Social World*, *3*. doi:10.1093/acprof:oso/9780195388435.003.0001

Hogan, C., Lunney, J., Gabel, J., & Lynn, J. (2001). Medicare beneficiaries' cost of care in the last year of life. *Health Affairs*, *20*(4), 189–195. doi:10.1377/hlthaff.20.4.188 PMID:11463076

Hsiao, C. J., & Hing, E. (2014). Use and characteristics of electronic health record systems among office-based physician practices: United States, 2001–2013. *NCHS data brief, no 143*. Hyattsville, MD: National Center for Health Statistics. Retrieved from http://www.cdc.gov/nchs/data/databriefs/db143.htm

Jan, P. T., Lu, H. P., & Chou, T. C. (2012). The adoption of e-learning: An institutional theory perspective. *The Turkish Online Journal of Education Technology*, *11*(3), 326–343.

Johnson, C., Dowd, T. J., & Ridgeway, C. L. (2006). Legitimacy as a social process. *Annual Review of Sociology*, *32*(1), 53–78. doi:10.1146/annurev.soc.32.061604.123101

Jung, C., Padman, R., Shevchik, G., & Paone, S. (2011). Who are portal users vs. early e-visit adopters? A preliminary analysis. *AMIA Annual Symposium Proceedings*, 1070–1079.

Karwalajtys, T., Kaczorowski, J., Chambers, L., Levitt, C., Dolovich, L., McDonough, B., & ... . (2005). A randomized trial of mail vs. telephone invitation to a community-based cardiovascular health awareness program for older family practice patients. *BMC Family Practice*, 6–35. PMID:16111487

Keltner, D., Van Kleef, G. A., Chen, S., & Kraus, M. (2008). A reciprocal influence model of social power: Emerging principles and lines of inquiry. *Advances in Experimental Social Psychology*, *40*, 151–19. doi:10.1016/S0065-2601(07)00003-2

Khalfan, A. M. (2004). Information security considerations in IS/IT outsourcing projects: A descriptive case study of two sectors. *International Journal of Information Management*, *24*(1), 29–42. doi:10.1016/j.ijinfomgt.2003.12.001

Klein, R. (2007). An empirical examination of patient-physician portal acceptance. *European Journal of Information Systems*, *16*(6), 751–760. doi:10.1057/palgrave.ejis.3000719

Krist, A. H., Woolf, S. H., Rothemich, S. F., Johnson, R. E., Peele, J. E., Cunningham, T. D., ... Matzke, G. R. (2012). Interactive preventive health record to enhance delivery of recommended care: A randomized trial. *Annals of Family Medicine*, *10*(4), 312–319. doi:10.1370/afm.1383 PMID:22778119

Liang, H., Saraf, N., Hu, Q., & Xue, Y. (2007). Assimilation of enterprise systems: The effect of institutional pressures and the mediating role of top management. *Management Information Systems Quarterly*, *31*(1), 59–87. doi:10.2307/25148781

Lin, C. H., Shih, H. Y., & Sher, P. J. (2007). Integrating technology readiness into technology acceptance: The TRAM model. *Psychology and Marketing*, *24*(7), 641–657. doi:10.1002/mar.20177

Lipworth, W., Little, J. L. M., Markham, P., Gordon, J., & Kerridge, I. (2013). Doctors on status and respect: A qualitative study. *Journal of Bioethical Inquiry*, *10*(2), 205–217. doi:10.100711673-013-9430-2 PMID:23515959

Liu, Y., Wu, M., & Sun, Z. (2014). Extending the TAM model to explore the factors that affect Intention to Use digital textbooks in primary teachers' views. *Intelligent Environments*, 127-136.

Lord, K. R., Lee, M. S., & Sauer, P. L. (1995). The combined influence hypothesis: Central and peripheral antecedents of attitude toward the ad. *Journal of Advertising*, *24*(1), 73–85. doi:10.1080/00913367.1995.10673469

Lorenzen-Huber, L., Boutain, M., Camp, L. J., Shankar, K., & Connelly, K. H. (2011). Privacy, technology, and aging: A proposed framework. *Ageing International*, *36*(2), 232–252. doi:10.100712126-010-9083-y

Lubitz, J. D., & Riley, G. F. (1993). Trends in Medicare payments in the last year of life. *The New England Journal of Medicine*, *328*(15), 1092–1096. doi:10.1056/NEJM199304153281506 PMID:8455667

Mata, R., Schooler, L. J., & Rieskamp, J. (2007). The aging decision maker: Cognitive aging and the adaptive selection of decision strategies. *Psychology and Aging*, *22*(4), 796–810. doi:10.1037/0882-7974.22.4.796 PMID:18179298

Mathieson, K. (1991). Predicting user intentions: Comparing the technology acceptance model with the theory of planned behavior. *Information Systems Research*, *2*(3), 173–191. doi:10.1287/isre.2.3.173

Mazman, S. G. (2011). Gender differences in using social networks. *The Turkish Online Journal of Educational Technology*, *10*(2), 133–139.

Millard, R. W., & Fintak, P. A. (2002). Use of the Internet by patients with chronic illness. *Disease Management & Health Outcomes*, *10*(3), 187–194. doi:10.2165/00115677-200210030-00006

Mitchell Peck, B. (2011). Age-related differences in doctor-patient interaction and patient satisfaction. *Current Gerontology and Geriatrics Research*, *2011*, 1–10. doi:10.1155/2011/137492 PMID:22007206

Moore, G. C., & Benbasat, I. (1991). Development of an instrument to measure the perceptions of adopting an information technology innovation. *Information Systems Research*, *2*(3), 192–222. doi:10.1287/isre.2.3.192

Morris, M. G., & Venkatesh, V. (2000). Age differences in technology adoption decisions: Implications for a changing workforce. *Personnel Psychology*, *3*(2), 375–403. doi:10.1111/j.1744-6570.2000.tb00206.x

Nicholson, N. R. Jr. (2008). Social isolation in older adults: An evolutionary concept analysis. *Journal of Advanced Nursing*, *65*(6), 342–352. PMID:19291185

Nunnaly, J. (1978). *Psychometric theory* (2nd ed.). New York: McGraw-Hill.

Or, C. K., & Karsh, B. T. (2009). A systematic review of patient acceptance of consumer health information technology. *Journal of the American Medical Informatics Association*, *16*(4), 550–560. doi:10.1197/jamia.M2888 PMID:19390112

Pachur, T., Rieskamp, J., & Hertwig, R. (2005). The social circle heuristic: Fast and frugal decisions based on small samples. In *Proceedings of the 26th annual conference of the cognitive science society* (pp. 1077-1082). Mahwah, NJ: Erlbaum.

Peck, B., & Conner, S. (2011). Talking with me or talking at me? The impact of status characteristics on doctor–patient interaction. *Sociological Perspectives*, *54*(4), 547–567. doi:10.1525op.2011.54.4.547

Petty, R. E., & Cacioppo, J. T. (1979). Issue involvement can increase of decrease persuasion by enhancing message-Relevant cognitive responses. *Journal of Personality and Social Psychology*, *37*(10), 1915–1926. doi:10.1037/0022-3514.37.10.1915

Petty, R. E., & Cacioppo, J. T. (1981). *Attitudes and persuasion: Classic and contemporary approaches*. Dubuque, IA: Wm. C. Brown.

Petty, R. E., & Cacioppo, J. T. (1984). Source factors and the elaboration likelihood model of persuasion. *Advances in Consumer Research. Association for Consumer Research (U. S.)*, *11*, 668–672.

Petty, R. E., & Cacioppo, J. T. (1986). *Communication and persuasion: Central and peripheral routes to attitude change*. New York: Springer-Verlag. doi:10.1007/978-1-4612-4964-1

Petty, R. E., & Wegener, D. T. (1999). The elaboration likelihood model: Current status and controversies. In S. Chaiken & Y. Trope (Eds.), Dual process theories in social psychology, (pp. 41-72). New York: Guilford Press.

Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *The Journal of Applied Psychology*, *88*(5), 879–903. doi:10.1037/0021-9010.88.5.879 PMID:14516251

Purdie, N., & Boulton-Lewis, G. (2003). The learning needs of older adults. *Educational Gerontology*, *29*(2), 129–149. doi:10.1080/713844281

Raz, O., & Ert, E. (2008). Size counts: The effect of queue length on choice between similar restaurants. *NA - Advances in Consumer Research. Association for Consumer Research (U. S.)*, *35*, 803–804.

Rivard, S., & Huff, S. (1988). Factors of success for end user computing. *Communications of the ACM*, *31*(5), 552–561. doi:10.1145/42411.42418

Sanders, G. L., & Courtney, J. F. (1985). A field study of organizational factors influencing DSS success. *Management Information Systems Quarterly*, *9*(1), 77–91. doi:10.2307/249275

Sanghavi Goel, M., Brown, T., Williams, A., Cooper, A., Hasnain-Wynia, R., & Baker, D. (2011). Patient reported barriers to enrolling in a patient portal. *Journal of the American Medical Informatics Association*, *18*(1Supplement 1), I8–I12. doi:10.1136/amiajnl-2011-000473 PMID:22071530

Sarkar, U., Karter, A. J., Liu, J. Y., Adler, N. E., Nguyen, R., López, A., & Schillinger, D. (2010). Social disparities in Internet patient portal use in diabetes: Evidence that the digital divide extends beyond access. *Journal of the American Medical Informatics Association*, *18*(3), 318–321. doi:10.1136/jamia.2010.006015 PMID:21262921

Schriesheim, C. A. (1979). The similarity of individual directed and group directed leader behavior descriptions. *Academy of Management Journal*, *22*(2), 345–355.

Scott, W. R. (2001). *Institutions and organizations* (2nd ed.). Thousand Oaks, CA: Sage.

Smith, G., Watson, K. J., Baker, W. H., & Pokorski, J. A. II. (2007). A critical balance: Collaboration and security in the IT-enabled supply chain. *International Journal of Production Research*, *45*(11), 2595–2613. doi:10.1080/00207540601020544

Smith, S. G., O'Conor, R., Aitken, W., Curtis, L. M., Wolf, M. S., & Goel, M. S. (2015). Disparities in registration and use of an online patient portal among older adults: Findings from the LitCog cohort. *Journal of the American Medical Informatics Association*, *22*(4), 888–895. doi:10.1093/jamia/ocv025 PMID:25914099

Straub, D., Boudreau, M. C., & Gefen, D. (2004). Validation guidelines for IS positivist research? *Communications of the Association for Information Systems*, *13*(24), 380–427.

Tam, K. Y., & Ho, S. Y. (2005). Web personalization as a persuasion strategy: An elaboration likelihood model perspective. *Information Systems Research*, *16*(3), 271–293. doi:10.1287/isre.1050.0058

Tang, P. C., Overhage, J. M., Chan, A. S., Brown, N. L., Aghighi, B., Entwistle, M. P., ... Young, C. Y. (2013). Online disease management of diabetes: Engaging and motivating patients online with enhanced resources-diabetes (EMPOWER-D), a randomized controlled trial. *Journal of the American Medical Informatics Association*, *20*(3), 526–534. doi:10.1136/amiajnl-2012-001263 PMID:23171659

Taylor, S., & Todd, P. A. (1995). Assessing IT usage: The role of prior experience. *Management Information Systems Quarterly*, *19*(4), 561–570. doi:10.2307/249633

Teo, H. H., Wei, K. K., & Benbasat, I. (2003). Predicting intention to adopt interorganizational linkages: An institutional perspective. *Management Information Systems Quarterly*, *27*(1), 19–49. doi:10.2307/30036518

Tversky, A., & Kahneman, D. (1975). Judgment under uncertainty: Heuristics and biases. *Science*, *185*(4157), 1124–1131. doi:10.1126cience.185.4157.1124 PMID:17835457

Van den Bulte, C., & Lilien, G. L. (2001). Medical innovation revisited: Social contagion versus marketing effort. *American Journal of Sociology*, *106*(5), 1409–1435. doi:10.1086/320819

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science*, *46*(2), 186–204. doi:10.1287/mnsc.46.2.186.11926

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *Management Information Systems Quarterly*, *27*(3), 425–478. doi:10.2307/30036540

Voogdt-Pruis, H. R., Beusmans, G. H. M. I., Gorgels, A. P. M., & van Ree, J. W. (2011). Experiences of doctors and nurses implementing nurse-delivered cardiovascular prevention in primary care: A qualitative study. *Journal of Advanced Nursing*, *67*(8), 1758–1766. doi:10.1111/j.1365-2648.2011.05627.x PMID:21545701

Weber, M. (1962). *Basic concepts in sociology. Philosophical Library*. New York, NY: Philosophical Library, Inc.

Wendt, D., & Vlek, C. (1975). Utility, probability, and human decision making. *Theory and Decision Library*, *11*, 141–162.

Weppner, W. G., Ralston, J. D., Koepsell, T. D., Grothaus, L. C., Reid, R. J., Jordan, L., & Larson, E. B. (2010). Use of a shared medical record with secure messaging by older patients with diabetes. *Diabetes Care*, *33*(11), 2314–2319. doi:10.2337/dc10-1124 PMID:20739686

Wickramasinghe, N., Davey, B., & Tatnall, A. (2013). Web 2.0 panacea or placebo for superior healthcare delivery? In R. Bali, I. Troshani, S. Goldberg, & N. Wickramasinghe (Eds.), *Pervasive health knowledge management* (pp. 317–330). New York: Springer. doi:10.1007/978-1-4614-4514-2_23

Wold, H. (1985). Partial least squares. In S. Kotz & N. L. Johnson (Eds.), *Encyclopedia of statistical sciences* (pp. 581–591). New York: Wiley.

KEY TERMS AND DEFINITIONS

Elaboration Likelihood Model (ELM): In the context of our study, ELM is concerned with the amount of cognitive effort the elderly are willing to invest when facing complex technical acceptance decision. Our study investigates whether prior technical knowledge and the social context has an impact on behavioral intention to accept patient portal.

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. 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.

Social Heuristics: In the context of this study, we define social heuristics as the decision making and behavioral guiding principles followed by the elderly. For example, ignoring certain complex aspects of technology or relying on more knowledgeable peers is an example of social heuristics as a tool of bounded rationality among the elderly.

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)

Social Forces / Coercive Pressure (adopted from Teo, et al., 2003; Liang, et al., 2007; Jan, et al., 2012)

CP-1: I trust the diagnosis and treatment my physician prescribes.
CP-2: My physician strongly encourages me to use and understand information on an Online Personal Health Information website.
CP-3: I understand that information related to my condition can be found on an Online Personal Health Information website.
CP-4: Interaction with my physician requires me to access an Online Personal Health Information website.
CP-5: 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)
CP-6: 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)

Imitate-the-majority / Normative Pressure (adopted from Teo, et al., 2003; Liang, et al., 2007; Jan, et al., 2012)

NP-1: I am aware that some of my close family or friends are regularly accessing their Online Personal Health Information website.
NP-2: 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.
NP-3: People around me believe that it is beneficial to access their Online Personal Health Information website.
NP-4: I feel that I would be better informed if I used an Online Personal Health Information website.
NP-5: 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?

Imitate-the-successful / Mimetic Pressure (adopted from Teo, et al., 2003; Liang, et al., 2007; Jan, et al., 2012)

MP-1: My close friends who regularly access their Online Personal Health Information website have benefited from it.
MP-2: My close friends who regularly access their Online Personal Health Information website are more respected for taking charge of their health.
MP-3: I feel that I would be favorably perceived if I used an Online Personal Health Information website.
MP-4: I feel motivated to find more information about my condition.

MP-5: If everyone near me were to use an Online Personal Health Information website, it would influence me to try it.

Behavior Intention to adopt patient portal (adopted from Venkatesh, et al., 2003, Liu, et al., 2010)

BI-1: I plan to access an Online Personal Health Information website in the next year for the first time.
BI-2: I plan to access an Online Personal Health Information website regularly.
BI-3: I plan to continue using an Online Personal Health Information website.

Prior Knowledge (adopted from Bhattacherjee & Sanford, 2009 and modified. All items were based on a 7 point Likert scale)

PK-1: How knowledgeable are you regarding patient portals? novice….expert
PK-2: Have you previously discussed patient portal with someone who is knowledgeable about this topic? never….often (new item).
PK-3: Have you previously read news coverage regarding patient portals? never….often (new item).

Patient Portal Design Features (adopted from Khalfan, 2004; Smith et al. 2007; Dhillon & Backhouse 2000;

DF-1: Confidentiality is the disclosure of information only to authorized persons, entities, and processes in the authorized method only at the authorized time. Would you address confidentiality concerns prior to using patient portals?
DF-2: Integrity is the preservation of accuracy and completeness of information or prevention of unauthorized modification. Would you address integritity concerns prior to using patient portals?
DF-3: Auditability is the ability of an EHR system to be able to trace a series of actions and processes performed by one or more users leading to a change in the input, process and/or output. Would you address auditability concerns prior to using patient portals?
DF-4: Systems interconnectivity offers benefits such as reduced operating cost, improved efficiency, greater functionality, and centralized data access. Would you address interconnectivity concerns prior to using patient portals?
DF-5: System security ensures unauthorized access to the patient portal. Would you address security concerns prior to using patient portals?

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 6
Better Future for Home-Cared Elderly Patients:
A Prototype of Smart Clothing

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ABSTRACT

The need for innovative technologies that monitor and assist the independent living of elderly people in their homes is growing. The socio-economic benefits by utilizing such solutions are shared between many parties including the elderly people, support services and caregivers, and the medical system. This chapter proposes a wearable smart clothing-based monitoring system for home cared elderly patients. The development of the prototype smart cloth, which currently senses and alerts about body temperature, is discussed in this chapter. The proposed system is expected to provide a more dignified life for the elderly home cared patients by maintaining their independence and privacy while saving public and private money.

INTRODUCTION

With the exponential growth of ubiquitous and pervasive computing, mobile health (mHealth) applications for healthcare are emerging with the objective of delivering better healthcare and/or wellness. One key consumer group for such systems is elderly patients. Providing home monitoring, assistive and other support services for elderly people living in their own home reduces the need for hospitalisation and the cost of care. At the same time, such solutions improve patients' quality of life (Norris, Stockdale, & Sharma, 2009), because many older people wish to remain as independent as possible in their own home for as long as possible (Magnusson, Hanson, & Borg, 2004).

Magnusson et al. (2004) classify mHealth systems as providing information and services for older people at home, for family carers, both older people and family carers, and for all. They further argue that the barriers to adoption of these systems, such as the elderly having low affinity for computing systems,

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and few elderly people having access to a computer (Irvine, 2003), could be overcome by appropriate training to enable older people to adopt new technology in their daily lives.

Scholars and practitioners alike predict that mHealth will be one, if not the key, driver for future healthcare initiatives (Gov2020, 2019). Despite smartphones having been pervasive for more than a decade, adoption of mHealth applications by elderly consumers is still in its infancy. Edirisinghe, Stranieri and Wickramasinghe (2017) argue that the adoption of mHealth applications has been hindered by three main factors: (i) device-specific, external server, or storage-related technology limitations; (ii) inability to meet user requirements, expectations and goals; and (iii) security concerns. A number of studies which have investigated the consumer group of elderly people claim that older adults (over 50 years old) remain reluctant to adopt smartphones (Pheeraphuttharangkoon et al., 2014; Mohadisdudis & Ali, 2014). Years later, elderly consumers continue to show reluctance to use smartphone services (Berenguer et al., 2017). Barriers to the adoption of smartphones and associated services by the elderly include financial limitations, vision impairments, and lack of interest or know-how (Mohadisdudis & Ali, 2014). Supportively, Nikou (2015) argues that sociological and psychological factors, in addition to aging-related characteristics, better explain the dynamics of mobile technology adoption by the young-elderly. According to Berenguer et al. (2017), physical and cognitive decline among seniors remained a persistent barrier to adoption. Further, Berenguer et al. (2017) argue that seniors do not adopt popular services simply because they are not designed for seniors; they are neither designed to cater to the life-style changes seniors experience, nor are they associated with seniors' needs and interests. A study in the US found that 90 per cent of elderly people prefer to 'age in place' (Bozan & Berger, 2019). Such unique preferences, characteristics and requirements from a consumer group place a significant strain on researchers and healthcare technologies to provide better support for elderly people to be cared for at home.

This chapter presents a monitoring system based on smart clothing that supports elderly home-cared patients as an answer to the following research question: how can technology solutions be developed to provide better support for home-cared elderly patients? The chapter also discusses the development of the smart clothing prototype.

The background section discusses various monitoring systems proposed for elderly people in the literature. Studies done since 2004 on home monitoring systems, assistive technologies and wearable clothing are discussed in this section. The home care monitoring system we propose is discussed next. The development of the smart clothing prototype is then presented, followed by our conclusions.

BACKGROUND

A tremendous number of mHealth systems were proposed for home cared elderly in the literature. Recently, Bozan and Berger (2019) presented a survey of ambient assisted living technologies for the elderly. This review classifies the literature based on the advancement of the technology (first, second and third generation) on the basis of each system's detection, responsiveness and prevention ability. An extensive review of the literature since 2004 revealed that classification of systems based on these pillars only considers the technology point of view. We believe, however, that more practical aspects, such as user-friendliness and ease of use, are more relevant to the specific consumer group, who are not technology-savvy, and amongst whom the adoption of smartphones and associated services is slow (Pheeraphuttharangkoon et al., 2014; Mohadisdudis & Ali, 2014; Berenguer et al., 2017).

Sensor/Body Area Network (BAN) based home monitoring systems for the elderly have been proposed (Rodrigues et al., 2014; Chan, Campo, & Estève, 2005; Hewson et al., 2007; Scanaill, Ahearne, & Lyons, 2006; Suryadevara & Mukhopadhyay, 2012; Yuan & Herbert, 2011; Lubrin, Lawrence, & Navarro, 2005; Baig, 2014; Ly et al., 2010), while some studies have focused on wearable devices/clothing to monitor elderly people (Lee & Chung, 2009; Paradiso et al., 2008; Agrawal & Lau, 2010; Deen, 2015), and the objective of some studies was to offer home assistive services (Doukas et al., 2011; Raad & Yang, 2009; Lyu et al., 2014; Lin et al., 2006; Nugent et al., 2007; Do et al., 2018). These studies are discussed in detail below.

Rodrigues et al. (2014) propose a mobile healthcare solution for the ambient assisted living environment. Sensors attached to the body of the elderly person provide electrocardiogram, blood pressure and temperature measurements. The sensors, forming a Body Area Network (BAN), connect to a personal computer, tablet, or smartphone through Bluetooth. The system immediately alerts both the wearer and caregivers of significant changes that might lead to life-threatening situations. The accuracy and performance of the system was investigated in controlled clinical trials with three levels of surveillance (alerting). Yuan and Herbert (2011) proposed web-based real-time healthcare monitoring. Paradiso et al. (2008) developed a wearable system to monitor ECG, heartrate, oxygen saturation, impedance pneumography and activity data, which were then transmitted via cellular network for remote access.

Wireless BAN-based sensors monitor the wearer's location, ECG, blood pressure 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) used an existing monitoring network tool, namely MRTG, to propose an infrastructure for recording environmental variables (specifically light) as a proof of concept for a remote monitoring system. iCare is a mobile health monitoring system developed for the elderly by Ly et al. (2010). It is composed of wireless body sensors and smartphones to monitor the wellbeing of the wearer. It can offer remote monitoring for the elderly person anytime, anywhere, and provides tailored services for each person based on their personal health condition. When an emergency is detected, the smartphone will automatically alert pre-assigned people, who could be the wearer's family and friends, and call the ambulance. The attractiveness of BAN as a technology for the elderly consumer group is still to be explored due to its practical inconvenience.

A multi-sensor home monitoring system (Chan et al., 2005) monitors the activities of the elderly person. Ten infrared (IR) sensors fitted in the ceiling of the person's house are connected to an acquisition interface, which is wired to a PC. The authors tested the accuracy of the behaviour assessment. Changes in activity data and correlations between in-bed restlessness and getting up variables showed trends in the behaviour of elderly people, for use as a predictive tool to detect abnormal situations. The system provides this information to caregivers. The system was trialled with four participants in a clinical setting. Because the system does not focus on burdening the elderly through tagging or forcing them to use smart devices or services, it is expected to be attractive to the consumer group. However, the reliability of behaviour monitoring in real-world applications is yet to be determined.

Hewson et al. (2007) proposed a posture and falls monitoring system for elderly people. Their system captures images from a camera, and uses advanced image-processing algorithms for fall prevention. Similarly, Scanaill et al. (2006) proposed the tele-monitoring of mobility trends of elderly people using accelerometer data. The data are sent to a central server via SMS messages over the mobile network. More recently, Baig (2014) also proposed a novel falls prediction system for elderly people.

Suryadevara and Mukhopadhyay (2012) developed a wireless sensor network-based home monitoring system to monitor the well-being of elderly patients. The proposed mechanism estimates well-being based on the use of household appliances connected to various sensing units. Normal behaviour and well-being were mathematically defined and tested with four elderly people. Whether the research reached practical testing of the above technologies is yet to be reported, as is the potential for full adoption of such a system by the consumer group.

Various home assistive services developed for elderly patients have been reported in the literature. Doukas et al. (2011) reviews the home assistive technology developed for the elderly and for people with disability, and highlights the social issues of acceptance and training with the technology. Raad and Yang (2009) proposed a smart home for people who are elderly or living with a disability. Medical wearable sensors, such as pulse oximeter and blood pressure sensors, together with a number of environmental sensors, a camera, weight sensors and motion detectors were used to form the smart home. A web interface enabled integration with physicians' reports.

Agrawal and Lau (2010) developed a remote blood pressure monitoring system to detect chronic diseases. The blood pressure data were collected via a mobile phone and sent to doctors over the Internet so that doctors could manage the chronic condition by providing feedback to the patient remotely. Lyu et al. (2014) developed a robotic walking-aid system with mobility assistance and remote monitoring of people with disability and elderly people. The walking accessibility robot included an embedded controller using a laser range finder, ultrasonic radar, grip sensors, and other environmental sensors. The robot was able to avoid collision and to adjust the speed during navigation while providing remote monitoring service. A healthcare system for elderly people with dementia (Lin et al., 2006) used radio frequency identification (RFID), GPS, global system for mobile communications, and geographic information system (GIS) data to construct a straying 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 with people with mild dementia as well as care givers were presented with the overview of the proposed system.

Portugal et al. (2015) proposed the concept of virtual social care for elderly by means of an interactive social robot, which is expected to provide personalised companionship for home-cared elderly people. The concept considers seniors as active collaborative agents who are able to make personal choices, and the robot self-adopts the care model to suit its owner's lifestyle, personal needs and capability changes over the aging process. The conceptual study was critiqued over the ability of such robots to fully satisfy the elderly people's needs, as well as on the reliability of its ability to detect those needs (Kon, Lam, & Chan, 2017).

Do et al. (2018) proposed an architecture for a home service robot-integrated smart home testbed in which the robot would be capable of perceiving the environment through audio signals. An indoor localisation system is used to provide the location ground truth for the robot, the human, and other targets that need to be tracked. The system offers four services: (i) auditory perception; (ii) wearable monitoring; (iii) human position tracking; and (iv) human activity monitoring. Early stage development of this concept is yet to be tested in real-world applications.

More recently, with the exponential growth of wearable technologies and IoT (Internet of Things) capabilities, a number of wearable technologies have also been proposed. Al-khafajiy et al. (2019) propose a smartphone app-based wearable as a home-based monitoring system. They present a case study in which heartrate data were sent as smartphone-based email notifications to the patients and records of abnormalities were pushed to the doctor. In this system, however, the sensors are expected to be worn by the patients, which limits the practicality of the system, as does the expectation that the wearer would use a smartphone for them to be monitored. Wearable clothing designed for elderly is of particular interest due to the style of interaction preferred by the consumer group.

Pandian et al. (2008) developed a wearable physiological remote monitoring system. In this system, a washable shirt contained 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 accelerometer data are transmitted via ZigBee.

As technologies are becoming more and more advanced, the ability to offer simple, easy-to-use systems for elderly people are becoming less of a focus. In this vacuum, we propose a smart clothing-based monitoring system for elderly people.

PROPOSED HEALTHCARE MONITORING SYSTEM

The proposed project monitors home-cared elderly people. The project aims to deploy a cloud-based wireless sensor network system, together with a piece wearable clothing to monitor general health conditions of elderly people, as well as activities involving movement, and to alert appropriate personnel of abnormalities. The proposed system is shown in Figure 1, below.

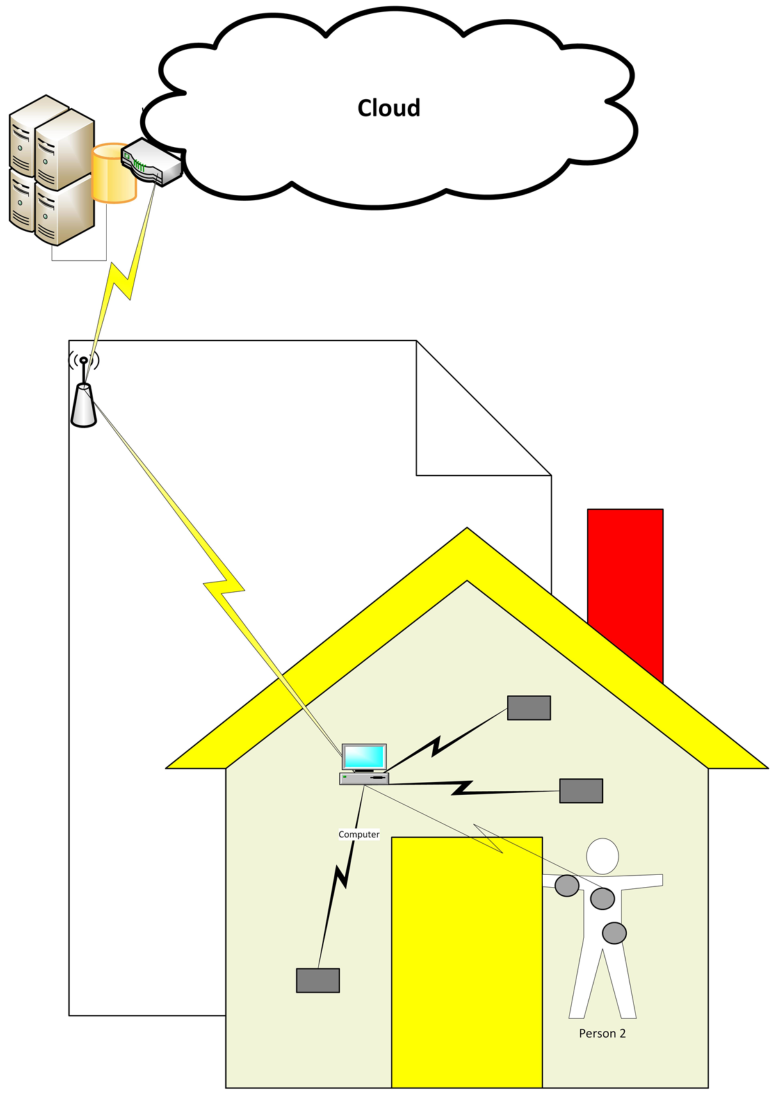
The proposed system is expected to be delivered in two customised forms. One form is intended to provide a simple clothing-based solution to trigger alerts for the patient or their caregivers. A more sophisticated and complete system (as depicted in Figure 1) is customised to cater for members of the elderly consumer group who have extensively adopted smartphones and smartphone services. The complete system is composed of two types of sensor:

1. **Wearable sensors:** the smart clothing is equipped with sensors to measure various health-related parameters of the elderly person, and can communicate with their home computer/smartphone.
2. **Environmental sensors:** the house will be equipped with sensors to measure various environmental parameters, e.g. gas sensors to alert the elderly person if the gas has not been switched off, room proximity detection sensors to detect the presence of the person in specific rooms, etc. This also capable of determining the likelihood of a fall while the patient is in the bathroom.

The sensors attached to the smart clothing measure parameters such as body temperature, pulse rate, electrocardiogram (ECG) and motion/activities, and then transmit the data to the mobile device, forming a BAN. The environmental sensors, such as fall/weight, temperature, light, humidity, gas and smoke sensors, are installed inside the home, communicating via Wi-Fi/ZigBee. The measured sensor data are communicated to the mobile device via Bluetooth. This basic unit of information flow enables self-education or self-awareness for the elderly patient. The mobile application visualizes the information and empowers the person to undertake self-care.

Continuously monitored sensor data are streamed to a local server, forming a Local Area Network (LAN). The data are ultimately sent to the cloud. The local information flow is dual purpose: to create a link with the outside world through internet protocol (IP); and to execute complex processing of the collected sensor data, such as signal and trend analysis, detection algorithms, and pattern recognition.

Figure 1. The Complete health monitoring system for home cared elderly patients



The processed sensor data are streamed to the cloud. The cloud enables patient monitoring information and information pertaining to treatment response to be sent to healthcare providers, physicians, other clinicians, and hospitals. In other words, all of this information can be fed to the health system as a whole.

Abnormality detection, and fall prediction and detection algorithms to be executed on the data will be performed on the server. The service will be designed to ensure the patients' data remain intact regardless of whether they are stored in the cloud or in the BAN at home. The system will provide real-time continuous visualisation of a patient's activity status.

For the focus of this chapter, the simpler version of the proposed smart clothing is presented and discussed below.

Figure 2. Wearable smart cloth

SMART CLOTHING PROTOTYPE

Smart clothing is defined as "Textiles that are able to sense stimuli from the environment, to react to them and adapt to them by integration of functionalities in the textile structure" (Van Langenhove & Hertleer, 2004, p. 63). As Buechley and Eisenberg (2008) put it, integrating computer science, electrical engineering, and fashion and textile design crosses unusual boundaries to provide novel opportunities for creative experimentation in both engineering and design. Potential applications of this next generation smart clothing are expected to appear in sectors including medical monitoring, therapy and rehabilitation (Dunne, 2010). The terms 'smart textile', 'intelligent clothing' and 'e-textile' are used interchangeably.

The first stage of the project involves the development of smart clothing that elderly people can wear. We developed a prototype of the smart clothing to sense body temperature – the development process is discussed in the next section.

PROTOTYPE DEVELOPMENT TECHNOLOGY

The LilyPad Arduino embedded platform (Buechley et al., 2008) was used to build the prototype. The microcontroller board was stitched into the fabric using conductive threads. The board was powered with a 3.7V LiPo battery (connected to the JST connector on the board), and was programmed in the Arduino programming environment. The smart clothing is shown in Figure 2, below.

A Lilypad Arduino temperature sensor was used to sense body temperature. The temperature was measured and recorded every second. To obtain a stable temperature reading, the average of ten readings was used to smooth out the variations and fluctuations. The temperature sensor was stitched into the smart clothing using conductive thread. A LilyPad Arduino tri-colour light-emitting diode (LED) and a LilyPad Arduino speaker were also stitched into the fabric using conductive thread. The input and output sensors of the smart cloth are illustrated in Figures 3 and 4. The temperature sensor and speaker are shown in Figure 3, and the tri-colour LED light is shown in Figure 4, below.

Figure 3. LilyPad Arduino temperature sensor and LilyPad Arduino speaker in the smart cloth

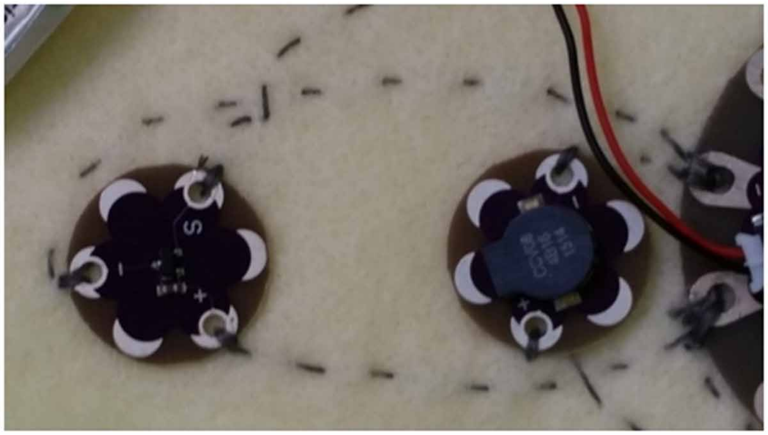


Figure 4. LilyPad RGB LED light in the smart cloth

ALERT MECHANISM

The temperature measurement was recorded every second. The average temperature value of ten readings was taken to smooth out the variations and fluctuations of the sensor readings. A stable temperature reading was obtained this way.

The smart clothing also features an inbuilt alert mechanism. The alert mechanism indicates abnormalities visually through a change of colour of its tri-colour LED, and audibly using a sound emitted by the speaker or buzzer.

In the prototype, temperature variations are signalled by an LED indicator on the back of the smart clothing. In the future, when a complete system implementation is achieved, this will be extended to send notifications to caregivers or medical professionals.

The temperature variations generated based on the pre-defined thresholds are indicated by a red, green or blue light on the back of the clothing. A reference temperature, together with an offset, is used to indicate the acceptable/normal temperature range. If the sensor reading is in the normal range, the green LED is activated. If the temperature reading is lower than the reference temperature and the offset temperature, the blue LED is activated, indicating a 'too cold' condition. If the temperature reading is higher than the reference temperature plus offset temperature value, the red LED is activated, indicating a 'too hot' condition. The alert mechanism's audio component uses the LilyPad speaker/buzzer. If the temperature is in the normal range, the buzzer is not activated. If the temperature is too cold, the buzzer emits a beep every 500ms. If the temperature is too hot, the buzzer is activated to play a warning music.

ALERT ALGORITHM

As discussed above, a reference temperature and offset values are used to indicate the acceptable temperature ranges in the alert mechanism. The alert mechanisms discussed above were implemented using the following algorithm:

IF temperature > reference + offset
THEN Red RGB LED & Danger Warning music
ELSE IF temperature < reference - offset
THEN Blue RGB LED & buzzer beeps
ELSE Green RGB LED & no audio

CONCLUSION

This chapter presents the development of a smart clothing prototype that can be worn by elderly people being cared for at home. This prototype is proffered in order to answer the research question: how can technology solutions be developed to provide better support for home-cared elderly patients? The chapter also discussed the preliminary algorithm used by the alert mechanism. This has implications for both theory and practice. The smart clothing developed is the first phase of a larger project aimed at developing a home monitoring system for home-cared elderly patients.

This project aims to help patients maintain their privacy and independence. The proposed home care monitoring system is expected to support elderly patients to live at home for longer, to enjoy a more dignified life, and to save public and private money.

Given the aging population in all OECD countries, ever more focus is being placed on caring for elderly people, and on how to ensure that care is of excellent quality while remaining affordable. The proposed solution is thus significant, and has far-reaching implications.

Future work will include extending the smart clothing, in concert with other sensors, into a complete monitoring system. A field study of the prototype, and the development of the home monitoring system with the relevant algorithms, are also future phases of this project. The prototype will be tested in a live environment to study its usability too. Issues related to user comfort and calibrating the sensors to various needs are to be addressed through such testing.

REFERENCES

Agarwal, S., & Lau, C. T. (2010). Remote health monitoring using mobile phones and Web services. *Telemedicine Journal and e-Health*, *16*(5), 603–607. doi:10.1089/tmj.2009.0165 PMID:20575728

Al-khafajiy, M., Baker, T., Chalmers, C., Asim, M., Kolivand, H., Fahim, M., & Waraich, A. (2019). Remote health monitoring of elderly through wearable sensors. *Multimedia Tools and Applications*, *78*(17), 1–26. doi:10.100711042-018-7134-7

Baig, M. M. (2014). *Smart vital signs monitoring and novel falls prediction system for older adults* (Doctoral dissertation). Auckland University of Technology, New Zealand.

Berenguer, A., Goncalves, J., Hosio, S., Ferreira, D., Anagnostopoulos, T., & Kostakos, V. (2017). Are Smartphones Ubiquitous? An in-depth survey of smartphone adoption by seniors. *IEEE Consumer Electronics Magazine*, *6*(1), 104–110. doi:10.1109/MCE.2016.2614524

Bozan, K., & Berger, A. (2019). Revisiting the technology challenges and proposing enhancements in ambient assisted living for the elderly. In *Proceedings of the 52nd Hawaii International Conference on System Sciences*. Piscataway, NJ: IEEE. 10.24251/HICSS.2019.520

Buechley, L., & Eisenberg, M. (2008). The LilyPad Arduino: Toward wearable engineering for everyone. *Pervasive Computing*, *7*(2), 12–15. doi:10.1109/MPRV.2008.38

Buechley, L., Eisenberg, M., Catchen, J., & Crockett, A. (2008). The LilyPad Arduino: Using computational textiles to investigate engagement, aesthetics, and diversity in computer science education. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 423–432). Florence, Italy: ACM. 10.1145/1357054.1357123

Chan, M., Campo, E., & Estève, D. (2005). Assessment of activity of elderly people using a home monitoring system. *International Journal of Rehabilitation Research. Internationale Zeitschrift fur Rehabilitationsforschung. Revue Internationale de Recherches de Readaptation*, *28*(1), 69–76. doi:10.1097/00004356-200503000-00010 PMID:15729100

Do, H. M., Pham, M., Sheng, W., Yang, D., & Liu, M. (2018). RiSH: A robot-integrated smart home for elderly care. *Robotics and Autonomous Systems*, *101*, 74–92. doi:10.1016/j.robot.2017.12.008

Doukas, C., Metsis, V., Becker, E., Le, Z., Makedon, F., & Maglogiannis, I. (2011). Digital cities of the future: Extending@ home assistive technologies for the elderly and the disabled. *Telematics and Informatics*, *28*(3), 176–190. doi:10.1016/j.tele.2010.08.001

Dunne, L. (2010). Smart clothing in practice: Key design barriers to commercialization. *Fashion Practice: The Journal of Design*. *Creative Process & the Fashion Industry*, *2*(1), 41–66.

Edirisinghe, R., Stranieri, A., & Wickramasinghe, N. (2017). A Taxonomy for mHealth. In N. Wickramasinghe (Ed.), *Handbook of research on healthcare administration and management* (pp. 596–615). Hershey, PA: IGI Global. doi:10.4018/978-1-5225-0920-2.ch036

Gov2020. (2019). *Explore the future of government*. Retrieved from https://www2.deloitte.com/au/en/pages/public-sector/articles/gov2020.html

Hewson, D. J., Duchêne, J., Charpillet, F., Saboune, J., Michel-Pellegrino, V., Amoud, H., ... Hogrel, J. Y. (2007). The PARAChute project: Remote monitoring of posture and gait for fall prevention. *EURASIP Journal on Applied Signal Processing*, (1): 109–109.

Irvine, B. (2003). *Computers for caregiving*. Paper presented at SPRY National Conference, Computer-based Technology and Caregiving for Older Adults, Betheseda, MD.

Kon, B., Lam, A., & Chan, J. (2017). Evolution of smart homes for the elderly. In *Proceedings of the 26th International Conference on World Wide Web Companion* (pp. 1095–1101). Geneva, Switzerland: International World Wide Web Conferences Steering Committee. 10.1145/3041021.3054928

Lee, Y. D., & Chung, W. Y. (2009). Wireless sensor network based wearable smart shirt for ubiquitous health and activity monitoring. *Sensors and Actuators. B, Chemical*, *140*(2), 390–395. doi:10.1016/j.snb.2009.04.040

Lin, C. C., Chiu, M. J., Hsiao, C. C., Lee, R. G., & Tsai, Y. S. (2006). Wireless health care service system for elderly with dementia. *Transactions on Information Technology in Biomedicine*, *10*(4), 696–704. doi:10.1109/TITB.2006.874196 PMID:17044403

Lubrin, E., Lawrence, E., & Navarro, K. F. (2005). Wireless remote healthcare monitoring with Motes. In *International Conference on Mobile Business* (pp. 235–241). Piscataway, NJ: IEEE. 10.1109/ICMB.2005.115

Lv, Z., Xia, F., Wu, G., Yao, L., & Chen, Z. (2010). iCare: a mobile health monitoring system for the elderly. In *Proceedings of the 2010 IEEE/ACM Internationa'l Conference on Green Computing and Communications & International'l Conference on Cyber, Physical and Social Computing* (pp. 699–705). Piscataway, NJ: IEEE Computer Society. 10.1109/GreenCom-CPSCom.2010.84

Lyu, S. R., You, W. T., Chen, Y. S., Chiang, H. H., & Chen, Y. L. (2014). Development of robotic walking-aid system with mobility assistance and remote monitoring. In *2014 IEEE International Conference on Automation Science and Engineering (CASE)*, (pp. 830–835). Piscataway, NJ: IEEE. 10.1109/CoASE.2014.6899422

Magnusson, L., Hanson, E., & Borg, M. (2004). A literature review study of information and communication technology as a support for frail older people living at home and their family carers. *Technology and Disability*, *16*(4), 223–235. doi:10.3233/TAD-2004-16404

Mohadisdudis, H. M., & Ali, N. M. (2014). A study of smartphone usage and barriers among the elderly. In *2014 3rd International Conference on User Science and Engineering (i-USEr)* (pp. 109–114). Piscataway, NJ: IEEE. 10.1109/IUSER.2014.7002686

Nikou, S. (2015). Mobile technology and forgotten consumers: The young-elderly. *International Journal of Consumer Studies*, *39*(4), 294–304. doi:10.1111/ijcs.12187

Norris, A. C., Stockdale, R. S., & Sharma, S. (2009). A strategic approach to m-health. *Health Informatics Journal*, *15*(3), 244–253. doi:10.1177/1460458209337445 PMID:19713398

Nugent, C., Mulvenna, M., Moelaert, F., Bergvall-Kåreborn, B., Meiland, F., Craig, D., & Bengtsson, J. E. (2007). Home based assistive technologies for people with mild dementia. In T. Okadome, T. Yamazaki, & M. Mokhtari (Eds.), *Pervasive computing for quality of life enhancement* (pp. 63–69). Heidelberg, Germany: Springer Berlin. doi:10.1007/978-3-540-73035-4_7

Pandian, P. S., Mohanavelu, K., Safeer, K. P., Kotresh, T. M., Shakunthala, D. T., Gopal, P., & Padaki, V. C. (2008). Smart vest: Wearable multi-parameter remote physiological monitoring system. *Medical Engineering & Physics*, *30*(4), 466–477. doi:10.1016/j.medengphy.2007.05.014 PMID:17869159

Paradiso, R., Alonso, A., Cianflone, D., Milsis, A., Vavouras, T., & Malliopoulos, C. (2008). Remote health monitoring with wearable non-invasive mobile system: The healthwear project. In *Engineering in Medicine and Biology Society, 2008. EMBS 2008., 30th Annual International Conference of the IEEE* (pp. 1699–1702). Piscataway, NJ: IEEE.

Pheeraphuttharangkoon, S., Choudrie, J., Zamani, E., & Giaglis, G. (2014). *Investigating the adoption and use of smartphones in the UK: A silver-surfers perspective* (Working paper). Hertfordshire Business School, UK.

Portugal, D., Santos, L., Alvito, P., Dias, J., Samaras, G., & Christodoulou, E. (2015). SocialRobot: An interactive mobile robot for elderly home care. In *2015 IEEE/SICE International Symposium on System Integration (SII)* (pp. 811–816). Piscataway, NJ: IEEE. 10.1109/SII.2015.7405084

Raad, M. W., & Yang, L. T. (2009). A ubiquitous smart home for elderly. *Information Systems Frontiers*, *11*(5), 529–536. doi:10.100710796-008-9119-y

Rodrigues, D. F., Horta, E. T., Silva, B., Guedes, F. D., & Rodrigues, J. J. (2014). A mobile healthcare solution for ambient assisted living environments. In *2014 IEEE 16th International Conference on e-Health Networking, Applications and Services (Healthcom)* (pp. 170–175). Piscataway, NJ: IEEE. 10.1109/HealthCom.2014.7001836

Scanaill, C. N., Ahearne, B., & Lyons, G. M. (2006). Long-term telemonitoring of mobility trends of elderly people using SMS messaging. *Transactions on Information Technology in Biomedicine*, *10*(2), 412–413. doi:10.1109/TITB.2005.859890 PMID:16617630

Suryadevara, N. K., & Mukhopadhyay, S. C. (2012). Wireless sensor network based home monitoring system for wellness determination of elderly. *Sensors Journal*, *12*(6), 1965–1972. doi:10.1109/JSEN.2011.2182341

Van Langenhove, L., & Hertleer, C. (2004). Smart clothing: A new life. *International Journal of Clothing Science and Technology*, *16*(1/2), 63–72. doi:10.1108/09556220410520360

Yuan, B., & Herbert, J. (2011). Web-based real-time remote monitoring for pervasive healthcare. In *2011 IEEE International Conference on Pervasive Computing and Communications Workshops (PERCOM Workshops)* (pp. 625–629). Piscataway, NJ: IEEE. 10.1109/PERCOMW.2011.5766964

Chapter 7
Optimization of Provider Ecosystem Through Actor–Resource Integration

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ABSTRACT

Information technology has enabled healthcare providers such as hospitals to extend their internal operations into external facilities such as urgent and ambulatory care centers and optimizeresources in support of patient care. With the development of the internet, social media, wearables, and telehealth technologies, the potential for patient engagement in preventive and post-discharge care transition has increased. Unlike other organizations where the provider has limited insight into the customer ecosystem, hospitals, for example, have an opportunity to gain insight into the patient ecosystem and influence patient behavior while the patients are within the provider ecosystem. This chapter looks at hospital engagement with patients in two settings—the emergency room (ER) and the patient room (PR)—to illustrate both the opportunities and the strategies that can help hospitals use patient touchpoints to improve continuity of care inside and outside hospital walls.

INTRODUCTION

Information technology has enabled organizations to not only extend their internal business operations across supply chains to optimize their resource utilization to reduce costs but also to partner with multiple technology partners to respond to market demands faster. With the internet/web enabling organizations to extend their business operations to assist and/or influence customer decision making, organizations must look at optimizing their resources using not only its internal and external supplier and partner resources, but also customer resources. This may include co-creating value propositions and using social media, the Internet of Things, and digital information exchanges that can let customers generate more information to help organizations react quickly to changing market demands and create new value propo-

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sitions to stay competitive. In other words, organizations need to include customer resources, both their value creating potential and real time feedback, in optimizing their response to customer expectations on multiple dimensions, including cost, service, responsiveness, and novelty.

Leveraging customer resources in value creation and assessing value-in-use (post-purchase) to stay competitive is the basic tenet of service dominant logic (Vargo & Lusch, 2008) and is becoming critical in today's knowledge economy. S-D Logic refers to this as actor-resource integration, where both actors and resources can come from both the provider and the customer ecosystems (Lusch & Nambisan, 2015). Optimization of the actor-resource mix of both ecosystems is especially critical for organizations with short product use cycles, i.e. service organizations, where customer expectations change rapidly. Not leveraging continual feedback from customers on value-in-use can only lead to sub-optimization of the provider resource (Vargo et al., 2016) .

While most service organizations try to build agility into their operations using an optimal mix of resources, healthcare organizations have both a unique opportunity and a challenge. Their customers are patients who spend significant part of their time within the hospital (or clinic) when they need a medical diagnosis and design of a care treatment plan. This provides hospitals with a unique opportunity to learn about patients and their ecosystem (actors and resources patients must use to care for themselves). It also provides a challenge: how to convince patients to use this actor-resource mix of their ecosystem to optimize care management, given the diverse nature of the patient capabilities. The social, economic, cultural, and other factors influencing the behavior of patients within their ecosystem to sustain care treatment is unlike the roles the same patients play as customers when they purchase service products like food, entertainment, travel, etc. (Doremus, 1976).

Even if sustaining the value created for patients after they are discharged from a hospital is a goal healthcare providers have always had, the complexity of the patient ecosystem as well as the lack of financial incentives has made providers focus on the value they can provide to patients while they are in the hospital (e.g. diagnosis and treatment care plans) and allowing patients and other actors (family, community, and other external care providers) to address care continuity outside the provider ecosystem. However, recent changes in healthcare reimbursement and regulation in the US ("Medicare Hospital Readmissions Reduction Program", 2013) as well as general costs, care related delays, and hospital congestion around the world have started to force hospitals to look outside their own ecosystem to begin to optimize the value created for patients. They have started to use external care providers like pharmacies, ambulatory and urgent care centers, etc. to support care transition (Dreyer, 2014) and allow technology-empowered patients with smart phones and wearables to give them access to care-related information for remote monitoring and consultation (Herzig et al., 2016; Koh et al., 2016). However, the optimization of resources in patient and provider ecosystems in the US is mostly limited to those patients whose unplanned readmission leads to penalties and whose care is paid for as a bundle, i.e. paid for over a longer period patients spend inside and outside the hospital.

Patient satisfaction is not as dominant a factor in healthcare as is customer satisfaction in other service industries, since patients choosing a hospital consider many other factors, such as a hospital's clinical reputation, physician recommendation, payment related constraints through insurance providers, etc. However, with the increased use of provider technologies, such as portals, telehealth consultation, and smart phone communication, and improvements in patient empowering technologies such as wearables, smart phone apps, etc. patient expectations on demand for services will continue to increase.

Many hospitals have begun investing large sums of money in rearchitecting hospitals around design thinking or customer centered thinking to create an environment that is welcoming to patients in order to reduce stress (“Caritas Project”). With many supporting facilities, such as cafeterias, gift shops, work-spaces to support patients and family members in the hospital and/or in a patient room, along with art and music to create a healing space, hospitals hope to attract patients and improve their satisfaction with the care provided inside the hospital (i.e. provider ecosystem). While investment in hospital amenities to improve patient satisfaction (a fixed cost, like any other capital investments) may improve the hospital brand or collective patient experience, it does not directly relate to patient responses to satisfaction surveys, as these surveys track many other metrics besides hospital environment such as staff interactions, communication, care quality and staff empathy.

In summary, the optimization of hospital resources to improve patient care has to consider not only lean management of hospital operations to reduce costs as patients move through various service units within the hospital (ER, OR, or patient room) using technologies, but also inform, engage and empower patients in the care related activities to improve patient experience and satisfaction while they are in the hospital. Hospitals also can use their access to patients within the provider ecosystem to learn about actors/resources that can influence patient care and satisfaction when they leave the hospital. This is the goal of this chapter— model patient touchpoints when patients are in the hospital and look for opportunities to improve their experience and learn about the actors/resources that can influence care delivery after they leave, all to sustain care outside the hospital. Specifically, we will look at two use cases—when a patient is in the ER and in the patient room.

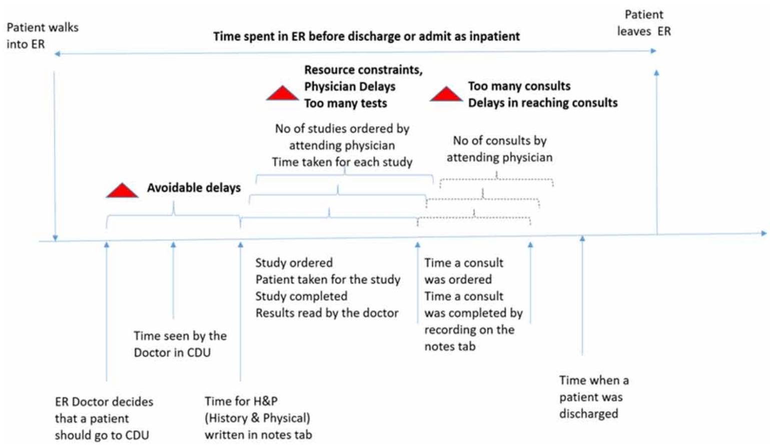
EMERGENCY ROOM (ER) USE CASE

Resource optimization in an ER has traditionally focused on looking at internal actors (clinical and administrative staff) and resources (test labs, transport vehicles, etc.) that are used as part of understanding patient flow and leveraging technology (e.g. RTLS badges on patients, RFID sensor tags on hospital facilities, etc.) to track the time spent at various points in the patient flow in order to reduce the length of stay of the patient in the ER.

Figure 1 below shows the flow of patients that move through multiple stages in the ER. The patient walks into the ER (unless brought by an emergency management vehicle) and, after admission, waits for a decision to be quickly discharged or be reviewed by an ER doctor to see if s/he needs to be seen by a doctor or discharged. If the patient is seen by a doctor, the patient waits in the clinical decision unit (CDU). The doctor comes in to review and order any tests that the patient needs before a final decision is made. If the doctor cannot make the final decision on discharge or move the patient to inpatient status, s/he may seek to consult with specialists. Once this is done, the patient is either discharged to outpatient status or inpatient status. The top half of the diagram shows potential reasons for delays, and analysis of patient data in a hospital in SE Michigan has revealed some of the reasons listed below.

- Most patients have 4-6 orders for tests each.
- The minimum average time linearly increases with the number of orders for tests.
- A few orders have a high standard deviation (> 6 hrs.) and a high occurrence compared to other orders. It was necessary to review three orders, as they have a high impact on the overall patient length of stay.

Figure 1. ER Operational Flow



- "EKG Lead Tracking" has the highest time required for patients to get into the room, and there were many orders for this test. It was necessary to check what can be done to reduce this time (i.e. add more resources).
- Report reading by doctors to make decisions is not taking much time in comparison to other actions and is probably not currently a factor in the patient length of stay.
- Most of the orders are placed on weekdays and Thursday, especially. This needs further review.
- The average time before discharge over the year is around 5 days, and the highest average delay in discharge is in June (10 days)
- Some physicians order many tests, and some have many consults. This needs further investigation into its relationship to specific patient conditions, as we didn't have enough information in the data to analyze this.

This analysis also led to additional questions that needed clarification, including:

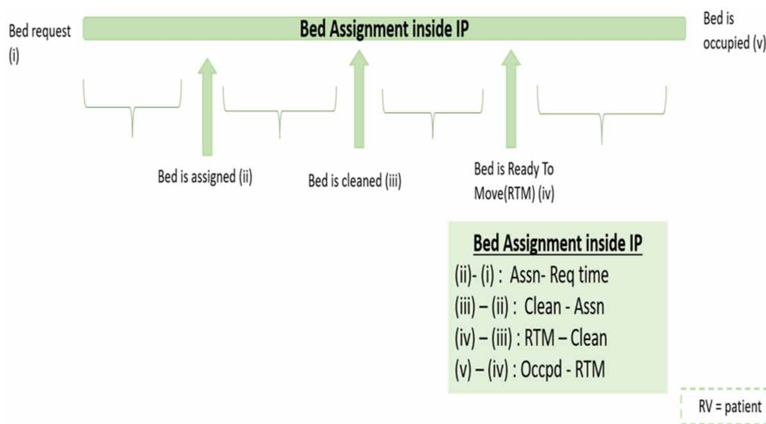
- Is the time a patient spends in the ER based on acuity or diagnosis, and what is its relationship to decision time on discharge as an outpatient or inpatient?
- What resources are needed most given an acuity or diagnosis?
- What resources are needed to reduce overall patient length of stay for a patient to
- **Stage 1:** become an outpatient
- **Stage 2:** become an inpatient and be discharged from the hospital

as some of the lab resources are the same for both ER and PR (patient rooms)?

However, one delay between the time a patient is admitted to the ER and when patient is physically in the patient room caused concern, as this is leading to congestion in the ER as shown in Figure 2.

This led to further analysis and the following observations. Most are related to non-clinical actor engagement in the patient flow management.

Figure 2. Bed Assignment Delays

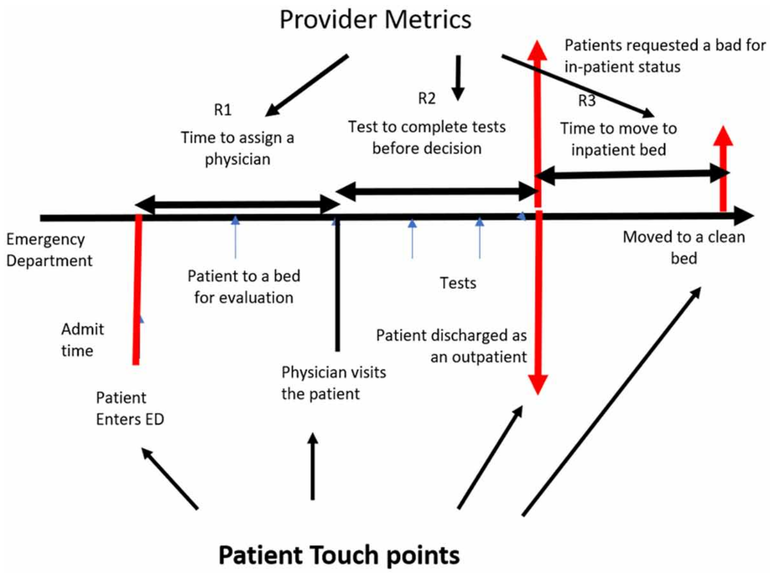


- Bed assignment delays are lower on weekends, and the number of bed requests increase throughout the day.
- It is taking on average two hours to move the patient from the ER to the PR, with one hour from request to bed assignment and one hour from assignment to the patient moving into the room.
- While the time from request to assignment is a function of bed availability, the time from assignment to patient moving to the bed is a function of multiple non-clinical engagements, such as getting cleaning staff to clean the room and transport staff to move the patient to the room. These delays increase towards the end of the day, as staff levels do not expand with the demand for patient rooms.
- Also, some patients who are supposed to be discharged according to the EMR were not discharged as quickly towards the end of the day, as nursing staff often do not want to deal with new patients before their shift ends.

As the analysis continued, another item surfaced that can lead to delays in getting a bed request made for patients who are discharged to inpatient status from the ER. Depending on how the ER is managed (by an external ER management firm or by the hospital itself), a decision made by an ER doctor must meet certain quality considerations. The inpatient readmit decision must be verified by a registered nurse based on interqual-evaluation. If it does not meet the standards, the RN must contact the resident physician for input, and communication delays do occur in getting a physician response. Even after a physician responds, there can be disagreements, and this can lead to additional tests and possibly three-way consultations before a final decision is made.

In summary, the optimization of patient flows to address several provider metrics such as reducing time spent in the ER requires the integration of clinical and non-clinical actors and hospital resources. However, delays in accomplishing these tasks can lead to increased patient wait times and patient dissatisfaction. In fact, an ER facility management firm that manages multiple ER rooms has asked for an analysis of the patient satisfaction data – how patients perceive the value of care they receive in the ER. Using text mining of patient comments as well as quantitative analysis of some key issues that surfaced from patient comments (Khuntia, Tanniru & Weiner, 2017, Varanasi & Tanniru, 2015), it was discovered that positive and negative experiences of nursing care, communication of information, and ER infrastruc-

Figure 3. Patient and Provider Touchpoints



ture influence overall satisfaction. Also, nurse interaction with patients and the overall flow in the ER, as perceived by patients, is more influential than how much time an ER doctor spends with a patient.

This means that hospitals need to consider a combination of patient experience at each touchpoint in the ER as well as provider metrics in optimizing patient flows. In other words, as shown in the Figure 3 below, a hospital's desire to optimize provider metrics must balance this need with the need to inform patients on what is occurring at each of these touchpoints and engage them in a way to improve their experience positively.

Patient goals here may include responding to their need to be treated well, shown empathy, learn about the reasons for discharge as outpatients if such is the case, and how best to use the actors/resources available within their ecosystem to sustain care upon discharge (Chang & Chang; Trzeciak et al., 2016). Educating patients about the flow of activities planned while they are in ER can be very helpful, given the stress they are under when they come to ER. Improved communications here can include letting patients know about:

- What to expect and the estimated time of various activities. Prior analysis has shown when resources are available on what days and times. Information is also available about when physician decisions are under review for consultation or clarification. This can provide estimates to inform patients.
- When there are delays, digital services can be deployed to reduce stress and support patient engagement. Examples include bringing patient ecosystem actors to support patient wait time, using digital media to educate and entertain, and creating opportunities to reduce stress or support healing.

In summary, the time spent in the ER is stressful for patients and optimizing care within the ER must go beyond patient flow management through resource optimization to engaging patients and actors/resources of the patient ecosystem to improve patient satisfaction. Next we will look at patient care within the patient rooms.

PATIENT ROOM (PR) USE CASE

Patient rooms have always been the center of focus for service innovations in hospitals to reduce costs and improve patient satisfaction, and distinct technologies have been used to address these challenges. Figure 4 illustrates a hospital in SE Michigan that has systematically analyzed its patient service needs and hospital performance metrics to identify several technologies that can simultaneously address these needs (Khuntia, Tanniru & Weiner, 2015). The optimization of patient room services by leveraging technologies (integrating nursing staff resources with technology resources), from the provider viewpoint, include:

1. PillowTalk with three different buttons for tailored patient support: bathroom, pain, and general info (HillRom)
2. Reduce complications due to food consumption of diabetic patients by providing either a pill or insulin (WallUnit supports glycemic control by allowing catering staff to communicate with nursing staff)
3. Reduce patient falls for fall-risk patients (HillRom SmartBed)
4. Inform and educate patients based on diagnosis and introduce staff as they walk in (GetWell Network connected to EMR patient diagnosis information and staff name tags for identification)
5. Wearables to track patient conditions at the nursing station for detecting abnormalities (Visensia and Sotera)
6. Reduce hospital acquired infections using GelDispenser connected to staff badge and RFID reader (HillRom)
7. Communicate with and coordinate patient services by nurse (Volte phone capable of voice and text messaging, as well as an escalation protocol to inform others if the nurse is busy)

Using the discussion earlier, we mapped the provider centric goals with patient and other staff touchpoints in order to assess how service exchanges between the provider and the patient inside the patient room could be optimized together. See Figure 5, and each of these are discussed below. As a part of this discussion, we will first talk about how the hospital has tried to optimize its resource mix of people, processes, and technology to address the provider metrics. Then, we will point out how considering the patient and staff metrics added to the provider metrics could have altered the overall strategy of the hospital.

PillowTak (Technology 1): The tailored support by allocating nurses for pain related calls, staff assistants for bathroom related support, and nursing staff available with escalation to support general calls was designed to improve responsiveness to patient calls. When the responsiveness did not meet expectations, response data was analyzed to see why the responsiveness varied among floors. This led to the discovery that nurses' view of urgency varied based on patient condition and the type of treatment they went through (surgical or cardiac vis-à-vis others), and they responded to at-risk patients faster (Khuntia et al., 2016). Using velocity and uncertainty dimensions, our analysis led to the conclusion that those patients whose conditions post operation is either unpredictable (high uncertainty) or can

Figure 4. Intelligence Care System Technologies and Services

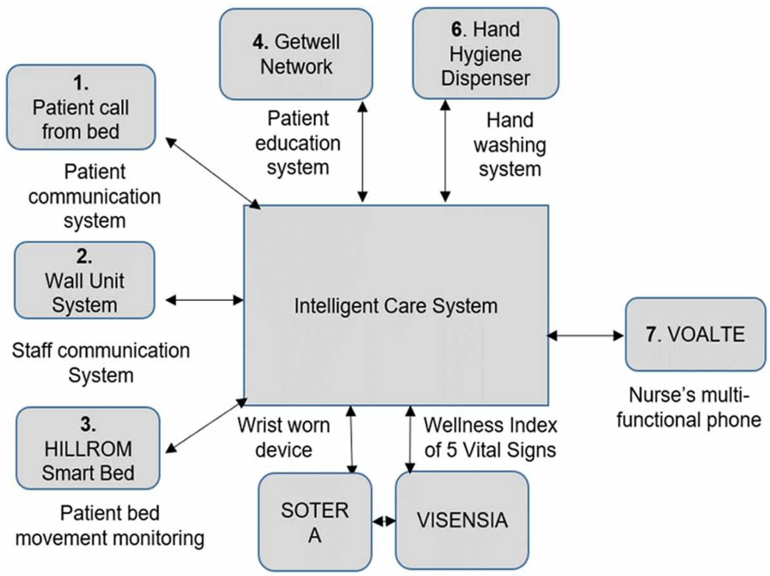
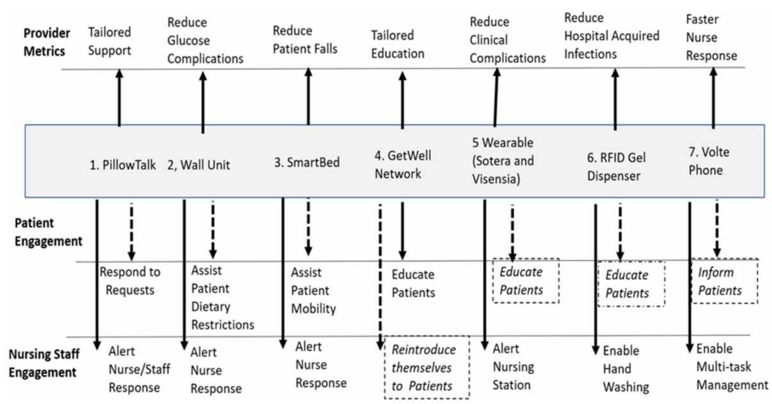


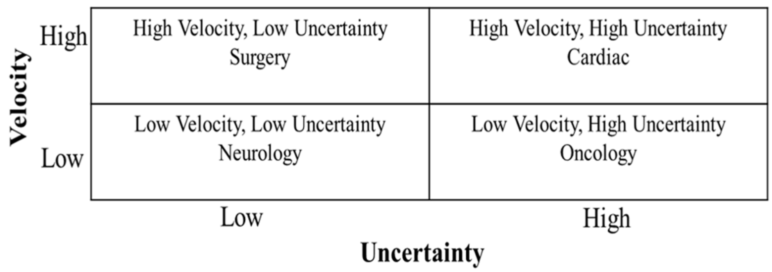
Figure 5. Patient touchpoints in Patient Room



change rapidly (high velocity) may elicit a faster response from nurses when patients call compared to the other conditions (Figure 6). The hospital felt that all patients should be treated the same way and decided to let the escalation protocols redirect calls to the next nurse available if the attending nurse is busy with other patients.

Incorporating patient engagement here could have led to informing and educating patients using an audio response that indicates to patients that the attending nurse is spending time on an urgent need and the call is being escalated to others, potentially with an estimated time when someone will arrive. This can possibly reduce patient anxiety that no one is responding and prevent the patient from repeating calls.

Figure 6. Patient characteristics influencing nurse response



WallUnit (Technology 2): One of the goals of this unit is to allow catering staff to call the nurse to administer insulin or provide a pill (if there is enough time) when they come to the patient room to deliver food, if the patient is a diabetic. Of course, other support services here include asking patients to select foods that are suitable for diabetics or providing the nurse an option (pill or insulin) so that s/he can come and provide the pill before the patient orders food.

Incorporating patient engagement here can include helping patients order the right food for their condition (with specific caloric content or color coded for those with diabetic condition), alerting them to the need for insulin if they fail to get the pill in time, or alerting the nurse as patients order food so the nurse does not have to remember this. Patient's active engagement here can also help them post-discharge by empowering them to make right food choices or take preventive actions prior to consuming food in order to minimize future complications.

SmartBeds (Technology 3): Smart bed use has not led to a reduction in patient falls as the hospital had hoped. The issues here relate to lack of adaptability of technology, such as not automatically adjusting the bed to an "active" condition after a nurse enters the patient room to attend to the patient and leaves the room (currently it becomes "inactive" after a nurse comes to the room). Newer versions of the product had this feature, but replacing beds with such features has become prohibitively expensive. Also, since the alert went to all the staff on the floor with a flashing light outside the room, it became an annoyance early on. The hospital recognized the challenges and tried to use other types of interventions, such as planned visits to patient rooms and changing of fall risk scoring using nurse engagement. One floor was used to test the impact of this intervention, and it has shown improvement. However, implementing this across the hospital was considered not feasible due to costs. It is continuing to use a mix of methods to address fall risks, but the smart bed technology is not being used at this time with alerts and flashing lights.

Incorporating patient engagement here could have made some difference. For example, patients could have been told how the technology works, allowing patients to remind nurses to reset the bed to "active" status before they left the room. Also, since patients often move from the bed to walk or sit in a chair (which may not be as urgent as visiting a bathroom), they could be educated to use the PillowTalk button that seeks general service. This could get a staff assistant to come and help them, as opposed to putting stress on the nursing staff.

Getwell Technology (Technology 4): The technology has been successfully used to educate patients on diagnosis related information. It has been used to introduce staff as they enter the room, and a pilot survey of patients at the end of the day on some areas of concern was tested, given that patient surveys that were sent post discharge were not specific to care given to the patient while they were still in the hospital. However, this type of patient feedback tracking was later moved to a different intervention (multi-disciplinary rounding discussed later in this section) to make it more personal. Also, the wider use of GetWell was put on hold due to the hospital moving its EMR from Cerner to EPIC systems, and potential internal products that may be available for more comprehensive education.

Incorporating patient engagement here could have included patients entering questions as they surface into the GetWell network using text or audio format and having them displayed when a nurse enters the room or having them answered by a remotely monitoring staff member. This could have made the network a device that supported two-way communication—education from provider to patient and consultation to the patient from the provider.

Wearables (Technology 5): Use of wearables to detect deteriorating patient conditions has shown promise, but its use for clinical reasons has been on one floor only. The Visensia data is important in tracking multiple vital signs and alerting those manning the nursing station to order "stat" (i.e. call those who need to attend to patient condition before it gets worse). However, nursing staff who visit the patient rooms and follow some of the vital signs are used to detecting anomalies and felt that wearable data is too complex to understand and use. It is used by one floor where staff are well trained to read and recognize the combined indicators.

Incorporating patient engagement here could have served dual purposes. The role of staff washing hands in and out of room could be used as a teachable moment to educate patients on the value of cleaning hands to reduce infections when patients visit various public facilities when they travel or are doing different chores within their home. Of course, patients could also alert staff to wash their hands if they forget as they rush to attend to patients in an emergency.

HAI technology (Technology 6): Staff use of gel to reduce hospital acquired infections did not initially lead to anticipated reductions, but adjustments were made to the technology and processes. Some of these adjustments involved making allowances on rewashing hands if the nurse is in the room for a short time without any patient-related service and creating peer ranking of staff on different floors based on their wash-in and wash-out rate to generate competition. Also, the gel mixture has been changed to reduce dryness of the hands. The metric was used not to penalize the nursing staff but to educate them on how it reduces the cost to the hospital and on the unnecessary extension of patient length of stay in the hospital (which is undesirable for the nurses as well).

Incorporating patient engagement here could have provided another teachable moment. While this is not directly related to other wearables that patients may be using at home (e.g. FitBit, glucose monitors, etc.), the hospital could have used the role of the different vital signs, such as high blood pressure, temperature, oxygen levels, etc., to educate patients about the symptoms when they are on a daily routine and alert them to take actions. The hospital later gave a similar technology to some critical patients as they were discharged to home to track their condition remotely and provided them with an iPad to track their weight and engage in tele-health consultation (Tanniru, 2019).

Volte (Technology 7): Initially, the goal of providing staff with a smart phone was to help them respond to multiple requests from a patient room and respond quickly, potentially improving patient satisfaction. Despite using many of these technology-based alerts, patient satisfaction has not improved significantly, and this led the hospital to undertake several changes in its processes. These included:

- Using multi-professional rounding to visit patients periodically to answer questions, with several people of different disciplines that might be able to provide such answers;
- Reducing the number of people in these rounds to minimize patient intimidation, as that was found to be a concern from some patient feedback;
- Using critical incident reports to address identified patient needs quickly, rather than waiting for the surveys to reveal their concerns (e.g. providing warm food as opposed to cold, which could be easily fixed)
- Using a care plan book to inform and educate patients, as the hospital found that providing patients with a book with detailed information about their care plans can be effective in reducing their uncertainty (Fowler et al., 2018). This allowed patients to record and ask questions and to identify the actions they need to engage in once they are discharged, including making their first follow-up appointment, which is one of the key goals of patient engagement.

Patient engagement here can include having patients participate in post-discharge care activities while they are still in the hospital, with staff support. Not only does it help patients learn how to use others in support of activities, but it also can help hospitals learn about actors who patients use to support these activities. For example, by having patients set up follow-up appointments to visit labs or pharmacies, they may discover that some patients do not have transportation or childcare support and this can lead to developing alternative options.

CONCLUSION

Service modeling and use of advanced technology has enabled businesses to gain insight into customer decision making in order to create value prior to their purchasing a product and following customers during product-in-use to sustain the value created. However, unlike businesses, hospitals have a unique opportunity to gain insight into the patient ecosystem and factors that can potentially influence patient behavior and actions post-discharge (value in use) while providers are creating value, i.e. giving clinical care while patients are in the hospital. This should make sustaining value (i.e. strategies used to improve patient adherence) more effective. The chapter summarizes two use cases (emergency room and patient room) to elaborate on how hospitals can use various patient touchpoints in these cases to learn more about actors and resources needed to enhance patient capacity to sustain care post-discharge. Such an understanding of patient capacity can guide hospitals develop strategies to not only inform and educate patients while they are in the hospital but also use the actors-resources of the patient ecosystem to assistant in patient adherence to care plans post-discharge.

REFERENCES

Caritas Project. (n.d.). Retrieved from http://www.thecaritasproject.info/aplacetoflourish/awardWinner_2014.html

Chang, W.-J., & Chang, Y.-H. (2013, September). Patient satisfaction analysis: Identifying key drivers and enhancing service quality of dental care. *Journal of Dental Sciences*, *8*(3), 239–247. doi:10.1016/j.jds.2012.10.006

Doremus, B. L. (1976). The Four R's: Social Diagnosis in Health Care. *Health & Social Work*, *1*(4), 120–139. doi:10.1093/hsw/1.4.120 PMID:992495

Dreyer, T. (2014, May). 2014, Care transitions: Best practices and evidence-based programs. *Home Healthcare Nurse*, *32*(5), 309–316. doi:10.1097/NHH.0000000000000069 PMID:24802602

Fowler, B. L. J., Johns, J., Tanniru, M. R., Ballijepally, V., Roumani, Y. F., Bobryk, D., & Mitchell, K. (2018). Engaging patients through Multi-Disciplinary Rounding – The case study at a Michigan hospital. *Journal of Hospital Administration*, *7*(5), 17–26. doi:10.5430/jha.v7n5p17

Herzig, J. L., Schnipper, J. L., Doctoroff, L., Kim, C. S., Flanders, S. A., Robinson, E. J., ... Auerbach, A. D. (2016). Physician Perspectives on Factors Contributing to Readmissions and Potential Prevention Strategies: A Multicenter Survey Shoshana. *Journal of General Internal Medicine*, *31*(11), 1287–1293. doi:10.100711606-016-3764-5 PMID:27282857

Khuntia, J., Tanniru, M., Fragoli, F., & Nawrocki, M. (2016). Mindfulness Differences in Hospital Unit Operations: Analysis of Response to Nurse Call Systems. *Pacific Asia Journal of the Association for Information Systems*, *8*(1), 33–64. doi:10.17705/1pais.08102

Khuntia, J., Tanniru, M., & Weiner, J. (2015). Juggling Digitization and Technostress: The Case of Alert Fatigues due to Intelligent Care System Implementation at a Hospital. *Health Policy and Technology*, *4*, 364–377. doi:10.1016/j.hlpt.2015.08.005

Khuntia, J., Tanniru, M., & Weiner, J. (2017). Dimensions of Patient Experience and Overall Satisfaction in Emergency Units. *Journal of Patient Satisfaction, SAGE Publications*, *4*(3), 95–100.

Koh, K. W., Wang, W., Richards, A. M., Chan, M. Y., & Cheng, K. F. (2016). Effectiveness of advanced practice nurse-led telehealth on readmissions and health-related outcomes among patients with post-acute myocardial infarction: ALTRA Study Protocol. *Journal of Advanced Nursing*, *72*(6), 1357–1367. doi:10.1111/jan.12933 PMID:26915719

Lusch, R. F., & Nambisan, S. (2015). Service Innovation: A Service-Dominant Logic Perspective. *Management Information Systems Quarterly*, *39*(1), 155–175. doi:10.25300/MISQ/2015/39.1.07

Medicare Hospital Readmissions Reduction Program. (2013, Nov. 12). *Health Affairs*. Retrieved from http://www.healthaffairs.org/healthpolicybriefs/brief.php?brief_id=102

Tanniru, M. (2019). Engagement Leading to Empowerment—Digital Innovation Strategies for Patient Care Continuity. *Journal of Hospital Management and Health Policy.* (forthcoming)

Trzeciak, S., Gaughan, J. P., Bosire, J., & Mazzarelli, A. J. (2016). Association Between Medicare Summary Star Ratings for Patient Experience and Clinical Outcomes in US Hospitals. *Journal of Patient Experience*, *3*(1), 2374373516636681. doi:10.1177/2374373516636681 PMID:28725825

Varanasi, O. M. T. (2015). Seeking Intelligence from Patient Experience using Text Mining - Analysis of Emergency Department Data. *Journal of Systems Management*, *32*, 1–9.

Vargo, S. L., & Lusch, R. F. (2008). Service-Dominant Logic: Continuing the Evolution. *Journal of the Academy of Marketing Science*, *36*(1), 1–10. doi:10.100711747-007-0069-6

Vargo, S. L., Wieland, H., & Akaka, M. A. (2016). Innovation in Service Ecosystems. *J. Serviceol*, *1*, 1–5.

Chapter 8
Minority Health and Wellness:
A Digital Health Opportunity

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ABSTRACT

With the advancement of the technologies of the internet of things (IoT), we are witnessing great advances in the areas of analytics, sensors, platforms, 3D printing, and mobile. At the same time and unrelated, we are also witnessing a growing increase in the decreasing health and wellness of people in minority communities especially with regard to increase in chronic conditions such as diabetes and obesity. Thus, there exists an opportunity to leverage these IoT technologies to try to support better minority health and wellness. This chapter explores this opportunity.

BACKGROUND

As the worldwide population continues to diversify, the prevalence of health disparity is expected to increase with the health inequalities deemed to become harder to diagnose especially amongst the marginalized communities. Gibbons (2011) argues that the number of people in America who are the members of the minority populations will increase by 10% by the year 2050 making it difficult to consider health disparities. However, recent digital technology in healthcare system indicates that the usage of tools such as mobile, sensors, and video conferencing technologies will be of great help in delivering health services to minority communities if adopted appropriately. This paper therefore seeks to present and discuss some of the major technological solutions that the healthcare system has implemented to address health issues and wellness for the underserved groups.

The developments in Information Technology that have been revolutionizing the present-day society have incredible potential to advance healthcare system in areas such as medical care, public health, consumer health, biomedical research, and clinical professional education. Indeed, IT is seen to have

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a central role in the remodeling of the healthcare system if considerable advancements in medical care quality for all people is to be attained (Gibbons, 2011). However, interest is growing in comprehending the latent role of digital health technology in solving healthcare inequalities amid racial and cultural minority communities.

HEALTHCARE DISPARITIES IN SOUTH CHICAGO

Despite the current improvements in medical care and disease interventions, health inequalities persist and may be escalating for chronic illnesses such as diabetes, cardiovascular ailment, obesity, and cancer. In southern Chicago, this health disparity exist among particular population groups and it can be measured by variance in disease incidence, burden of illness, adverse health situation, mortality, and disease occurrence. Current interventions activities to reduce health disparities in in this region have been disease-specific, often targeting individuals and the healthcare system determinants without addressing the social factors. This paper, therefore, seeks to present and discuss healthcare disparities in South Chicago and the various interventions taken to solve the issue. It will also seek to discuss specifics about diabetes and obesity conditions in South Chicago.

Though the term disparity is commonly interpreted to reveal gaps between racial and ethnic groups, it can also exist across many other extents such as age, geographic condition, socioeconomic status, gender, and disability condition. Healthy people (2020) indicates that all of these aspects help to shape a person's capability to attain optimal health. Additionally, the conditions at which people live, play, work, and learn can affect health and cause disparities. Social factors that negatively affect health and welfare of people in South Chicago include poor and unhealthy housing, lack of access to education, unemployment, unfavorable working conditions, poverty, and exposure to neighborhood violence (Thornton et al., 2016). For example, a study carried out by Sinai Community Health Survey (2017) show that the Chicago Lawn community has few resources to inspire physical activity as well as healthy eating. Compared to other southern Chicago communities, the neighborhood has fewer grocery stores to buy fresh foodstuff or places for physical activities. More than 40% of houses in Southern communities in Chicago have been recorded to be food insecure in the past years, compared to about 13% of households nationally (Tung et al., 2018). Chicago south side, therefore, faces numerous challenges including a significant shortage of broad range outlets, crime, and safety problems. Assessing these social determinants is really important, and unfortunately, ignored when talking about traditional health measures. According to Shah & Silva (2006), social and behavioral aspects have a larger impact on health as compared to traditional health measures such as clinical care. Exposure to these disadvantages can have detrimental neurodevelopment as well as biological effects that start at childhood and accumulates to produce illness. Therefore, the solution to these disparities must be multifaceted. Improving the patient's know-how and growing their drive to make healthy lifestyle changes will have little or no effect if limited access to healthy foods and physical activities is not addressed.

In South Chicago, particularly in the Lawndale community, more than 40% of male and approximately 50% of women gender are reported to have poor general health. Nationally, this figure represents nearly 12%. These study findings are among the many health inequalities detailed by a research carried out by the Sinai Community Health Survey. The study evaluated more than 1900 houses within nine South Chicago neighborhoods (Sinai Community Health Survey, 2017). According to the research, the data points out a complex depiction of health and wellbeing in numerous Chicago communities, difference in terms of race, ethnicity, and income. People in the southern side of Chicago lack the same opportunities to improve their health conditions. Thus, they are not able to access early treatment and this delays the progression of the illness. Certainly, there is no healthcare system to adequately take care of the 1.1 million residents of the South Chicago populations (Thometz, 2017). Thus, too many patients lack access to healthcare until a small illness becomes critical ones which are costly to treat.

According to Thometz (2017), many residents in South Chicago as per the study claims that they forgo medical treatment, eyeglasses, surgery, or prescriptions due to costs regardless of the increased access to healthcare brought about by Affordable Care Act as well as the State Medicaid care expansion. For instance, in Gage Park community, one out of six adults failed to receive needed treatment or surgery in the past years due to the high-cost (Shah & Silva, 2006). For now, about one in four adults in the cities of South Chicago such as Lawndale and West Englewood also failed to take the prescribed treatment in the past years due to the high expenses of medications. Chicago is therefore taken to be one big statistical region whose disparities are notable.

Up to now, few interventions have taken a multifaceted method of improving results among South Chicago patients. Traditionally, healthcare interventions have neither taken a key interest in community-based programs nor have quality development efforts included a focus on minimizing health inequalities. As a result, this has probably reduced the advantages of prior efforts to minimize health disparities among racial and ethnic minorities (Peek et al., 2012).

Nevertheless, the current trends in South Chicago's healthcare policy and process are inspiring greater relations and teamwork among healthcare providers and populations. Notably, Chicago south side has many community strengths including community-based firms, whose abilities can be harnessed in dealing with diseases' outcomes. As certified by the affordable care Act of 2010, there has been the creation of accountable care organizations which have inspired collaboration (Peek et al., 2012). These organizations are likely to have financial aids to take responsibility for wide healthcare results and costs for a specific population. Hence, accountable care organizations are possibly driven to prioritize evidence-based measures of prevention that develop community resources and establish a continuum of healthcare from a social setting to healthcare systems.

The community-based organization program has worked to solve the inequality issue in south Chicago as it has been able to employ a multidimensional, integrated method to address a number of root causes of these health disparities. Presently, this intervention program is in its third year and it comprises of efforts to attain system-level quality improvement within six hospitals in south Chicago (Peek et al., 2012). This work is expected to continue in informing the plan and development of accountable healthcare methods with the aim of improving health and minimizing disparities.

Diabetes

According to a new report released by the Chicago Public Health Department, diabetes prevalence is on the rise in South Chicago. Altgeld Gardens community and Hegewisch have recorded the highest increase. In the year 2000 only 20 hospitalized diabetes cases were registered, however, the number rose to 139 cases by 2011. Other neighborhoods have also recorded the same increment (Hunt et al., 2014).

Peek et al. (2012), asserts that genetics plays a major role in diabetes with Southern Chicago populations at higher risks than other communities. With an increase in consumption of inexpensive, unhealthy foods in the food supply, most people are being diagnosed with diabetics. The incidence of type 2 diabetes is growing nationally, with lifestyle and behavioral aspects supporting obesity cited as the major culprit. Obesity disorder is the major driving force behind Type 2 diabetes endemic. The southern side of Chicago has a very high occurrence of diabetes (Hunt et al, 2014). It has a 19.3% estimated incidence than a national incidence of 10.7% and a mean occurrence in Chicago of about 7%. Generally, in South Chicago, those neighborhoods that are majorly African American records a 5x degree of Leg amputation as compared to white neighborhoods. However, there is also other racial and ethnic inequalities in diabetes treatment, such as the percentage of African Americans and Latinos populations receiving eye care and influenza vaccinations compared to the whites (Kanaya et al., 2014).

The healthcare system in southern Side of Chicago has come up with intervention programs to attain system-level quality progression within six health facilities, four of which are governmentally owned and two of which are academically related. These intervention system level programs are culturally designed for patient education, community partnerships that assist in self-care programs at home, and professional communication training to providers. However, the healthcare system is tracking transitional health outcomes such as the control of cholesterol, glucose as well as blood pressure (Kanaya et al., 2014). These are connected to diabetes complications including leg amputations, heart attacks, cardiovascular disorders, and renal failure. Therefore, the main work of the healthcare institutions is to inform planning and improvement of accountable care organizations, and other institutions that focus on integrating healthcare and community methods with the aim of improving health and minimizing disparities.

Collaboration in improving quality of care is one of the fundamental interventions in diabetes. Such collaborative activities, which usually bring together professionals from varying healthcare places to learn better care approaches and share best practices, have proven to be effective in improving diabetes care in safety-net health centers (Peek et al., 2012).

Patient activation intervention is designed for low-income population or the minorities. It helps to address the problem of patients' distrust of the healthcare organization or patients' supposed discrimination within the healthcare structure (Peek et al., 2012). Moreover, although shared decision making is enhanced where patients are equal partners with their doctors in consultations and assessments about treatment, is linked to positive diabetes outcomes. Evidently, African Americans from South Chicago are less likely to be involved in the shared decision-making process than their non-Hispanic white counterparts (Peek et al., 2012). Therefore, the patient activation intervention is developed in collaboration with culturally designed education with skills training in shared management of diabetes.

Training for providers' intervention by South Chicago healthcare is a physician training that complements the patient's education effort. This training helps physicians to develop expertise in cultural competency, effective communication, assisting patients to change their behavior, and collective decision making (Peek et al., 2012). Following the improved capability to use the techniques, clinicians are able to improve their communication and medical outcomes.

Community partnership is the fourth major intervention that focuses on engaging diabetes patients within community settings. Recently, the outreach activities used in this intervention program has enhanced the south Chicago healthcare system to identify more than 4000 populace with diabetes who lacked a regular source of clinical treatment and to link them to medical households (Peek et al., 2012). However, the long term goal to minimize the threat for diabetes is to control obesity, eat healthily, and increase physical activities. Therefore, these community-based organizations are partnering with some local farmers who offer fresh food produce. As a result, a pilot program majoring on food prescription has been established. This program grants diabetes patients access to affordable, discounted free healthy foods, such as fresh food produce. Also, in the collaborative efforts, the healthcare system partners with other high-use organizations which offers popular monthly food store (Peek et al., 2012). Clinicians and nutritionists offer healthy cooking demonstrations to patients in South Chicago using the donated healthy foods, conduct screening for cardiovascular and diabetes, distribute health information, and makes referrals to support and medical homes. This intervention has proven to be effective as it has reached more than 600 patients in the South Chicago community thus far (Peek et al., 2012). Other intervention measures to increase patient communication, as well as outreach activities, include digital communication, such as, use of text messages in phones to communicate with patients. This helps to send automated, patient-based diabetes treatment reminders. Peek et al. (2012), argues that about 94% of the patient's population have reported being highly satisfied with the technology, their self-care confidence and expertise has improved over some short period of time. Nevertheless, it is crucially important to stress that when people have diabetes, they should take advantage of healthcare interventions to treat the illness.

Obesity

Childhood obesity is without a doubt becoming an alarming issue in South Chicago. The prevalence percentage of obesity for children between the ages of 2 to 11years in the minority communities is twice or thrice higher than that of the U.S as a whole; 16.8%. This means that half of the children population in this region are obese (Gopalan et al., 2016). Shockingly, such elevated percentages of pediatric obesity have never been recorded. The shift in obesity levels suggests that children's' obesity epidemic in South Chicago has escalated beyond the state epidemic.

Gopalan et al. (2016) argue that the obesity condition is primarily associated with chronic illnesses and incapacitating conditions. It is also believed to affect racial and ethnic minorities unreasonably. Thus, it has major effects on the quality of life and the welfare of these minority population groups as well as their families. Statistically, the Hispanic children and teenagers between the ages of 2 to 19 years have the highest occurrence of obesity in America with about 21.9%.

When comparing South Chicago with other large cities such as New York, where the prevalence of obesity is low, Tung et al. (2018) note that the condensed geography of South Chicago is so much isolated, and segregated. Thus people have no access to grocery shops, health centers, and green spaces. In addition to that, the sprawling South Chicago is faced with the issue of poorer neighborhoods that have few safe parks (Tung et al., 2018). There are numerous cases of insecurity and breed crime hence causing concern due to safety issues. As a result, children are inhibited from physical exercises, playing, outdoor activities and walking. As a result, children become sedentary in their houses.

According to Lord (2013), the healthcare system has been taking the initiative to create healthier places over the last decade. In collaboration with the CLOCC, the city is fostering on implementing sustainable systems, policies, and environmental changes that solve obese issues in South Chicago by establishing healthier environments where Chicagoans from the South live, play, learn, and work peacefully (Gopalan et al., 2016).

Moreover, the healthcare system in South Chicago is increasing access to healthy foods through the various vending machines option across the city parks. Mobile food carts have also been introduced to bring in affordable fresh fruits and vegetables to low-income households (Lord, 2013). The city has also emphasized the need for physical activity by tailoring street and sidewalk access for cycles, walking paths for pedestrians, and safe access to city parks.

In light of the above discussion, it is evident that racial and ethnic minorities such as African Americans in South Chicago experience high rate of disparities in the health care system and also in their health outcomes as compared to their white counterparts. This inequalities in healthcare is a critical issue with multiple causes. Apart from racial or ethnic aspects, social, and behavioral factors are some of the other major causes of healthcare disparities in the Southern side of Chicago. As a result, the prevalence for most of the chronic illnesses is high than other white Americans region in the US. However, due to the high cost of treatment for these illnesses and the gaps in the healthcare system, most people have had to endure the burden of diseases, delayed care, and ultimately causing high mortality. Though the healthcare system and the United States have established the Medicaid expansion, and Affordable Care Act to cater for the cost of care for some of these chronic diseases, it is evident that most people in South Chicago forego treatment due to the high costs. However, by creating integrated systems that solve these multiple causes, there is a greater likelihood that these minority groups in the South side of Chicago will start experiencing progress in minimizing disparities. The healthcare approach to reducing disparities among Chicago's population, therefore, combines the power of communities, the health systems, and patients, thus showing evidence of efficiency.

Mobile Technology

Compelled by the Affordable Care Act emphasis on patient satisfaction, quality care, value, advanced outcomes, and disease prevention, technology is revolutionizing the healthcare delivery and social care across the world, but mostly in the United States. According to McLymont (2018), digital health, the novel trend in healthcare system makes use of information and communication tools, including mobile phones also referred to as MHealth, and Videoconferencing commonly known as TeleHealth. These technological advancements are increasingly being used in healthcare to deliver low-cost, faster, and more effective care services (McLymont, 2018). It enables patients to access care at any given time using either a web browser, their devices, smartphones, a mobile clinic or a tablet.

According to Oldenburg et al., (2015), the use of mobile phones has increasingly become a part of the day to day life for most people across the world with wireless consumers sending and receiving a mean of 6billion text in a day. This technology has been widely adopted with about 90% subscriptions globally and has also achieved an 80% subscription rate in the rural areas. With the technology serving as a two-way interactive communication device, mobile health can offer chances for scientists and program developers to get the most out of the existing cultural behaviors of their target study populaces. This is enhanced by their high rate of access to and utilization of the mobile technology. According to Anderson-Lewis et al. (2018), the prevalent use of the technology and almost global coverage by a network signal has offered MHealth a huge opportunity to advance worldwide health. For this reason, MHealth interventions have increasingly turned out to be common in low-income and developing states. In regions where financial resources, as well as healthcare employees are insufficient, and high illness prevalence take place, short messages services could greatly make the capability to attain the healthcare more affordable, and accessible (Anderson-Lewis et al., 2018).

For those within the lower socioeconomic status, the MHealth technology is the most cost-effective manner to access health information. Additionally, mobile tools have the perspective to upgrade the management of chronic illness and smoking termination while at the same time advancing communications between patients and the caregivers. According to the findings from the Institute of Medicine, health information tools offers a chance for engaging people not generally well taken care of by the traditional healthcare system (Oldenburg et al., 2015). The influence of promoting patient and population involvement too, and control of their health data, has the capability to offer further awareness into, and chances to solve inequalities in minority populations.

With the high number of people owning smartphones in the US, health communication tools might be amazingly useful for those with some degree of English proficiency, persons living in isolated places, places from poor backgrounds and those with disabilities. The capacity to adapt MHealth interventions in an ethnically proficient way and apply program curriculum at the literacy extent of the target populace makes MHealth acceptable, and also ideal (Oldenburg et al., 2015). The flexibility of this high-tech platform enables populaces to experience the ultimate health disparities to attain advanced access to healthcare, as well as health resources. Currently, the MHealth programs are being applied in health-care interventions to these minority groups which are presently being highly prioritized (Oldenburg et al., 2015). The MHealth capacities include the instant messaging, internet access, social media, video streaming, and text messaging.

The use of mobile devices for internet access enables a higher possibility for MHealth involvements and programs being implemented among minority groups. Anderson-Lewis et al. (2018) claim that about 88% of US residents use the internet consistently, while 73% use the high-speed broadband internet services in their houses. Among those Americans, the minority groups such as the Hispanics and the African Americans have the lowest rate of high-speed internet access at their homes as compared to their white counterparts. Nonetheless, it can still be noted that the rate of internet access has increased across all groups. Increase in minority internet utilization has also been realized due to the ease of access to internet services. This realization has bridged the digital gap between the upper and lower social classes. Actually, some innovative uses of mobile technologies have been effectively developed among low-income pregnant mothers, homeless, Spanish-speaking immigrants, and youths who are at risk. According to Lewis et al. (2018), one of the most outstanding interventions in America is the Text4Baby program geared towards advancing maternal and child health results among lower socioeconomic, underserved, and minority women. The program uses culturally designed health messages and utilizes deep methods to investigate and identify the optimal approaches for the delivery of care and service provision among the minority populations. In addition, the program encompasses regular evaluation to make certain that the size, frequency, content of the communication sent to patients are suitable. The text4baby program also takes into consideration the degree of literacy of the population at the development stage. Therefore, just like Lewis et al. (2018) argues, mobile devices are being utilized to communicate locally-generated and relevant scientific and health data, to target rural societies whose populaces normally have low education and income levels, and would not then benefit from such information. As a result, this benefit could be of great importance as it can save lives in rural societies. This, therefore, heightens the need for having MHealth interventions to help these minority population subgroups.

According to Lewis et al. (2018), MHealth has been presented to boost the quality of healthcare by improving observance to therapeutic policy, and code of behavior as well as informing medical decisions and reducing medication mistakes. Particularly, there is now good evidence that the mobile technology can advance recognition, linkage to care, maintenance in care, and devotion to taking the Anti-Retro Viral Therapy (ARV) in HIV patients. Evidently, the text messages sent from these mobile devices helps to remind the patients of the ARV's and this has ultimately improved their adherence. For instance, this mobile technology has also been applied in British Colombia among populations with latent tuberculosis, and in Canada among minority populations with HIV. This technology has, in turn, helped to improve the underlying tuberculosis medication completion, and in offering aid to Aboriginal Canadian young populaces who are recorded to be the high-risk HIV/AIDS patients (Oldenburg et al., 2015). Moreover, in South Africa, the text messaging has also been utilized to advance the HIV healthcare service provision by advancing the communication between the clinical experts, and patients, and also acts as an appointment reminder.

ASSISTIVE TECHNOLOGY; TELECARE, AND TELEHEALTH

According to Doughty et al. (2007), telecare assists patients who require the assistance of health services, and also social care to continue living at home with their families. This form of care uses tools that are designed to display activities and ensures safety. They offer virtual home visitation, deliver information, activate reminders, and home security. It is aimed at helping patients to cope with their own long-term health conditions, such as chronic heart failure, and obstructive pulmonary illness while still at the comfort of their homes. Assertive technology is, therefore, a widespread idea covering any tool or system that enables a patient to undertake a task that they would then be not capable of doing (Doughty et al., 2007). These technologies help to increase easiness, and safety with which these tasks can be carried out by the respective patient. Some of these telecare tools may include fall detectors, large button mobile phones, enuresis sensors, key safes, well connected alarming systems, epilepsy sensors, and gas and flood sensors. On the other hand, telehealth may include, spirometers, blood oxygen, pressure monitors, and simple weighing devices that are connected to a central screening unit that can itself be concomitant to a hospital or surgery (Doughty et al., 2007).

Gibbons (2011) asserts that the telehealth technology continues to be viewed as the main solution to aid in solving rural healthcare access concerns. Through this technology, rural patients can be able to access medical professionals in a timely way while still at home or within their local facilities. Local healthcare clinicians can also use the subspecialists' knowhow offered through telehealth.

According to Gibbons (2011), telehealth technology has the capability to advance remote 24-hour care as well as self-care methods and in the end, minimize treatment costs by keeping patients out of the health centers and emergency room, and minimizing doctor office visitations. Evidently, chronic illness rates are increasing as well as mental health problems, such as depression, which are upsetting millions of minority groups in America. In a report by the Department Of Health and Human Services, the findings indicate that approximately 80 million US residents live in mental health centers which are scarce. Telehealth technology, in this case, may help to solve these situations (Doughty et al., 2007).

Sensory Technology

Gibbons (2011) claims that another way in which healthcare technology tools that link physicians with patients may influence healthcare inequality is by allowing improved monitoring of medical considerations amongst patients from minority groups. Since patients are often not able to manage and monitor their conditions, patient sensor technology can allow remote monitoring. Additionally, it can enhance the direct delivery of patient data such as the vital signs, musculoskeletal injuries, weight, and sugar levels to a machine or even to electronic health records. With this data, clinical personnel are able to facilitate improved management and supports disease control. As a result, lower complication rates are realized, narrowing of potential disparities, and delays in illness progression. The sensory or smart tools may also be used to promote relationships between patients, and caregivers by allowing patients to overcome hindrances to attaining regular communication, access to medical care or else maintaining physicians' relationships (Gibbons, 2011). By advancing provider-patient communication, and allowing more stable therapeutic relations, these technological tools may also aid in supporting better patient engagement in care, enable shared decision making, and improve patient-centeredness of medical care, all of which are acknowledged to be determinants of healthcare inequalities and are important for excellent healthcare (Gibbons, 2011).

Furthermore, through mobile technology, interventions for cervical cancer screening has been established. For instance, the Korean American female is recorded to have the highest mortality rates in relation to cervical cancer. According to Anderson-Lewis et al. (2018), mobile devices can be used to support cervical cancer screenings and evaluates the changes in know-how and behavior. Using the text messaging feature in mobile devices, health experts are able to deliver important information most especially during cancer text campaigns designed according to the needs of the target women groups. Women from minority groups thus receive personalized text messages in regards to cervical health, cancer, and the available screenings within their localities. Evidently, this has increased the apprehension of wide-ranging cervical cancer, Pap tests, health, and risk factors.

Serious Games

Szczepura (2005) argues that minority groups across the world are associated with poverty and low-esteem. They are thus more often stressed and this plays a role in their health disparities. These disparities affect their behavior that is negative for their health. They include drug and substance abuse, and physical inactivity thus leading to obesity and depression. These conducts and outcomes such as obesity are closely associated with illnesses such as cancer, diabetes, heart failure, and heart attacks. It is for this reason that serious games technology are highly recommended within the minority communities.

Thompson et al. (2010) assert that the high regard for video games amongst young people makes it a perfect medium for informative purposes. This trend has therefore led to an in-depth approach to the issue, emerging into a more detailed term, a serious game. A serious game is a game that is tailored for a fundamental role other than wholesome entertainment. Thus, the use of these tailored games to replace some of the repetitive tasks have proven to yield better results. In recent years, numerous serious games have been established to solve health issues and to offer health education. For instance, one of these serious games include the virtual reality games, as well as the augmented reality. These games provide great interactivity in a virtual world using audios, sensory stimulus at times, and visuals to augment patient engagement and latent therapeutic influence (Fleming et al., 2017).

According to Fleming et al., (2017) these games have the potential to influence mental health internet programs and therefore there is need extend the reach for online software database to those who might not be able to access them. This internet-based program helps to improve engagement by using both the games and the serious motivational changing aspects. Additionally, the program can impact health by using varied methods for change, such as the clinical processes and gaming features. It can be helpful to patients in training them on some of the procedures about their health habits. For example, a serious game can be used to teach a diabetic patient about healthy alimentary habits.

CONCLUSION

Minority health and wellness provides many opportunities to apply the plethora of digital health solutions to effect better access and quality care. As caregivers effectively adopt and use health technologies, it will be possible to enhance access to quality and affordable care among the minority groups in any community. It is likely that digital solutions will be an effective strategy to stem the growing healthcare challenges of diabetes and obesity. Moreover, these solutions can enable people with often lower levels of health literacy and socio-economic standing to get tailored quality care support and information to address their health and wellness needs. A critical success factor in this regard is the design, development and deployment of responsible digital soltuions.

REFERENCES

Anderson-Lewis, C., Darville, G., Mercado, R. E., Howell, S., & Di Maggio, S. (2018). mHealth Technology Use and Implications in Historically Underserved and Minority Populations in the United States: Systematic Literature Review. *JMIR mHealth and uHealth*, *6*(6), e128. doi:10.2196/mhealth.8383 PMID:29914860

Doughty, K., Monk, A., Bayliss, C., Brown, S., Dewsbury, L., Dunk, B., ... McAlister, L. (2008). Telecare, telehealth, and assistive technologies: Do we know what we're talking about? Housing. *Care and Support*, *11*(3), 36–41. doi:10.1108/14608790200800023

Fleming, T. M., Bavin, L., Stasiak, K., Hermansson-Webb, E., Merry, S. N., Cheek, C., ... Hetrick, S. (2017). Serious games and gamification for mental health: Current status and promising directions. *Frontiers in Psychiatry*, *7*, 215. doi:10.3389/fpsyt.2016.00215 PMID:28119636

Gibbons, M. C. (2011). Use of health information technology among racial and ethnic underserved communities. *Perspectives in Health Information Management, 8*.

Goldberg, S. (2018). *These are the health concerns facing Chicago youth*. Retrieved from: https://www.chicagobusiness.com/health-care/these-are-health-concerns-facing-chicago-youth

Gopalan, A., Makelarski, J. A., Garibay, L. B., Escamilla, V., Merchant, R. M., Wolfe, M. B. Sr, ... Lindau, S. T. (2016). Health-Specific Information and Communication Technology Use and Its Relationship to Obesity in High-Poverty, Urban Communities: Analysis of a Population-Based Biosocial Survey. *Journal of Medical Internet Research*, *18*(6), e182. doi:10.2196/jmir.5741 PMID:27352770

Hunt, B. R., Whitman, S., & Henry, C. A. (2014). *Age-adjusted diabetes mortality rates vary in local communities in a metropolitan area: racial and spatial disparities and correlates*. Diabetes Care.

Kanaya, A. M., Herrington, D., Vittinghoff, E., Ewing, S. K., Liu, K., Blaha, M. J., . . . Kandula, N. R. (2014). Understanding the high prevalence of diabetes in the US south Asians compared with four racial/ethnic groups: the MASALA and MESA studies. Diabetes Care, 132656.

Lord, M. (2013). *Living Too Large, A Look at the Chicago Childhood Obesity Epidemic*. Retrieved from: https://chicagohealthonline.com/living-too-large/

McLymont, R. (2018). *Digital Health: Revolutionizing Delivery Quality for African-Americans*. Retrieved from: https://tnj.com/digital-health-revolutionizing-delivery-quality-for-african-americans/

Oldenburg, B., Taylor, C. B., O'Neil, A., Cocker, F., & Cameron, L. D. (2015). Using new technologies to improve the prevention and management of chronic conditions in populations. *Annual Review of Public Health*, *36*(1), 483–505. doi:10.1146/annurev-publhealth-031914-122848 PMID:25581147

Peek, M. E., Wilkes, A. E., Roberson, T. S., Goddu, A. P., Nocon, R. S., Tang, H., ... Chin, M. H. (2012). Early lessons from an initiative on Chicago's South Side to reduce disparities in diabetes care and outcomes. *Health Affairs*, *31*(1), 177–186. doi:10.1377/hlthaff.2011.1058 PMID:22232108

Shah, A. M., Whitman, S., & Silva, A. (2006). Variations in the health conditions of 6 Chicago community areas: A case for local-level data. *American Journal of Public Health*, *96*(8), 1485–1491. doi:10.2105/AJPH.2004.052076 PMID:16809605

Sinai Community Health Survey. (2017). *Community Health Counts*. Retrieved from: https://news.wttw.com/sites/default/files/article/file-attachments/Community%20Health%20Counts_Sinai%20Community%20Health%20Survey%202017.pdf

Szczepura, A. (2005). Access to health care for ethnic minority populations. *Postgraduate Medical Journal*, *81*(953), 141–147. doi:10.1136/pgmj.2004.026237 PMID:15749788

Thometz, K. (2017). *Survey Reveals 'Alarming' Health Disparities in Chicago Neighborhoods*. Retrieved from: https://news.wttw.com/2017/03/23/survey-reveals-alarming-health-disparities-chicago-neighborhoods

Thompson, D., Baranowski, T., Buday, R., Baranowski, J., Thompson, V., Jago, R., & Griffith, M. J. (2010). Serious video games for health: How behavioral science guided the development of a serious video game. *Simulation & Gaming*, *41*(4), 587–606. doi:10.1177/1046878108328087 PMID:20711522

Thornton, R. L., Glover, C. M., Cené, C. W., Glik, D. C., Henderson, J. A., & Williams, D. R. (2016). Evaluating strategies for reducing health disparities by addressing the social determinants of health. *Health Affairs*, *35*(8), 1416–1423. doi:10.1377/hlthaff.2015.1357 PMID:27503966

Tung, E. L., Boyd, K., Lindau, S. T., & Peek, M. E. (2018). Neighborhood crime and access to health-enabling resources in Chicago. *Preventive Medicine Reports*, *9*, 153–156. doi:10.1016/j.pmedr.2018.01.017 PMID:29527469

Chapter 9
Intelligent Mental Health Analyzer by Biofeedback:
App and Analysis

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ABSTRACT

Many apps and analyzers based on machine learning have been designed to help and cure the stress issue. The chapter is based on an experimental research work that the authors performed at Research Labs and Scientific Spirituality Centers of Dev Sanskriti VishwaVidyalaya, Haridwar and Patanjali Research Foundations, Uttarakhand. In the research work, the correctness and accuracy have been studied and compared for two biofeedback devices named as electromyography (EMG) and galvanic skin response (GSR), which can operate in three modes—audio, visual, and audio-visual—with the help of data set of tension type headache (TTH) patients. The authors have realized by their research work that these days people have lot of stress in their lives, so they planned to make an effort for reducing the stress level of people by their technical knowledge of computer science. In the chapter, they have a website that contains a closed set of questionnaires from SF-36, which have some weight associated with each question.

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INTRODUCTION

As we can see that almost everyone is suffering from many kinds of stress and we all get some indicators which shows that we are suffering from stress rather it be physical, emotional, personal, sleep or behavioral. But manually the level of stress is difficult to calculate and also the people are much more reliable on medication for getting relief. Many times, the individual is lost in physical pleasure, accumulation of facilities and due to lack of right understanding about the self, one bears the ignorance about one's own being. Due to which they suffer from stress most of the time. These consist of pharmacological treatment, physical therapy, acupuncture, relaxation therapy or alternative medicine. So the main focus of our project is to check the stress level of a person and give remedies to them accordingly. We are more focused on giving remedies to people which do not include any kind of medications.[Singh, V. et al., 2018i] and [Saini, H. et al., 2018j]

Motivation

The experimental research work done by us has motivated us to use our knowledge and make an effort to reduce the stress level of people. Automation and mechanization is rapidly increasing with intelligent machines. Science has done miracles and almost in all walks of life, most works are being done by scientific gadgets and it has no doubt made human life simpler. It has helped to handle complex issues but contrary to this, there is a dark side of the picture that it has created some negative aspects and challenging situations too. The present crisis of science to human life is that the stress, tension, depression, anxiety, hatred, headache, frustration, suicidal tendencies and violence is increasing in our world day by day. The happiness index has been reduced rapidly everywhere. The Human personality is degraded in terms of value system.[Yadav, V. et al., 2018k] and [Yadav., V. et al., 2018j] and [Gupta, M. et al., 2019a]

Biofeedback

Biofeedback therapy is a non-drug therapy in which patients learn to control physical processes that are usually involuntary, such as muscle tone, high blood pressure, and heart rate.

Useful for various conditions such as chronic pain, urinary incontinence, high blood pressure, tension headaches, and migraine. Because the disease is non-invasive and does not include drug therapy, the risk of side effects is low.[Nordqvist, J. 2018].

Working of Biofeedback

Biofeedback therapy by interpreting factors such as brain electrical activity can help people change their unhealthy habits.

There are three common ways to treat biofeedback.

- Thermal biofeedback measures skin temperature.
- An electromyogram measures muscle tone.
- Neurofeedback or EEG biofeedback focuses on brain electrical activity.

Biofeedback therapy by interpreting factors such as brain electrical activity can help people change their unhealthy habits.

Uses of Biofeedback Therapy

- Migraine
- Hyperactivity
- Post-traumatic stress disorder
- Incontinence
- Child anxiety at the dentist
- Reynaud's disease

Mental Fitness and Health

There is evidence that exercise can increase mental health, but scientists don't know much about whether physical fitness can prevent mental health. General mental health issues such as depression and anxiety are global issues. They reduce overall well-being and life satisfaction, but may increase the risk of cardiovascular disease and increase the risk of death.

Biofeedback training, also called biofeedback training, helps manage many physical and mental health issues, including:

- Anxiety and stress
- asthma
- Side effects of chemotherapy
- Chronic pain

Biofeedback Appeals to People for a Variety of Reasons

- Non-invasive
- It may reduce or eliminate the need for drugs.
- This may be a cure for those who cannot tolerate medicine.
- There is also an option that the drug does not work well.

Global Annals of Social Mental Fitness Health

The Indian Psychiatric Association has a total of five areas under its wings. The western branch of the Indian Psychiatric Association has been around for nearly 50 years. From the first meeting held in the small Malorian town of Gujarat in 1970, the 50th annual meeting will be held in Thane in 2019. IPSWZB has members who are mental health professionals in three states: Maharashtra, Gujarat and Goa. The region conducts several scientific activities every year, including medium-term CME, annual conference, and PG CME. Throughout the year, we have implemented community outreach programs and won several awards at the national level.

The three state branches are divided into 13 branches, each producing mental health. There are several subcommittees in the region that review regional performance and goals. Each branch and sub-department sends an annual report to the regional branch about the various activities performed during the year.

IPS WZB recognizes the excellence of young researchers in this field by awarding national awards every year in the fields of psychiatry and mental health at annual meetings, and praises the lifelong success of senior experts.

Psychiatric India is the official journal of the Western West Branch. This site has its own interactive website and archive section that provides members with updates and new information in the hope of making mental health a business priority.[Medknow,S. 2019].

Mental Fitness Data in Indian Society

According to the annual Practo Digital Digital Health Care Map, 82% are psychologists, psychiatrists, psychologists in Tier 2 cities such as Indore, Kanpur, Nagpur, Jaipur, Visakhapatnam, Bhopal, Chandigarh and Lucknow. I met with a therapist., Coimbatore, Ahmadabad, Patna. People in these cities tended to seek management of depression, post-traumatic stress disorder (PTSD), marriage counseling, stress, addiction and anger.

In meetings with psychologists, psychiatrists and psychotherapists, meetings with major cities such as Delhi, Mumbai, Bangalore, Pune, Chennai, Kolkata and Hyderabad have increased by 24%.

According to a World Health Organization (WHO) report, 7.5% of the Indian population suffers some form of mental distress or disability.

OBJECTIVE OF RESEARCH

1. To study and compare the correctness and accuracy of Electromyography(EMG) and Galvanic Skin Response(GSR) biofeedback in three modes: audio, visual and audio-visual.
2. Our project is to check the stress level of a person and give remedies to them accordingly, by classifying them into one of three categories: low, medium and high stress level.
3. Comparing the efficiency of different algorithms used for classification.

SCOPE OF THE RESEARCH WORK

Measuring the effect of various indicators like physical, sleep, behavioral, personal and emotional parameters are indicators of stress on different levels of stress. The purpose is to reduce the use of medication to lower the level of stress. Measuring the accuracy of the range decided to track the level of stress of a person. A runnable system which checks the stress level of a person. The main objective is to develop a system which gives the remedies which do not involve any kind of medication to a person according to their stress level. [Singhal, P., et al., 2019b] and [Saini, H. et al., 2019c]

LITERATURE SURVEY

MoodKit a popular app based on IOS which uses the foundation of Cognitive Behavioral Therapy (CBT) and provides different mood improvement activities to different users which are more than 200 in number. Developed by two clinical psychologists, MoodKit helps one to change the thinking pattern and method, to develop self confidence, awareness, creativity, situation handling and problem solving and wise healthy attitude[Sharma, P. et al., 2018d].

Another very good mental health helping app is Mind Shift which has been developed to facilitate teenagers and adults to face the challenges of depression and frustration along with anxiety. The app Mind Shift focuses the sight of users about their thought process for.

Khanna A, Paul M, Sandhu JS. exhibited a detailed research work and in depth study to check accuracy and comparison of efficiency of GSR and EMG biofeedback training process and consequently progressive muscle relaxation process for decreasing the blood pressure and respiratory rate for those subjects who were suffering heavily from acute level of headache [Agarwal, A. et al., 2018g].

Biofeedback is getting popular now as an alternate therapy and informs the subject and experimenter both about the current status of headache. It also helps to avoid the excessive use of medications and antioxidants for muscle relaxation. It helps the subjects from shifting the dependency on costly medications and consecutive side effects[Yadav, V. et al., 2019b].

Chronic TTH was found as the most common problem in all subjects of every type of gender, age, rural-urban sector of any demographic regions. Since most of the problems are psychosomatic so psycho and psychosocial factors are in consideration to study it [Gulati, M. et al., 2018f].

According to Julia Anna Glombiewski Biofeedback (BFB) is an ongoing intervention for headache rehabilitation and other pain disorders. Little is known about this treatment option for fibromyalgia syndrome (FMS). The purpose of the author of this review is to integrate and critically evaluate the evidence for the biofeedback effect of FMS. Method.

The author conducted literature search using Pubmed Search, clinicals.gov (National Institutes of Health), Cochrane Central Register, Controlled Trials, PsycINFO, SCOPUS, and manual search. The effect size estimate was calculated using a random effects model.

The methodology used by the author was following: One hundred sixteen records were excluded. The meta-analysis included seven studies of 300 patients on EEG biofeedback and EMG biofeedback. Compared to the control group, BFB had a larger effect size and significantly reduced pain intensity. Subgroup analysis showed that only EMG-BFB, not EMG-BFB, reduced pain intensity compared to the control group.

They described limitations of BFB sleep disorders did not reduce depression, fatigue, or health-related quality of life compared to the control group.

Catherine Bernardi showed that there is limited interpretation of these results due to lack of research on the long-term effects of EMG-BFB on FMS. Further research should focus on the long-term efficacy of BFB in fibromyalgia and identify predictors of treatment response.

According to him, Biofeedback is a promising intervention in the rehabilitation of headaches and other pain disorders, and is also effective in FMS. However, little is known about this treatment option for FMS and it is not part of the usual care of FMS patients.Therefore, they conclude that the purpose of this study is to integrate and critically evaluate the evidence for the biofeedback effect of FMS.[Glombiewski, JA. et al., 2018].

According to Rubin, A. Biofeedback therapy has long been known to treat chronic headaches such as TTH due to various psychological challenges, stress, and cognitive and physiological control loss due to stress from TTH, resulting in reduced function May cause symptoms such as headaches and gastro-intestinal tract. Disorder, high blood pressure, chest pain, insomnia, gastric ulcer, sexual dysfunction, skin disease, etc.

MMBD is more efficient than IoT when considering health-related applications. This is because development activities focus on scale sensor data. Unique complexity and nature of IoT MMBD expansion using biofeedback sensors.

He described in this paper, the analysis of two GSR and EMG biofeedback therapies in the treatment of TTH for 12 months in different modes such as acoustic, visual, and visual modalities. Individual physical, mental, and total scores in both electromyography therapy and electro dermal responses to auditory, visual, and compositional processes have been studied.

The author has made attempts to test hypotheses and evaluate the effectiveness of biofeedback methods in individual and potential combination states [Rubin, A. 1992].

The paper "Audio Visual EMG & GSR Biofeedback Analysis and Spiritual Methods for Understanding HumanBehaviour and Psychosomatic Disorders" was written by Biswa Mohan Sahoo,Amar Deep Gupta and Basu Dev Shivahare.

According to him, In young professionals between the ages of 20 and 24, psychological imbalances are caused by emotional inactivity and lack of self-awareness. Spirituality with conscious mind meditation and a positive attitude is the only way you can see everyone coming soon through some discipline.

They have described the purpose of this study is not to compare the effects of EMG and GSR biofeedback on subject headache and quality of life stress. Headache-induced stress (TTH) is the most common primary headache. The purpose of this study is to evaluate electromyogram (EMG) biofeedback and GSR (electric skin resistance) as effective treatments for headaches. There is no such comparative effect of visual and auditory EMG biofeedback for headaches. Tension headache (TTH) is the most common type of primary headache. Biofeedback (BF) is information about biological activities that are normally unconsciously exposed and is an established treatment for TTH2. Hypertensive pain therapy, which has a better effect on coping with psychological and psychosocial consequences, highlights the patient's active role in managing these conditions. BF has few unnecessary side effects. If it is effective for preventive treatment or miscarriage of headaches, the use of drugs is clearly preferred.

They revealed the BF forms was used for migraine, tension headache, hybrid headache, and BF electromyogram (EMG) was shown maximum benefits [Shivahare, B D. et al., 2018].

The paper was written by Nagai Y et al., titled as "Galvanic Skin Response (GSR)/ Electro dermal / Skin Conductance Biofeedback on Epilepsy: A Systematic Review and Meta-Analysis"

He described the dynamic changes in psychological arousal appear directly on the skin sympathetic nerves. This activity can be measured as the tonicity of electrode activity and fuzzy oscillations. Biofeedback training can voluntarily control this autonomous response and its central communication.In theory, psychological arousal control is used as a treatment for epilepsy and reduces pre-discovery conditions. Evidence is gathering about the clinical effectiveness of GSR biofeedback training in the management of drug-resistant epilepsy.

They have analyzed evidence on the effectiveness of GSR biofeedback and evaluation of work methods for each study. They have used the following methodology in which they searched published literature on epilepsy intervention GSR biofeedback studies via the MEDLINE and Cochrane databases. Summarizing existing findings using meta-analytic methods has been used as a measure of seizure efficacy as a measure of the therapeutic effect of GSR biofeedback. It also compares and contrasts study design and interpretation of results.

The author found the results: Of the twenty one articles received for GSR / EDA / skin-induced biofeedback, four were conducted as interventional trials involving patients with drug-resistant epilepsy. Three of these studies reported positive treatment effects of the control group and biofeedback in each of these cases. This timely assessment is the large scale currently used to more accurately determine the potential value of GSR biofeedback treatment and the application of this non-invasive and non-pharmacological intervention for drug-resistant epilepsy. It emphasizes the design of prospective research designs. Give awareness [Nagai, Y. et al., 2019].

RESEARCH METHODOLOGY

The Whole Process has been completed in following steps.

- The Data Was collected through Questionnaire
- The Data Was Analyzed
- The App through software tools was designed
- By machine Learning Algorithms, the App was predicting the future results.

In our experimental investigation, a website was designed which contains closed set of Questionnaires from SF-36[Sharma, A. et al., 2019a], which have some weight associated with each question. All those users who have successfully registered then user will be first login to our website and then answer those questions. If they have responded to questionnaire earlier they will be redirected to their dashboard. On their dashboard they will find displayed stress level along with three options: given a re-questionnaire responses, remedies and statics.

The weight of the user is calculated according to the weight, user will be classified into one of three groups: less, average and high level of chronic TTH. After the classification, some remedies were advised to the user depending upon his/her stress level. After practicing those remedies for few days he/she can again give test and check the reduction in his stress level.

For stress level measurements, Short form of health Survey SF-36 questionnaire was used questionnaire and Biofeedback therapy to know current intensity, duration and frequency of headache of subject and for remedy, we applied meditative techniques and alternative therapies.We only used questionnaires to measure the participant's stress level.

Our product measured the subject stress level in specified time and helped them to handle it as per their scores and stress intensity.

We have used 70% data to train four classification algorithms Naïve Bayes, Logistic Regression, SVM and Decision tree and 30% for testing purposes.

During our research work, we used some data visualization techniques that EMG(Electromyography) in audio mode is best among all other modes and in this experiment, we have used a data set of SF-36 and successfully clustered them into three clusters i.e. low, medium and high using K-means algorithm and after clustering we have used classification algorithm to classify a user (depending upon the sum of all the weights of questions he had answered) into one of these three classes. We have also implemented various algorithms for classifications and compared their accuracy.

We have used in the Decision tree various test cases given as the input to the trained model and by the help of outputs of these test cases we were able to find the range in which the test weight will be classified: low, medium or high. Out of which Decision tree has most high accuracy in our case.

The different diagrams of Mental Health Analyzer (MHA) App are shown in the apportioning of requirements section. This app is analyzer, a guide for those who want immediate and online relaxation in some critical circumstances.

REQUIREMENT SPECIFICATION

Experimental Perspective

The Proposed experimentation and analysis is totally based on our earlier research work named "Chronic TTH analysis by EMG and GSR biofeedback on various modes and various medical symptoms"[1] and on "Analytical Comparison of Efficacy for Electromyography and Galvanic Skin Resistance Biofeedback on Audio-Visual Mode for Chronic TTH on Various Attributes". This work has been well published and cited by many in the same domain of research.

In this work, we created a website which comprises Short Form of Health Survey popularly known as SF-36 as the initial survey for the mental status of the subject. Each participants was required to answer the questions and based on their responses, their individual different scores on various parameters were calculated. Some set of questions were giving one kind of score and other set of questions were giving other kind of responses. The scores were clear indicators for the current status of mental, social, physical and inner health of an individual and high score always indicate that one posses good health and he/ she should maintain it. Average score is indicator of precautions and related guidelines and advisory are issued to him/ her. The low score is alarming bell and immediately subject is warned to visit psychiatrist and nearby mental hospital. Since the extreme situation can be panic and worst to be as suicidal tendency. This app is analyzer, a guide for those who want immediate and online relaxation in some critical circumstances.[Singh, A. et al., 2019d] and [Gulati, M. et al., 2019e] and [Chaturvedi, D.K. et al., 2012]

SYSTEM INTERFACES

1. Anguler6, CSS, JavaScript and Bootstrap are used for front end of web portal.
2. Node Js and Express Js are widely used in web platform as back end.
3. Mongo Db is applied for data storage and database creation purposes.
4. Jupyter is used to implement Machine Learning Algorithm in Python.
5. Visual Studio Code platform is used to develop the website [Chaturvedi, D.K. et al., 2013].

HARDWARE INTERFACES

The project occurred in different configurations of system as below:

1. Operating System: Linux, Unix, Windows
2. x86 - 64 processor
3. 8 GB RAM
4. Web Server: local host provided by Angular CLI and NPM server
5. For Mongo Db version 4.0 installed in OS
6. NPM packages should be installed. [Chaturvedi, D.K. et al., 2013]

SOFTWARE INTERFACES

Python 3.6, Angular 6, Node 10.0.0, Mongo db 4.0

PyCharm Platform

Currently, it is very popular as an integrated development environment (IDE). Python is especially used for computer programming designed by Czech Jet Brains. Code analysis provides end-user integration with graphical debugging, a single integration tester, version control system (VCS), and supports web development with Django. [Singh, V. et al., 2018i]

Machine Learning with Python Language

Machine learning uses data mining techniques and other learning algorithms to create models of what is happening behind some data and predict future results. This is a specific approach to artificial intelligence.

Deep Learning

This is one of a kind of machine learning, and learning to display the world as a nested hierarchy actually gained a lot of power and flexibility concepts, each concept with a simpler concept and It is defined by a more abstract expression.

Artificial Intelligence

These models use models created by machine learning and other methods of reasoning about the world to create intelligent movements, whether in games or robot / machine driving. Artificial intelligence predicts how the world will function and how the world will best achieve its goals. This app is very deployed.[Chaturvedi, D.K. et al., 2004]

Machine learning is the name given to a generalizable algorithm that allows computers to perform tasks by looking at data instead of hard coding. It is a subset of computer science and artificial intelligence that focuses on developing systems that can learn from data and make decisions and predictions based on it. With ML, computers can make decisions based on data rather than explicitly planning specific tasks. Mathematics provides a model. Understand those relationships and apply them to real objects. [Chaturvedi, D.K. et al., 2014]

Supervised Learning

These are "predictive" in nature. The purpose is to predict the value of a particular variable (target variable) based on values of some other variables or explanatory variables). Classification and Regression are examples of predictive tasks. Classification is used to predict the value of a discrete target variable while regression is used to predict the value of a continuous target variable. To predict whether an email is spam or not is a Classification task while to predict the future price of a stock is a regression task. They are called supervised because we are telling the algorithm what to predict. Methods are Linear Regression, Logistic Regression, Decision Trees, Random Forests, Naïve Bayes Classifier, Bayesian Statistics and Inference, K-Nearest Neighbor.[Chaturvedi, D.K. et al., 2014]

Unsupervised Learning

These are "descriptive" in nature. The purpose is to derive patterns that summarize the underlying relationships in data. Association Analysis, Cluster Analysis and Anomaly detection are examples of Unsupervised Learning. They are called unsupervised because in such cases, the final outcome is not known beforehand. With unsupervised learning there is no feedback based on the prediction results. Methods are K-Means Clustering, Hierarchical Clustering, Clustering using DBSCAN, Feature Selection and Transformation, Principal Components Analysis (PCA). .[Chaturvedi, D.K. et al., 2013]

MEMORY CONSTRAINTS

To run data on python programs, 2 GB memory space will be required and for both to run the node local host server and angular frontend local host, 1 GB space will be used.

OPERATIONS

Operations that will be done by user on our product are:

- A user can do registration if they are new users.
- After successful registration, user will be able to login to our site any time.
- All those registered users, if don't have given any test then they will be redirected to test page as soon as they will login
- All those users who have successfully registered, if they have responded to questionnaire earlier they will be redirected to their dashboard.

- On their dashboard they will find displayed stress level along with three options: given a re-questionnaire responses, remedies and statics.
- He can go to any of the options.
- All the users will get some remedies to follow and practice in their daily life
- After few days they can go through the retest.

FUNCTIONS OF EXPERIMENTAL APP

- Our product measured the subject stress level in specified time and helped them to handle it as per their scores and stress intensity.
- We are using dataset of SF-36[5] and we have clustered it into three clusters using k-means algorithm and after clustering we have modified and added the dataset with their respective clusters and used it as new dataset for training and testing of classification algorithms
- We have used 70% data to train four classification algorithms Naïve Baye's, Logistic Regression, SVM and Decision tree and 30% for testing purpose.
- Out of which Decision tree has most high accuracy in our case.
- Now in Decision tree we have used various test cases given as the input to the trained model and by the help of outputs of these test cases we were able to find the range in which the new weight will be classified: low, medium or high.
- We have used the same range limit in website for decided the stress level of the person depending upon the weights of the questions he has answered.

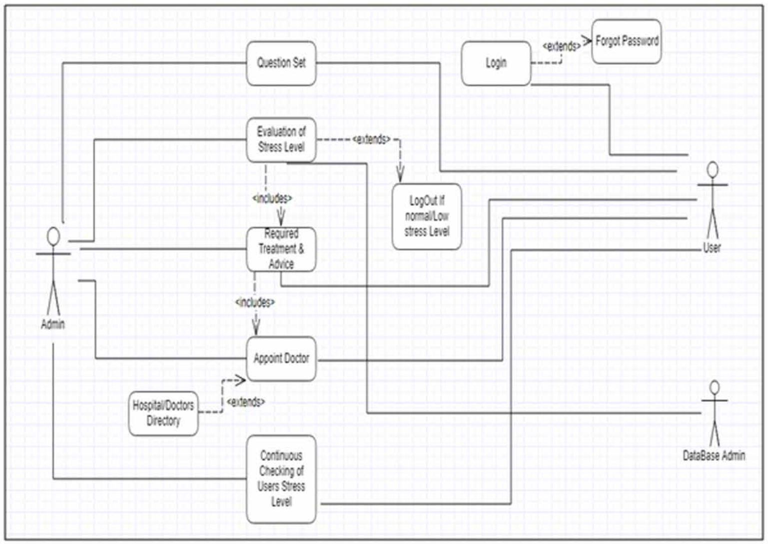
USER CHARACTERISTICS

Subject under considerations were users of all ages (18-65), genders, locality and is mainly focused on adolescents.

CONSTRAINTS

- The system complied with all local regulatory policies and ethical committee.
- The users had to answer all the questions honestly otherwise they may be classified into wrong stress level.
- Our research work was based on EMG and GSR machines with are very costly and very hard to find and do analysis.
- This product will be windows-based. So all the users must have windows operating system running on their pc's.
- Our product will use client server architecture and therefore be able to handle multiple participants at onetime.
- Our product will use cookies to help identify the registered users attempting to use the product via the internet.
- Our product will provide a backup capability to protect the data.

Figure 1. Use Case Model of MHA App



ASSUMPTIONS AND DEPENDENCIES

It is assumed that every user who will use our product will have windows operating system or Linux and all will satisfy the software and hardware requirements mentioned above.

APPORTIONING OF REQUIREMENTS

We may not be able to do thermal imaging. We only used questionnaires to measure the participant's stress level. The different diagrams of Mental Health Analyzer(MHA) App are as below.

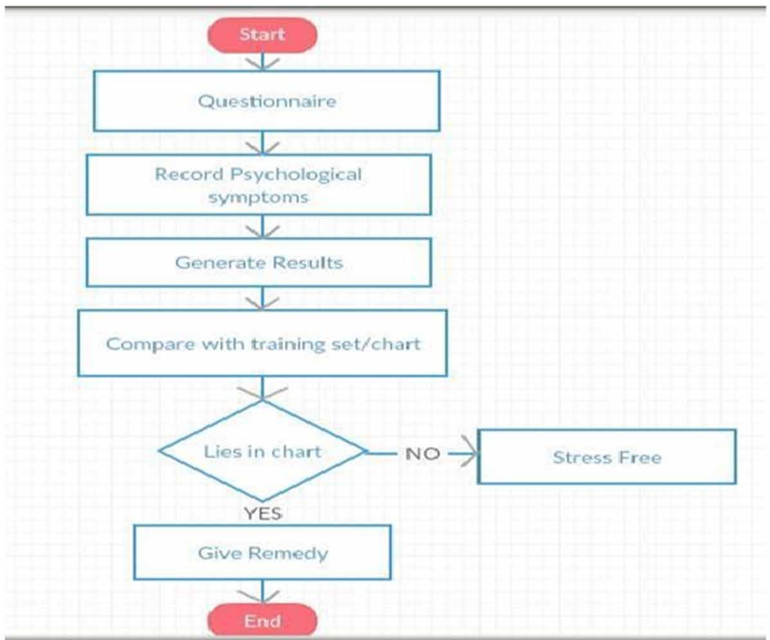
UML SPECIFICATIONS

Use Case Model

Case diagrams are used to show system performance or parts of a system. They are widely used to describe the functional needs of a system and the interaction with external actors (actors). Use cases are illustrations of different scenarios used in the system. The diagrams used show an overview of what a system or part of a system does without giving a detailed explanation.

A use case model was used to represent the functions and activities of all users and participants in the study. It also shows the performance of a program that shows the actions that a particular user can perform depending on the location.

Figure 2. Flowchart of MHA App



In the figure 1, we can see that a particular participant can login, register on site, can take test, can get a result. An administrator can manage the whole database and login on website. The user will get the question set and the evaluation of stress level will be done which will be saved in the database. If the stress level is too high, then he will be advised to go to a doctor or psychiatrist.

SYSTEM DESIGN AND METHODOLOGY

System Design and System Architecture

In figure 2, Flowchart shows the flow in which the whole work of site will go on. In this flowchart, we can see that when the user will login into the site then they will counter a questionnaire. They will attempt that on the basis of given answer their result will be calculated and remedies will be given to them, according to where they lie whether low, medium or high.

ACTIVITY DIAGRAM

The activity diagram which shows the control flow of a system. Activity diagram illustrating the steps involved in executing a usage file. Use an activity diagram to model sequential and concurrent activities. Therefore, you basically use an activity diagram to visualize the workflow. The activity diagram focuses on the state of the stream and the order in which the stream occurs. Use activity diagrams to explain or graph the cause of a specific event.

Figure 3. Activity Diagram of MHA App

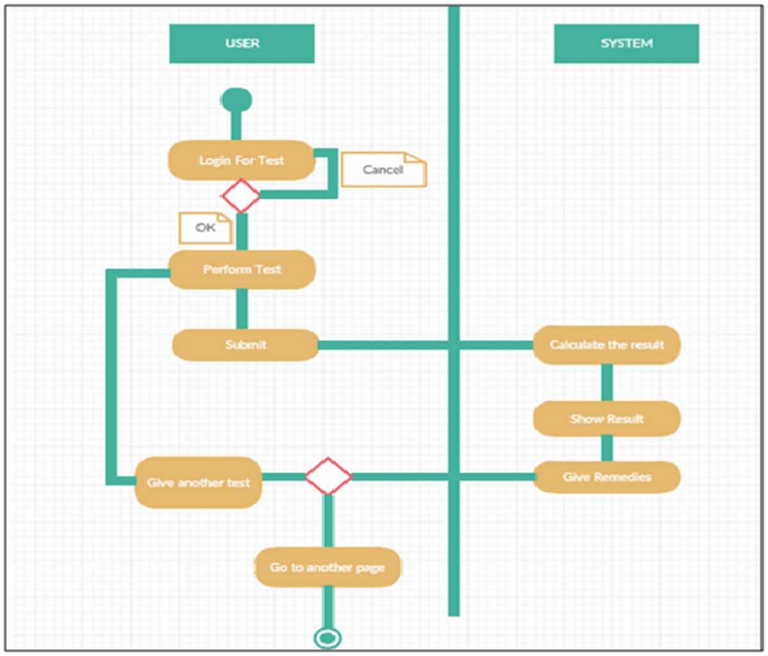


Figure 4. DFD level 0 of MHA app

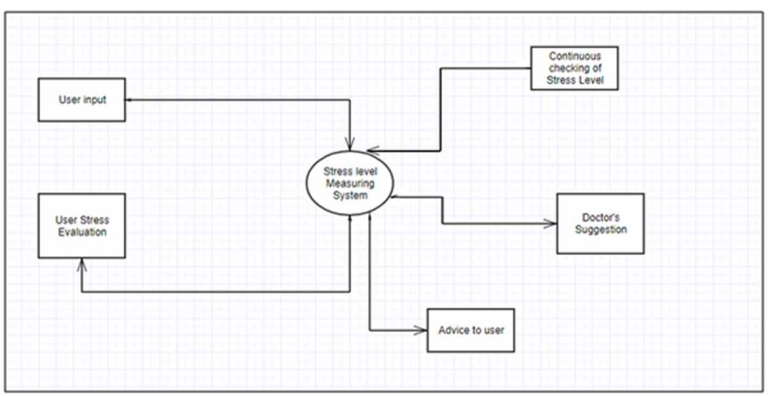


Figure 5. DFD level 1 of MHA app

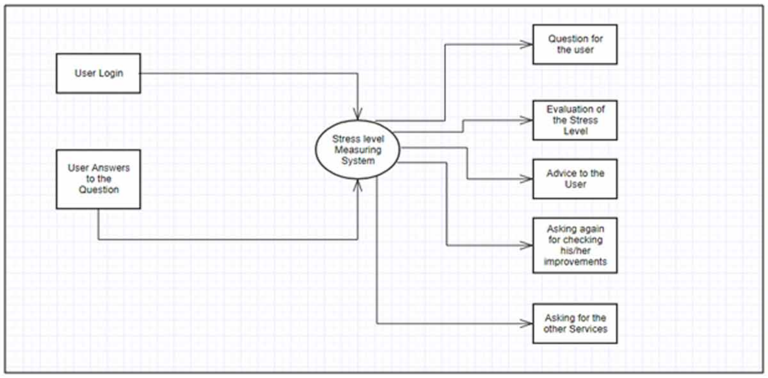


Figure 6. DFD level 2 of MHA app

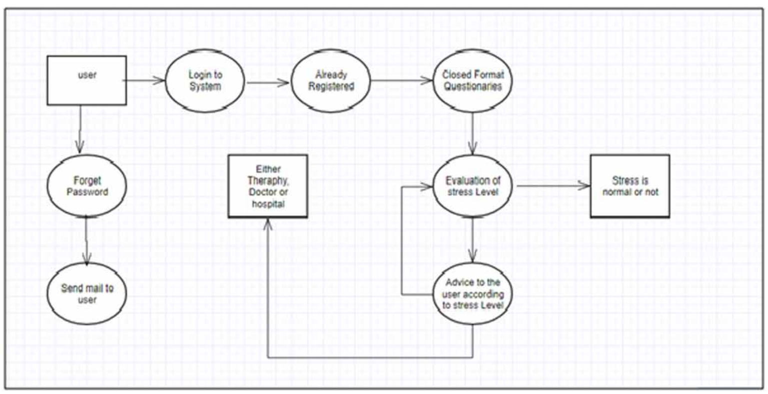


Figure 7. ER Diagram of MHA app

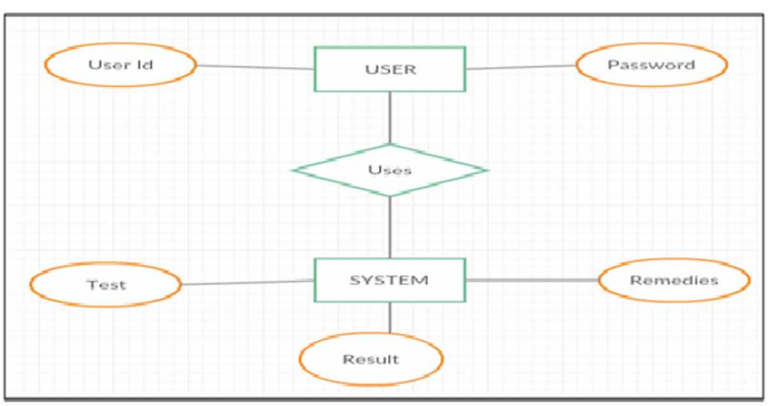


Figure 3, the activity diagram shows all the activities performed in the project are shown.

DFD

DFD (Data Flow Diagram) can be drawn to display the system at various levels of abstraction.

This is also called a context diagram. This design is designed as an abstraction and represents the system as a single process with relationships to external entities. Appears as a single bubble containing input and output data represented by input / output arrows.

In figure 4, data flow diagram level 0 is shown.

1 At the DFD level, the field diagram is broken down into several bubbles / processes. This level emphasizes the core functionality of the system and processes 0 level DFD high level processes into sub processes. In the figure 5, data flow diagram level 1 is shown.

DFD 2 Level Go deeper into part of DFD Level 1. Can be used to plan or record specific / required details about system performance. In the figure 6, data flow diagram level 2 is shown.

ER DIAGRAM

The ER model is used to model the logical view of the system in terms of data such as: component: Entity, entity type, entity set, an entity can be an object with a physical entity (a specific person, car, house, or employee), or an object with a conceptual meaning (company, job, university degree).

In figure 7, Entity relationship diagram is shown with entities, attributes and relationships that are used in the project.

IMPLEMENTATION AND RESULTS

Software and Hardware Requirements

Software Requirements

1. Python 3.6
2. Angular 6
3. Node js 10.0.0
4. Express js
5. Mongo db 4.0
6. PyCharm
7. Angular CLI
8. Mongo shell
9. Visual Studio Code

   10.Tablue (Data visualization)

Hardware Requirements

Figure 8. Home Page of the MHA app

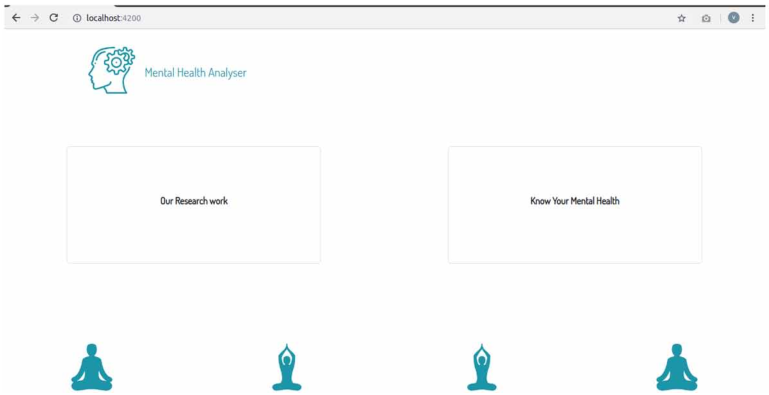
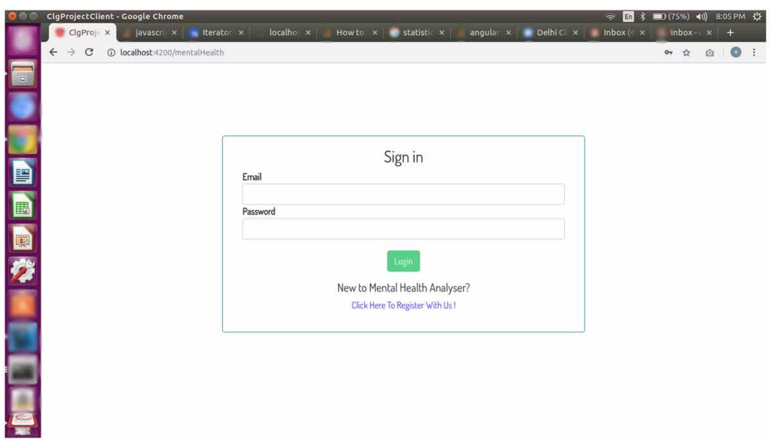


Figure 9. Login Page of MHA app



1. Operating System: Linux, Unix or Windows
2. Web Server: Node js and Express js provided by NPM package
3. Ram size: 8 GB
4. x86 - 64 processor
5. EMG (only used for research not for website)
6. GSR (only used for research not for website)

ASSUMPTIONS AND DEPENDENCIES

It is assumed that every user who will use our product will have windows operating system and will satisfy all the software and hardware requirements mentioned above.

Figure 10. Test Page of MHA app

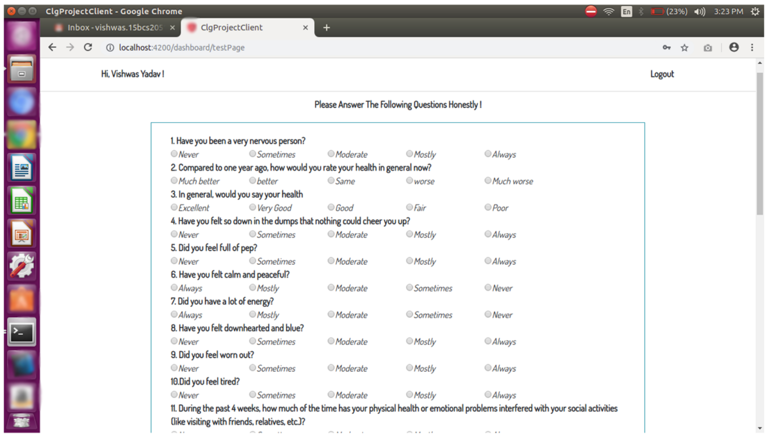


Figure 11. Dashboard of MHA app with Medium level of Stress

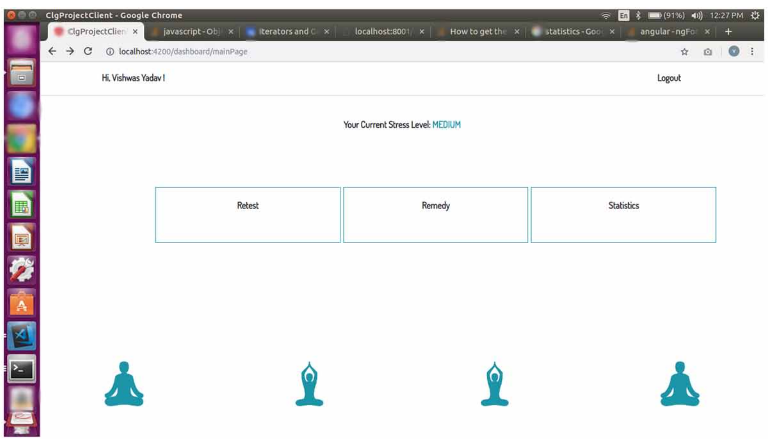


Figure 12. Dashboard of MHA app with Low level of Stress

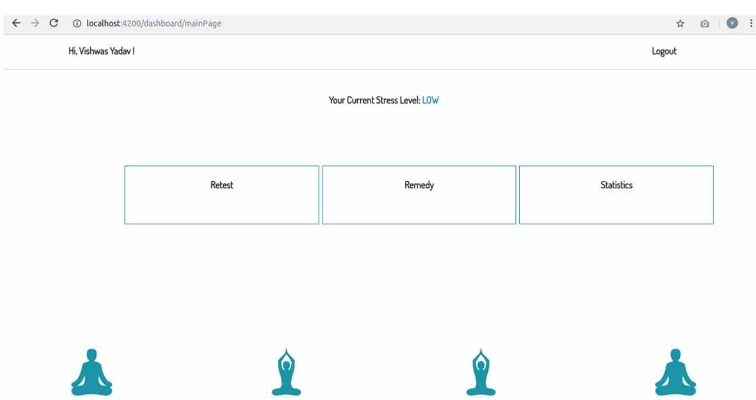


Figure 13. Dashboard of MHA app with High level of Stress

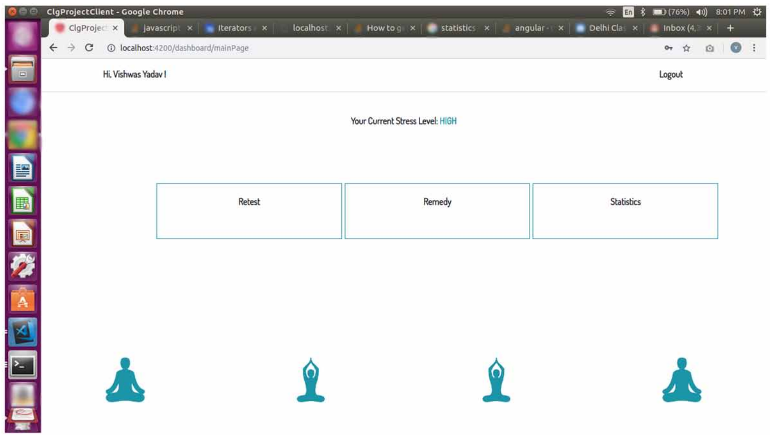


Figure 14. Log of Different responses by a user of MHA app

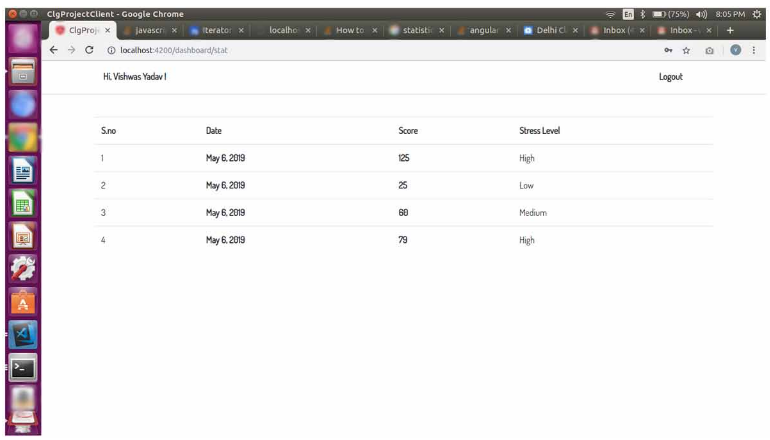
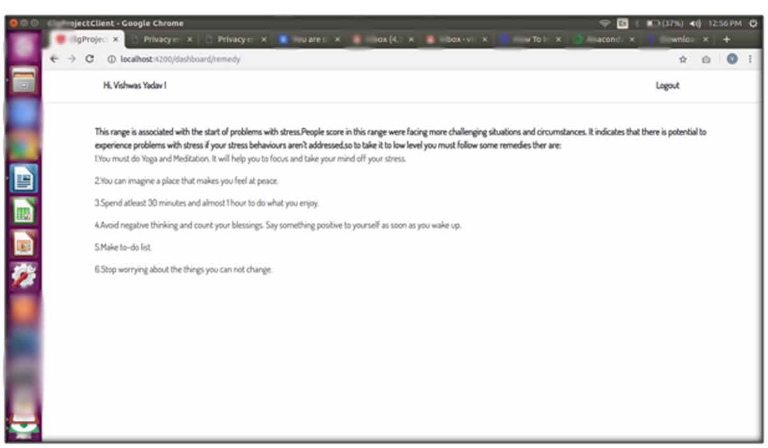


Figure 15. Remedies proposed of MHA app



IMPLEMENTATION DETAILS

Snapshots of Interfaces

In the figure 8, Home page which will be loaded on the screen of user

In the figure 9, Login screen will be shown after clicking on Know your mental health option the user will have to login or register if he is new to our website.

In the figure 10, Test page is shown in which the user will answer the questions and submit.

In the figure 10- figure 14, dashboard is shown which will be opened after the user has given first time his test. This page will contain the result along with three other options to go with i.e. Retest, Remedy and Statics. He can again give retest or go to the remedy page.

In figure 15 remedies depending upon the stress level of the user is shown. It is expected from the user that they will follow the steps sincerely.

TEST CASES

1. If stress level lies in range of S >= 25 and S <=57.
2. If stress level lies in range of S >= 58 and S <=68.
3. If stress level lies in range of S >= 68 and S<=125.

RESULTS AND DISCUSSION OF OUR RESEARCH WORK

We have found the result that EMG in Audio mode is best among all the other modes of EMG as well as it is also better than GSR in all modes i.e. Audio, Visual andAudio-visual. We have published this results in a book chapter.[1]

RESULTS OF EXPERIMENTS

In the figure 16, mean calculated by the python code is shown. It is the mean of all the questions answered by 399 people as present in the dataset.

1. We have successfully clustered responses from dataset into three clusters i.e. low, medium and high stress level by the help of K-means algorithms and now we classify new user into one of these three classes.

The figure 17 shows the clusters that we have got using k-means algorithm on the dataset of 399 people response of SF-36 questionnaires[5].

Cluster 1 represents Low Stress Level
Cluster 2 represents Medium Stress Level
Cluster 3 represents High Stress Level

Figure 16. Mean of all questions

q1	2.967419
q2	2.716792
q3	3.022556
q4	2.832080
q5	2.350877
q6	2.852130
q7	3.225564
q8	2.451128
q9	2.238095
q10	2.832080
q11	2.694236
q12	2.471178
q13	2.696742
q14	2.057644
q15	2.558897
q16	1.822055
q17	2.203008
q18	1.944862
q19	2.203008
q20	2.859649
q21	2.498747
q22	1.794486
q23	2.263158
q24	2.403509
q25	3.035088
Total	62.994987

2. After making three clusters we have modified the dataset and added the respective clusters in each row and used the new dataset to train various classification algorithms that we have used: Logistic Regression, Naïve Bayes, SVM, Decision Tree algorithm.
3. For training the machines, we used 70% data and for testing and accuracy, 30% data was used for the purposes.

Figure 17. Clusters of the Analyzed datasets

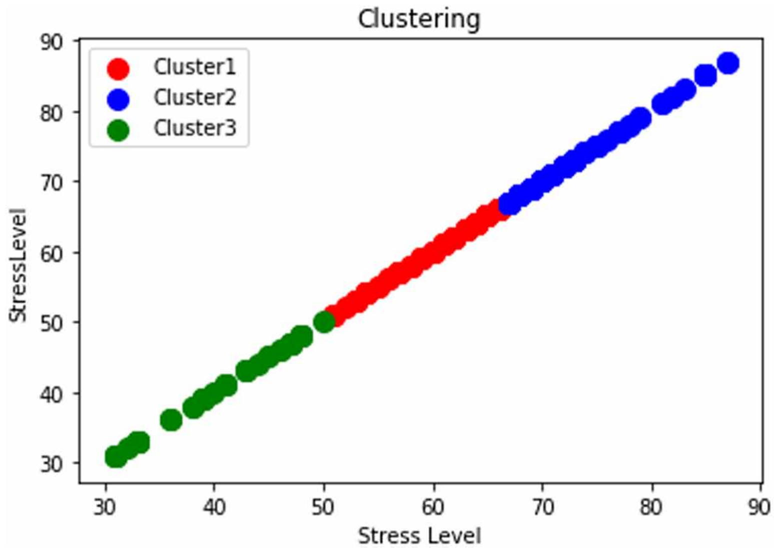
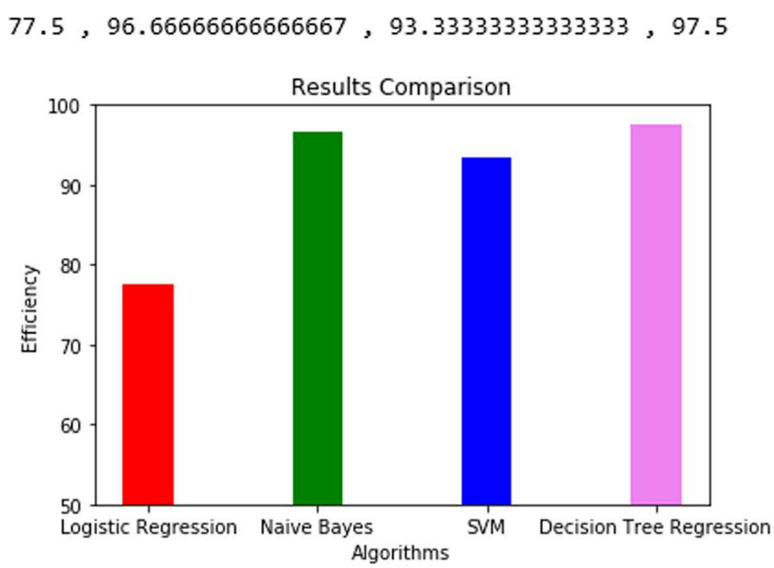


Figure 18. Accuracy of various algorithms applied



4. Out of all the algorithms Decision tree gives the best accuracy so we have find out the range of each class i.e. low, medium and high using various test cases onDecision tree algorithm and we have got range limits from it that we are using in our website for giving results.

The Figure 18 shows the accuracy of various classification algorithms that are used for classification.

Table 1. Accuracy of various Algorithms applied

S.NO	Algorithm Name	Accuracy(%)
1.	Logistic Regression	77.5
2.	Naïve Bayes Classifier	96.667
3.	SVM	93.333
4.	Decision Tree Regression	97.5

CONCLUSION

Performance Evaluation

The time duration for the whole experiment was 6 months which included stress recognition through biofeedback devices and providing its remedy through app. For stress level measurements, Short form of health Survey SF-36 questionnaire was used questionnaire and Biofeedback therapy to know current intensity, duration and frequency of headache of subject and for remedy, we applied meditative techniques and alternative therapies. For backup, we stored the data in Google Drive or Hard Disk to avoid any data loss [Chaturvedi, D.K. et al., 2014] and .[Chaturvedi, D.K. et al., 2013].

We have used 70% data for training and 30% for testing purposes. The clusters that we have got using k-means algorithm on the dataset of 399 people response of SF-36 questionnaires[5].Low Stress Level represented by cluster 1,Medium Stress Level represented by cluster 2 and High Stress Level represented by Cluster 3.

After making three clusters we have modified the dataset and added the respective clusters in each row and used the new dataset to train various classification algorithms that we have used: Logistic Regression, Naïve Bayes, SVM, Decision The logistic Regression algorithm gives the 77.5% accuracy,the Naïve Bayes Classifier gives 96.667% accuracy while SVM gives 93.333%.

We have found the result that EMG in Audio mode is best among all the other modes of EMG as well as it is also better than GSR in all modes i.e. Audio, Visual and Audio-visual. We have published this results in a book chapter.

Out of all the algorithms Decision tree gives the best accuracy as shown in table 1, so we have to find out the range of each class i.e. low, medium and high using various test cases on Decision tree algorithm and we have got range limits from it that we are using in our website for giving results. .[Chaturvedi, D.K. et al., 2015] and .[Chaturvedi, D.K. et al., 2019]

EXPERIMENTAL RESEARCH BASED LEARNING

1. Different technologies like: Angular 6, Mongo db, Node js, Express js, Python,

Tableau, k-mean clustering, logistic regression algorithm.

2. Practical implementation of tools like: Visual Studio, Tableau and Mongodb Shell
3. Team Work.
4. Dividing and Managing the work.

FUTURE DIRECTIONS

1. Give suggestion of nearby hospitals or psychiatrists by tacking GPS location of the user's device.
2. Send the result with the remedies to the user through email.
3. Make a team for doing survey among people in our college and offices for getting larger dataset so that we may increase the accuracy.
4. Conducting awareness camps for telling people to use this type of application for getting better stress free lifestyle.

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REFERENCES

Agrawal, A., Rastogi, R., Chaturvedi, D. K., Sharma, S., & Bansal, A. (2018g). Audio Visual EMG & GSR Biofeedbac Analysis for Effect of Spiritual Techniques on Human Behavior and Psychic Challenges. *Proceedings of the 12th INDIACom*, 252-258.

Chaturvedi, D. K. (2004). *Science, Religion and Spiritual Quest*. DEI Press.

Chaturvedi, D. K. (2012). Human Rights and Consciousness, International Seminar on Prominence of Human Rights in the Criminal Justice System. *Proceedings of Organized Ambedkar Chair, Dept. of Contemporary Social Studies & Law,* 33.

Chaturvedi, D. K. (2013). Correlation between Human Performance and Consciousness. *Proceedings of Saveetha School of Engineering, Saveetha University*.

Chaturvedi, D. K. (2013). The Correlation between Student Performance and Consciousness Level. *Proceedings of International Conference on Advanced Computing and Communication Technologies (ICACCT™-2013)*, 200-203.

Chaturvedi, D. K. (2013). A Study of Correlation between Consciousness Level and Performance of Worker. *Industrial Engineering Journal*, *6*(8), 40–43.

Chaturvedi, D. K. (2014). The correlation between Student Performance and Consciousness Level. *International Journal of Computing Science and Communication Technologies, 6*(2), 936-939.

Chaturvedi, D. K. (2014). Correlation between Energy Distribution profile and Level of Consciousness. *Shiakshk Parisamvad, International Journal of Education, 4*(1), 1-9.

Chaturvedi D.K. (2015). Dayalbagh Way of Life for Better Worldliness. *Quest Journals, Journal of Research in Humanities and Social Science, 3*(5), 16-23.

Chaturvedi, D. K. (2019). Relationship between Chakra Energy and Consciousness. *Biomedical Journal of Scientific and Technical Research, 15*(3), 1-3. Doi:10.26717/BJSTR.2019.15.002705

Chaturvedi, D. K., Kumar, J., & Bhardwaj, R. (2015, September). Jyoti Kumar Arora and Ravindra Bhardwaj(2015). Effect of meditation on Chakra Energy and Hemodynamic parameters. *International Journal of Computers and Applications*, *126*(12), 52–59. doi:10.5120/ijca2015906304

Chauhan, S., Rastogi, R., Chaturvedi, D. K., Arora, N., & Trivedi, P. (2017a). Framework for Use of Machine Intelligence on Clinical Psychology to study the effects of Spiritual tools on Human Behavior and Psychic Challenges. *Proceedings of NSC-2017(National system conference)*.

Glombiewski, J A., Bernardy, K., & Häuser, W. (2013). Efficacy of EMG- and EEG-Biofeedback in Fibromyalgia Syndrome: A Meta-Analysis and a Systematic Review of Randomized Controlled Trials. *Vid Based Complement Alternat Med., 962741*.

Gulati, M., Rastogi, R., Chaturvedi, D. K., Satya, S., Arora, N., & Singhal, P. (2018f). Statistical Resultant Analysis of Spiritual & Psychosomatic Stress Survey on Various Human Personality Indicators. *The International Conference proceedings of ICCI 2018.*

Gulati, M., Rastogi, R., Chaturvedi, D. K., Sharma, P., Yadav, V., Chauhan, S., . . . Singhal, P. (2019e). Statistical Resultant Analysis of Psychosomatic Survey on Various Human Personality Indicators: Statistical Survey to Map Stress and Mental Health. In *Handbook of Research on Learning in the Age of Transhumanism* (pp. 363-383). Hershey, PA: IGI Global. doi:10.4018/978-1-5225-8431-5.ch022

Gupta, M., Rastogi, R., Chaturvedi, D. K., Satya, S. A., Verma, H., Singhal, P., & Singh, A. (2019a). Comparative Study of Trends Observed During Different Medications by Subjects under EMG & GSR Biofeedback. *IJITEE, 8*(6S), 748-756. Retrieved from https://www.ijitee.org/download/volume-8-issue-6S/

Nagai, Y., Jones, C.I., & Sen, A. (2019). Galvanic Skin Response (GSR)/Electrodermal/Skin Conductance Biofeedback on Epilepsy: A Systematic Review and Meta-Analysis. *Frontier Neurology.* doi:10.3389/fneur.2019.00377

Nordqvist, J. (2018, August 8). What is biofeedback therapy and who can benefit? *Medical News Today.* Retrieved from https://www.medicalnewstoday.com/articles/265802.php

Rastogi, R., Chaturvedi, D. K., Arora, N., Trivedi, P., & Mishra, V. (2017b). Swarm Intelligent Optimized Method of Development of Noble Life in the perspective of Indian Scientific Philosophy and Psychology. *Proceedings of NSC-2017(National system conference)*.

Rastogi, R., Chaturvedi, D.K., Satya, S., Arora, N., Yadav, V., Chauhan, S., & Sharma, P. (2018c). SF-36 Scores Analysis for EMG and GSR Therapy on Audio, Visual and Audio Visual Modes for Chronic TTH. *Proceedings of the ICCIDA-2018 on 27 and 28th October 2018, CCIS Series, Springer, Gandhi Institute for Technology*.

Rubin, A. (1992). Biofeedback and binocular vision. *Journal of Behavioral Optometry*, *3*(4), 9598.

Sahoo, B. M., Gupta, A. D., & Shivahare, B. D. (2018). Audio Visual EMG & GSR Biofeedback Analysis and Spiritual Methods for Understanding Human Behaviour and Psychosomatic Disorders. *Amity Journal of Computational Sciences, 2*(1). Retrieved from www.amity.edu/ajcs

Saini, H., Rastogi, R., Chaturvedi, D. K., Satya, S., Arora, N., Gupta, M., & Verma, H. (2019c). An Optimized Biofeedback EMG and GSR Biofeedback Therapy for Chronic TTH on SF-36 Scores of Different MMBD Modes on Various Medical Symptoms. Studies Comp. Intelligence, 841. doi:10.1007/978-981-13-8930-6_8

Saini, H., Rastogi, R., Chaturvedi, D. K., Satya, S., Arora, N., Verma, H., & Mehlyan, K. (2018j). Comparative Efficacy Analysis of Electromyography and Galvanic Skin Resistance Biofeedback on Audio Mode for Chronic TTH on Various Indicators. In *Proceedings of ICCIIoT- 2018*. Elsevier.

Sharma, A., Rastogi, R., Chaturvedi, D. K., Satya, S., Arora, N., Trivedi, P., ... Singh, A. (2019a). *Intelligent Analysis for Personality Detection on Various Indicators by Clinical Reliable Psychological TTH and Stress Surveys. In Proceedings of CIPR 2019 at Indian Institute of Engineering Science and Technology*. Springer-AISC Series.

Sharma, P., Rastogi, R., Chaturvedi, D. K., Satya, S., Arora, N., Yadav, V., & Chauhan, S. (2018d). *Analytical Comparison of Efficacy for Electromyography and Galvanic Skin Resistance Biofeedback on Audio-Visual Mode for Chronic TTH on Various Attributes. In Proceedings of the ICCIDA-2018. Springer*.

Singh, A., Rastogi, R., Chaturvedi, D. K., Satya, S., Arora, N., Sharma, A., & Singh, A. (2019d). Intelligent Personality Analysis on Indicators in IoT-MMBD Enabled Environment. *Nature in Singapore*, 185–215. doi:10.1007/978-981-13-8759-3_7

Singh, P., Rastogi, R., Chaturvedi, D. K., Arora, N., Trivedi, P., & Vyas, P. (2018h). Study on Efficacy of Electromyography and Electroencephalography Biofeedback with Mindful Meditation on Mental health of Youths. *Proceedings of the 12th INDIACom*, 84-89.

Singh, V., Rastogi, R., Chaturvedi, D. K., Satya, S., Arora, N., Sirohi, H., . . . Verma, P. (2018i). Which One is Best: Electromyography Biofeedback Efficacy Analysis on Audio, Visual and Audio-Visual Modes for Chronic TTH on Different Characteristics. In *Proceedings of ICCIIoT- 2018.* Elsevier.

Singhal, P., Rastogi, R., Chaturvedi, D. K., Satya, S., Arora, N., Gupta, M., . . . Gulati, M. (2019b). Statistical Analysis of Exponential and Polynomial Models of EMG & GSR Biofeedback for Correlation between Subjects Medications Movement & Medication Scores. *IJITEE, 8*(6S), 625-635. Retrieved from https://www.ijitee.org/download/volume-8-issue-6S/

Vyas, P., Rastogi, R., Chaturvedi, D. K., Satya, S., Arora, N., & Singh, P. (2018e). Statistical Analysis for Effect of Positive Thinking on Stress Management and Creative Problem Solving for Adolescents. *Proceedings of the 12th INDIACom,* 245-251.

Yadav, V., Rastogi, R., Chaturvedi, D. K., Satya, S., Arora, N., & Bansal, I. (2018k). Intelligent Analysis for Detection of Complex Human Personality by Clinical Reliable Psychological Surveys on Various Indicators. *National Conference on 3rd MDNCPDR-2018.*

Yadav, V., Rastogi, R., Chaturvedi, D. K., Satya, S., Arora, N., Gupta, M., . . . Sharma, P. (2019b). Book chapter titled as Chronic TTH Analysis by EMG & GSR Biofeedback on Various Modes and Various Medical Symptoms Using IoT. Advances in ubiquitous sensing applications for healthcare, Book-Big Data Analytics for Intelligent Healthcare Management.

Yadav, V., Rastogi, R., Chaturvedi, D. K., Satya, S., Arora, N., Yadav, V., ... Chauhan, S. (2018j). Statistical Analysis of EMG & GSR Biofeedback Efficacy on Different Modes for Chronic TTH on Various Indicators. *Int. J. Advanced Intelligence Paradigms*, *13*(1), 251–275. doi:10.1504/IJAIP.2019.10021825

Chapter 10

From Resource to Outcome:
Addressing the Barriers of Healthcare Policy Implementation

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ABSTRACT

Governments often create policies that rely on implementation by arm's length organizations and require practice changes on the part of different segments of the healthcare system without understanding the differences in and complexities of these agencies. This research describes 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 chapter explains that the outcome of health policy implementation determines the availability, quality, and equability of program service delivery. The chapter further argues that policy implementation barriers affect the poor and vulnerable groups from benefiting from public spending on public health policies and programs.

INTRODUCTION

Governments often create policies that rely on implementation by arm's length organizations and require practice changes on the part of different segments of the health care system without understanding the differences in and complexities of these agencies (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 inter-sectional initiatives

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(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 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 which can facilitate or impede policy implementation.

Nearly 20 years ago, Grol and Grimshaw (1999) asserted that evidence-based practice must be complemented by evidence-based implementation. The past two decades have been marked by significant progress, as the field of implementation science has worked to develop a better understanding of implementation barriers and facilitators (i.e., determinants) and generate evidence for implementation strategies (Eccles & Mittman,2006; Bauer et al., 2015). 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 policies 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.

This chapter, therefore, 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 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 ELABORATION

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 science, 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), to better understand the factors that impede or facilitate implementation (Powell et al., 2019). 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 are 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 & 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 (Tully, 2002), 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.

REASERCH METHOD

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 & 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 (Hurley, 2001). 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 is 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 (Rouzbehani, 2019) and community-based distribution network. These health policies can also support other program activities.

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 has 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.

HEALTH POLICY IMPLEMENTATION BARRIERS

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.

Demand

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**: It includes distance cost and also opportunity cost.
d. **Household Preferences**: A symmetric control over household resources.
e. **Community and Cultural Preferences, Attitudes and Norms**: There are various reasons why some people are reluctant to seek healthcare which can range from being far from their homeland to using modern technology in heath sector. For example, cultural barriers 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 & SZelag, 2000). Such restrictions may also interact with other barriers. Community factors may include cultural and religious influences and other traditional social factors (Taber, Leyva & Persoskie, 2015) that affect individual preferences. When it comes to online healthcare, it is interpreted as health care providers lack certain level of emotional intelligence to feel the preference of the public, which increase the unwillingness of people to use online healthcare (Rouzbehani, 2019).
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

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.

a. **High Medical Care Costs**: Medical-care costs (Thorpe, 2005) 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).

b. **Quality:** 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.

c. **Unequal Access:** 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.

d. **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.

e. **Financial Inequities**: 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

Policy implementation in any health care system relies upon provider commitment. Policies that do not address the organizational, professional and socioeconomic contexts are unlikely to achieve successful implementation. That is political objectives alone, however well intentioned, are inadequate to change practice. When barriers to policy implementation exist in any of these contexts, the policy may fail to meet its objectives.

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 and 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.

REFERENCES

Aaron, H. J. (1991). *Serious and Unstable condition: Financing America's Healthcare*. Washington, DC: Brooking Institutions.

Akinsola, H. A. (2007). *The Principles of Health Services Administration and Management: Perspectives from Clinical and Public Health Practices*. Ibadan: College Press and Publishers Ltd.

Anderson, G., & Sotir, H. (2006). Influencing government policy. In D. Pencheon, C. Guest, D. Melzer, & J. A. Gray (Eds.), *Oxford Handbook of Public Health*. Oxford University Press.

Bauer, M. S., Damschroder, L., Hagedorn, H., Smith, J., & Kilbourne, A. M. (2015). An introduction to implementation science for the non-specialist. *BMC Psychology*, *3*(1), 32. doi:10.118640359-015-0089-9 PMID:26376626

Buse, K., Mays, N., & Watts, G. (2005). *Making Health Policy: Understanding Public Health Series*. Open University Press.

Cochran, C. E., Mayer, L. C., Carr, T. R., & Cayer, N. J. (1986). *American Public Policy: An introduction* (2nd ed.). New York: St Martins Press.

Dunn, W. N. (2012). *Public Policy Analysis* (5th ed.). Pearson Education.

Eccles, M. P., & Mittman, B. S. (2006). Welcome to implementation science. *Implementation Science; IS*, *1*(1), 1–3. doi:10.1186/1748-5908-1-1

Ensor, T., & Cooper, S. (2002). *Resource Allocation and Purchasing: Influencing the demand side*. York, UK: Centre for Health Economics, University of York. Prepared for the World Bank, Resource Allocation and Purchasing Project.

Gholipour, R., & Rouzbehani, Kh. (2016). *Social, Economic and political perspective on public health policymaking*. IGI Global publishing house.

Grol, R., & Grimshaw, J. M. (1999). Evidence-based implementation of evidence based medicine. *The Joint Commission Journal on Quality Improvement*, *25*(10), 503–513. doi:10.1016/S1070-3241(16)30464-3 PMID:10522231

Grossman, M. (2000). The human capital model. In Handbook of Health economics: volume 1A. Amsterdam: North-Holland.

Health Insurance Association of America. (1993). *Source Book on Health Insurance*. Washington, DC: The Association.

Hurley, J. (2001). Ethics, economics, and public financing of health care. *Journal of Medical Ethics*, *27*(4), 234–239. doi:10.1136/jme.27.4.234 PMID:11479353

Jenkin, R. A., Frommer, M. S., & Rubin, G. L. (2006). Translating indicators and targets into public health action. In D. Pencheon, C. Guest, D. Melzer, & J. A. Muir Gray (Eds.), *Oxford Handbook of Public Health*. Oxford University Press.

Peter, T. (Ed.). (1988). *Inequalities in Health: The Black Report*. London: Penguin.

Peteromode, V. F., & Peretomode, O. (2005). *Human Resource Management*. Lagos: Onoosomegbwho Ogbinaka Publishers.

Quality Assurance Project TASC 2, Eritrea. (2003). *Quality Assurance Core Course*. Associate Student Nurses State of Eritrea, Ministry of Health.

Rashid, S. F., Hadin, A., Afsana, K., & Begum, S. A. (2001). Acute respiratory infections in rural Bangladesh: Cultural understanding, practices and the role of mothers and community health volunteers. *Tropical Medicine & International Health*, *6*(4), 249–255. doi:10.1046/j.1365-3156.2001.00702.x PMID:11348514

Rouzbehani, K. (2019). Emotional Intelligence and Online Healthcare: The case study of Canada. *International Journal of Applied Research on Public Health Management*, *4*(2), 1–14. doi:10.4018/IJARPHM.2019070101

Rouzbehani, K. (2019). (in press). Let's Collaborate but How: A Dynamic Model for Discussing Barriers and Opportunities in the Digital Era. *Canadian Journal of Public Administration.*

Taber, J.M., Leyva, B., & Persoskie, A. (2015). Why do people avoid medical care? A qualitative study using national data. *J Gen Intern Med., 30*(3), 290–7.

Thorpe, K. E. (2005). *The Rise in Health Care Spending and What to Do About It Health Affairs*. Academic Press.

Tully, J. (2002). Political philosophy as a critical activity. *Political Theory*, *30*(4), 533–555. doi:10.1177/0090591702304005

Weimer, D. L., & Vining, A. (2011). Policy analysis (5th ed.). Academic Press.

Weiner, B. J. (2019). Enhancing the Impact of Implementation Strategies in Healthcare: A Research Agenda. *Frontiers in Public Health*, *7*, 3. doi:10.3389/fpubh.2019.00003 PMID:30723713

Whiteford & Szelag. (2000). Access and Utility as reflections of culture construction of pregnancv. *Primary Care Update, 7*, 98-104.

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 11
Scaling Up Telemedicine Initiatives:
Requirements for a New Telemedicine Maturity Model

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ABSTRACT

Telemedicine maturity models aim to support telemedicine scaling up. Even though a diversity of telemedicine maturity models, and further support tools, exist, they are often unable to support users proactively or offer substantial guidance for the improvement of the status quo. A new maturity model is therefore needed that overcomes the shortcomings evident in existing approaches. This chapter aims to identify requirements that such a model has to fulfil based on an analysis of existing maturity models. The results guide future research and can support the scaling up of telemedicine initiatives.

INTRODUCTION

Telemedicine maturity models aim to support telemedicine scaling up (van Dyk & Schutte, 2012), i.e. the process of pilot projects reaching more people who can benefit from the larger scale of the spread of such initiatives (Simmons, Fajans, & Ghiron, 2007). As long as this scaling up process is hampered (Boonstra & van Offenbeek, 2010; van Dyk, 2014), the promised increase in access to care for patients at decreasing cost (Hjelm, 2005) cannot be reached. The need for scaled up telemedicine initiatives has also been recognised by the European Commission (EC) and the World Health Organization (WHO),

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which included the scaling up of e.g., new applications, organisations and territories (EC, 2015; Uvin, 1995) in their policy and research agendas (EC, 2015; WHO, 2009).

Even though a diversity of telemedicine maturity models, and further support tools, exist (Mauco, Scott, & Mars, 2018; Otto, Whitehouse, & Schlieter, 2019; Yusif, Hafeez-Baig, & Soar, 2017), they are often unable to support users proactively or offer substantial guidance for the improvement of the status quo. These models help in defining the status quo from different perspectives, but mainly without being holistic and easily re-usable (Otto et al., 2019). Therefore, a new telemedicine maturity model is needed, which has to overcome the shortcomings evident in existing approaches. This chapter aims to identify the requirements that such a new model has to fulfil in order to overcome the deficiencies in current models. The requirements are derived from an analysis of existing maturity models and aim to support future research in this field.

The remainder of this chapter is structured as follows. In the next section, the concepts of telemedicine and maturity are introduced before the existing analysis of telemedicine maturity models is explained in section 3. The requirements for a new maturity model are then derived from the analysis. The results are placed in the context of existing research and the limits of this research are described (section 4). To complete the chapter, conclusions – accompanied by an outlook for future work – are set out (section 5).

TELEMEDICINE AND MATURITY

Telemedicine, as part of eHealth, describes the location- and time-independent delivery of healthcare services and/or medical education by professionals through the use of information and communication technology (ICT) (Sood et al., 2007). Healthcare disparities, especially in rural or underserved areas, can be overcome by the use of telemedicine since it connects electronically patients and professionals who are geographically distributed (Zapka et al., 2013). Telemedicine initiatives are highly complex, and are influenced not only by their users, their behavioural and ethical concepts, but also by surrounding factors like legal, organisational or financial conditions (Broens et al., 2007; Ly et al., 2017). To successfully scale up telemedicine initiatives, this complexity needs consideration. Addressing telemedicine initiatives' complexity is mostly done prior to implementation by referring to "telemedicine readiness". Readiness describes the "degree to which users, healthcare organisations, and the health system itself, are prepared to participate and succeed" (The Alliance for Building Capacity, 2002, p. 2) with telemedicine implementation. Supporting tools for telemedicine scaling up should include the provision of improvement measures, by helping users understand which steps could be taken in what context and by guiding them during the implementation process. As one such support tool, a maturity model describes a path to reach an advanced stage of maturity, including the definition of the current status quo, an overview of next steps, and the provision of a common understanding for different stakeholders to work on (Katuu, 2016; Klimko & Remenyi, 2001). Being mature is hereby defined as "having reached the most advanced stage in a process" (Oxford Dictionaries, n.d.). The entity under consideration can be people, processes or objects (Klimko & Remenyi, 2001).

Maturity models typically consist of dimensions – that are described and that reflect the domain to which the model refers – and levels, including a descriptor (e.g. initial, defined, optimising) and characteristics for each level (Fraser, Moultrie, & Gregory, 2002). Depending on the model's design, three types of models have been differentiated: Capability Maturity Model (CMM)-like models, Likert-like questionnaires, and maturity grids. CMM-like models are based on a formal design: a specific number of levels are described, with no further details for each activity per level. Likert-like questionnaires are seen as simple maturity models where each question displays a good practice and needs to be ranked by the respondent with a score, mostly from 1 to *n*. No additional information for each score is provided. Maturity grids describe each level of each dimension in a textual manner and further guide the assessment process (idem). Independent from the type of maturity model used, each model can be descriptive, prescriptive or comparative in nature. Descriptive maturity models describe the as-is situation, while prescriptive models further add the provision of steps for improvement from that point on. Comparative maturity models permit comparison between different industries or regions but require that a wide range of adequate data is collected. This implies the development of a descriptive model first, before understanding and addressing the need for improvement in a prescriptive model (De Bruin, Freeze, Kaulkarni, & Rosemann, 2005).

ANALYSIS OF MATURITY MODELS FOR TELEMEDICINE

In the study reported in this chapter, a systematic literature review in five different databases and a grey literature search (Tillett & Newbold, 2006) of the World Wide Web were conducted in order to identify maturity models relevant to telemedicine. The detailed search process is described in the original analysis (Otto et al., 2019). Ten maturity models met the inclusion criteria and were then considered for further analysis. Models were included whenever they constituted a tool that could help to define the status quo related to telemedicine maturity in any given context or setting, i.e. the model was a maturity model.

To assess and compare existing maturity models, classification characteristics were defined. The classification scheme for maturity models of Mettler et al. (2010) was taken as a basis, as its focus is on characteristics that describe maturity models in general. Further attributes were added to the scheme, in order to obtain a more detailed impression of each model. These include characteristics of maturity models and of telemedicine initiatives (which help selecting an appropriate tool in the complex field of telemedicine with its different stakeholders, applications and technologies). The proposed classification scheme (see Table 1) was subject to a four-part examination: Research information, general model attributes, maturity model design, and maturity model use. Each **category** (displayed in bold in the following) consists of related *attributes* (in italics) with alternative characteristics (displayed in grey in the classification scheme) that are described in Otto et al. (2019).

Analysing the classification of all the identified models was done in two steps. Firstly, due to the high variety in the models' focus and structure, each model was described individually. Secondly, general statements were made about all models.

Individual Statements

Individual statements can be drawn for each model according to *author* and *year* of publication, *name* and *acronym* of the model, *topic addressed* and the *country* in which it was developed. While some models are restricted in their use to the country in which they were developed, others are more general. Detailed information can be found in Table 2.

Table 1. Classification scheme (attributes from Mettler et al. (2010) are underlined)

Research information	**General model attributes**	**Maturity model design**	**Maturity model use**
- Author *- Year* *- Title of publication* *- Identified via review or grey literature search*	*- Name of the model* *- Acronym* *- Addressed topic* *- Origin* (academia | practice | government | combination) *- Purpose* (descriptive | prescriptive | comparative) *- Respondents* *- Technology* (telemedicine | telehealth | eHealth | digital health) *- Perspectives considered* *- Country* *- Disease* *- Availability* (free of charge | not free of charge)	*- Concept of maturity* (maturity of: processes | objects | people | combination) *- Design strategy* (development of a new model | adaptation/combination of existing models) *- Development method* *- Composition of the model* (Capability Maturity Model-like model | Likert-like questionnaire | maturity grid) *- Dimensions* *- Levels* *- Reliability* *- Mutability* (form | function | form and function)	*- Method of application* (self-assessment | third-party assisted assessment | certified professionals) *- Support of application* (documentation | textual description | handbook | supporting tool) *- Practicality of evidence* (general recommendations | specific improvement activities) *- Further usage of the model*

Table 2. Individual information for each model (sorted by date of publication)

Author (Year)	**Name of the model (Acronym)**	**Topic addressed**	**Country (use restricted/not)**
Campbell et al. (2001)	Framework for assessing provider's readiness to adopt telemedicine	Readiness for telemedicine of health providers	Developed in Missouri, United States (no restriction reported)
Jennett et al. (2003)	Framework for rural and remote readiness in telehealth	Readiness for telehealth of different stakeholders within a community	Developed in Canada (no restriction reported)
Broens et al. (2007)	Layered implementation model	General determinants for successful telemedicine services	Western societies (restricted use)
Khoja et al. (2007)	E-Health Readiness Assessment Tools for Healthcare Institutions in Developing Countries	e-Health readiness of managers and healthcare providers in healthcare institutions	Pakistan/developing countries (restricted use)
Van Dyk and Schutte (2012)	Telemedicine Maturity Model (TMMM)	Maturity of telemedicine services and their related factors and processes	Developed in South Africa (no restriction reported)
Abera et al. (2014)	Strategy, Technology, Organization, People and Environment (STOPE) model	e-Health readiness in healthcare institutions (in Ethiopia)	Ethiopia/ Sub-Saharan Africa (restricted use)
Jensen et al. (2015)	MOMENTUM-TREAT toolkit	Readiness of telemedicine services for large-scale deployment	Developed in Europe (no restriction reported)
Sokolovich and Fera (2015)	UPMC Telehealth Adoption Model	Maturity of telemedicine services and their readiness to expand	Developed in the United States (no restriction reported)
Gholamhosseini and Ayatollahi (2016)	E-Health readiness assessment tool	e-Health readiness in healthcare institutions	Iran (restricted use)
iCOPS (2017)	Commissioning Technology Enabled Care Services	Readiness of TECS before adopting or expanding	Developed in the United Kingdom (no restriction reported)

The *composition* of the model with its *dimensions*, *levels* and intended *respondents* needs to be analysed individually. Also, *reliability* and *further usage,* identified via forward search, are considered.

The oldest identified model was developed by Campbell et al. (2001). The six dimensions of turf, efficacy, practice context, apprehension, time to learn and ownership are crossed with the three levels of fertile soil, somewhat fertile soil and barren soil. The model is similar to a maturity grid and its focus on telemedicine providers leads to the inclusion of physicians, nurses and administrative staff as target groups of the model. Reliability tests are not reported and further development or usage of the model could not be identified. Two years later, Jennett et al. (2003) published their model as a kind of maturity grid. The four identified stakeholder groups, patients, practitioners, public and organisations, serve as dimensions, crossed with four types of readiness: core, engagement, structural and non-readiness. Each type of readiness contains six different themes arising for all stakeholders at all times (core readiness, structural readiness, projection of benefits, assessment of risk, awareness and education, and intra-group and inter-group dynamics). Nevertheless, this initial model cannot be considered as an actual maturity model since the readiness themes do not necessarily have a relationship with each other or describe an evolutionary path (The Alliance for Building Capacity, 2002), i.e. levels are missing. The initial model was not tested by the authors, but has been further developed since. In 2004, three 5-point, Likert-like questionnaires were designed for organisations, patients/public and practitioners (NSW Agency for Clinical Innovation, 2015). Each questionnaire results in one of three readiness levels (being in a good position for implementation; some items may hinder a successful implementation; and remaining barriers needing to be addressed). This survey has further been translated into and validated in various languages (Légaré et al., 2010) and applied in other countries (Muigg et al., 2018; Schwarz, Ward, & Willcock, 2014). Broens et al. (2007) ordered their five identified determinants of technology, acceptance, financing, organisation, as well as policy and legislation, in a layered implementation model (which can be classified as a CMM-like model). Each determinant builds on the previous one, indicating that the levels increase from determinant to determinant. The authors identify different telemedicine stakeholders, but the target audience of the model is not stated explicitly. The model remains untested, and is not easily benchmarked (van Dyk and Schutte, 2012). Khoja et al. (2007) focus on healthcare institutions in developing countries. Two 5-point, Likert-like questionnaires were provided, one for managers and another for healthcare providers. Both questionnaires included the three dimensions of core-readiness, societal readiness, and policy readiness. For managers, the dimension "technological readiness" was added; healthcare providers additionally assess the dimension "learning readiness". The authors conducted validity and reliability testing and showed good content and face validity and high reliability for both questionnaires. The tool has been applied in different settings (e.g. Chipps & Mars, 2012) and was taken up again partly in the development of the Khoja-Durrani-Scott framework (Khoja et al., 2013). Unfortunately, the surveys for the framework (referenced by Khoja et al. (2013)) are no longer available online. Five years later, van Dyk and Schutte (2012) presented a maturity grid in the form of a three-dimensional cube, based on existing models (e.g. by Broens et al. (2007), Jennett et al. (2003) and Khoja et al. (2007)). The cube consists of five dimensions (technology, users, finances, procedures and policy) which are crossed with the steps of the underlying telemedicine process. Each box in this matrix is then rated at one of five levels (initial; managed; defined; measured process; optimising). A target audience is not clearly stated. Nevertheless, the authors applied and validated their model with the help of workshops and focus groups, involving healthcare professionals (doctors and nurses) as well as technical staff members responsible for information technology from different regions. Later usage of the model has only been found in the further development by the same authors (van Dyk & Schutte, 2013). However, this further developed model is even more complex than the original, and contradicts the expectation that a maturity model should be easy to understand and use (Klimko & Remenyi, 2001). Abera et al. (2014) present two 5-point, Likert-like questionnaires where the dimensions of the STOPE model (Strategy, Technology, Organisation, People and Environment) are ranked and related to a colour code from the McConnell International tool, thereby implying that the site/location has a certain level of readiness. Opinions about the three dimensions, strategy, organisation and environment, were collected from managers and administrative staff by using a single questionnaire. Another questionnaire was administered to healthcare professionals and information technology staff and included the dimensions of technology, people and environment. Validity and reliability tests were undertaken. However, the model seems not to have been used further. Jensen et al. (2015) combined the MOMENTUM blueprint with the Telemedicine Readiness Self-Assessment Tool (TREAT) and got the MOMENTUM-TREAT toolkit. This toolkit is a 5-point, Likert-like questionnaire, assessing various indicators from 18 critical success factors which are categorised into the four areas of context, people, plan and run. The toolkit can be adapted to different settings by its users, which are described as "telemedicine doers and decision-makers" (Jensen et al., 2015, p. 32). All indicators were validated and tested and the toolkit has been applied in different settings, e.g. by Walters et al. (2016). In the same year, Sokolovich and Fera (2015) presented the UPMC (University of Pittsburgh Medical Center) model as a conference presentation in which the development process and structure of the model were introduced. Therefore, little information is available regarding the model. A clear statement on the respondents of the model is missing, but it can be determined that the tool was based on a practitioner survey in different health facilities. The model is a CMM-like model with eight levels (from 0 to 7: governance, providers, patients, simple, complex, complete, expanded, integrated). Further statements on application or testing of the model cannot be made with the limited information publicly available. Another 5-point, Likert-like questionnaire was published by Gholamhosseini and Ayatollahi (2016). It consists of five dimensions (e-health readiness, ICT functions, environmental readiness, human resources readiness, ICT readiness), including different indices. Each index is assessed on the Likert scale and multiplied with an additional weight for each dimension, resulting in a score between 0 and 1. A literature search for other tools on which the questionnaire can be built, e.g. Khoja et al. (2007), has been undertaken, but it is not evident which precise parts of which models were considered. A clear statement about who are the intended respondents is also missing. The authors applied their model with the help of hospital employees, including managers, health professionals and technical staff. Validation was conducted during the development phase of the model. Further usage of it could not be found. The most recently developed model was the maturity grid by iCOPS (2017). It is presented as an online tool, incorporating standards from a code of practice developed by Donelly (2017). The tool contains 16 dimensions (e.g. involvement of stakeholders, users and carers; investment and funding; implementation), which can be rated using four levels (inadequate; requires improvement; good; or outstanding). Different descriptions for each dimension and level are provided. The tool can be used by "all staff responsible for planning, commissioning, procuring, project and contract managing" (iCOPS, 2017) in technology enabled care services, but it is not available free-of-charge. Information on testing or application of the model is not publicly available.

GENERAL STATEMENTS

A number of general statements can be made for each of the four following categories: research information; general model attributes; maturity model design; and maturity model use.

Research Information

The author and year of each published maturity model were shown in Table 2, and each *publication title* is located in the reference list to this chapter. Publication dates for the models range from 2001 to 2017 (see Figure 1). In fact, the topic of telemedicine maturity is not a new one, but published research on it increased over the four years between 2014-2017.

Seven of the ten models were *identified via the literature review*; three, which are among the latest four models to be made available, through the *grey literature search*.

Figure 1. Number of models per year

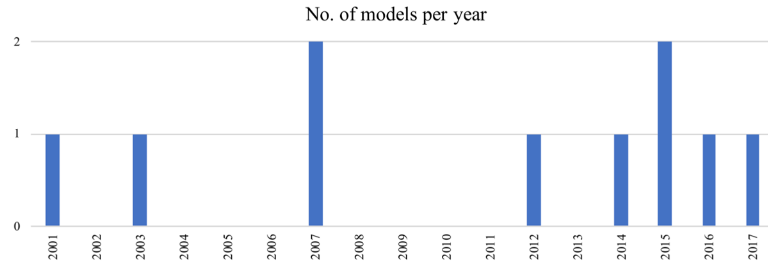


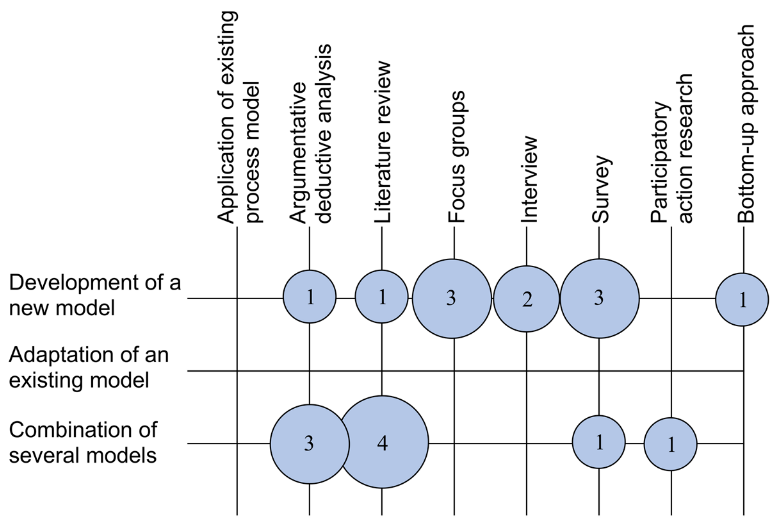
Table 3. Perspectives on telemedicine initiatives covered in each model – "x": perspective is directly included, "(x)": perspective is indirectly included in the model

	core readiness	provider readiness	patient readiness	public/ community readiness	health sector readiness	strategic readiness	technological readiness	organisational readiness	financial readiness	legal readiness
Campbell et al. (2001)	(x)	x								
Jennett et al. (2003)	x	x	x	x	x	x	x	x	x	x
Broens et al. (2007)		x	x		x	x	x	x	x	x
Khoja et al. (2007)	(x)	x	x		x	x	x	x	x	x
Van Dyk and Schutte (2012)		x				x	x	x	x	x
Abera et al. (2014)	(x)	x	x		x	x	x	x	x	x
Jensen et al. (2015)		x	x	x	x	x	x	x	x	x
Sokolovich and Fera (2015)		x			x		x	x		
Gholamhosseini and Ayatollahi (2016)	(x)	x				x	x			(x)
iCops (2017)		x	x		x	x	x	x	x	x

General Model Attributes

The name, acronym, topic and country in which the model was developed can be found in Table 2 for each model. The seven models identified via the literature review all *originate* from researchers working in academia. From the three models identified through the grey literature search, two were created by practitioners (iCOPS, 2017; Sokolovich & Fera, 2015) and one from a combination of academic, practitioner and governmental stakeholders (Jensen et al., 2015). Regarding *purpose*, nine out of the ten models outlining the status quo are descriptive models that make no recommendations. Only one model addresses the improvement of the status quo, i.e. it is a prescriptive model (Campbell et al., 2001). Intended respondents for each model were analysed individually in the section "Individual Statements". Four models are classified as being applicable to the *technology* of telemedicine (Broens et al., 2007; Campbell et al., 2001; Jensen et al., 2015; van Dyk & Schutte, 2012), one to telehealth (Jennett et al., 2003), and two to eHealth (Gholamhosseini & Ayatollahi, 2016; Khoja et al., 2007). Two others are applicable to telemedicine and telehealth (iCOPS, 2017; Sokolovich & Fera, 2015), and a further one to telemedicine and eHealth (Abera et al., 2014). Each model covers various *perspectives* of telemedicine initiatives, as displayed in Table 3. The perspectives, i.e. core readiness through to legal readiness, were derived by the authors of this chapter by examining the items mentioned in all ten models.

Figure 2. Combination of design strategy and development method (size of and number within each bubble represent the number of times each combination was identified)



No clear trend can be seen in the various types of readiness that have been added over time. Rather, the authors of the ten models combined different types of readiness for their own purposes, without necessarily claiming to be holistic in their approach. None of the models are *disease*-specific. Eight of the models are *available* free-of-charge, but not two of the three models developed by practitioners, which limits the usability of both models (iCOPS, 2017; Sokolovich & Fera, 2015). However, for the iCOPS (2017) tool, users can undertake a one-month free trial to test the tool.

Maturity Model Design

In general, seven out of the ten models combine process-, object- or people-focussed elements in their *concept of maturity*. Only three focus specifically on the maturity of people (Campbell et al., 2001; Jennett et al., 2003; Khoja et al., 2007). Most identified models were *designed* as new models (6/10) or combined/extended for the first time (4/10), using different *development methods* (see Figure 2). However, a theory (e.g. regarding adoption or diffusion) was not incorporated in any of the models in order to strengthen its theoretical basis.

Information about model composition, dimensions, levels and reliability was also discussed in the section "Individual Statements". The *mutability* of models is not addressed in seven of the ten models. Jensen et al. (2015) and Khoja et al. (2007), however, report a possible mutability regarding the form of the model, and Van Dyk and Schutte (2012) name a form and function mutability.

Maturity Model Use

The *method of application* for all the models is self-assessment. Nevertheless, *support/guidance for the application* is not given in eight out of the ten models. Even though each of the models is described in the individual publications, largely no form of additional support is provided to guide later users on how to apply the models. This observation also applies to the work of Abera et al. (2014), Gholamhosseini and Ayatollahi (2016) and Van Dyk and Schutte (2012), who all applied their models directly to assess specific institutions/processes. These later authors only described the content of the models, and failed to offer detailed descriptions that would be helpful for the models' reuse. Support for the application of the models is given in only two of the models. These are Jensen et al. (2015), with a step-by-step procedure to applying the model and the naming of an email address for further support, and iCOPS (2017), where a software assessment tool and an email address for readers/users to pose further questions are provided. Regarding *practicality of evidence,* it can be said that only one model offers general recommendations (Campbell et al., 2001); specific improvement activities are not given in any of the models. Generally, in all of the models, the description of the more mature stages of telemedicine could also offer guidelines on improvement measures (since they would explain the circumstances needed to achieve higher maturity), but they do not give direct guidance. Each model was further used differently as described in the section "Individual Statements".

DISCUSSION AND RECOMMENDATIONS FOR FUTURE RESEARCH

The analysis in this chapter has shown how diverse are the different approaches to telemedicine maturity models. Even though each model has different characteristics and foci, the analysis nevertheless reveals various possible, systematic aspects for future research. Firstly, none of the models analysed provides guidance as an application for increasing telemedicine maturity. This occurs for two reasons: Either perspectives to be considered or documentation to apply the model are lacking, or the models are solely descriptive and do not provide supporting steps that could improve the status quo. To develop a supportive maturity model in future research, therefore, the following nine requirements have to be fulfilled. Five of these solutions affect the development of the model, whereas two each influence the stage after development and the actual presentation of the model. For each requirement, the findings leading to it are discussed first, before specific solutions to address the requirements are given (All requirements are formatted as follows "*Requirement" – "Discussion of results"* || *"Solution*").

During the Development of the Model

1. **Strengthen the Theoretical Basis**: In none of the models analysed was there a theory that was incorporated that would strengthen the model's theoretical basis. || To address this weakness, existing theories, e.g. regarding adoption of innovations, should be considered when building a new model. However, existing evidence should not be left out, but should be absorbed by including aspects of existing maturity models into a new model.
2. **Apply Existing Process Models**: None of the models analysed was developed by applying existing process models which guide the development of maturity models in general. || The application of such a process model can be helpful, and should be considered when developing a new tool. The process models that exist are, however, quite general when describing the steps to be followed (Becker, Knackstedt, & Pöppelbuß, 2009; De Bruin et al., 2005; Poeppelbuss & Roeglinger, 2011); they do not offer specific guidance on the usage of methods. When developing a new maturity model for telemedicine, the steps taken can be abstracted to maturity model development in general and provided as further methodological guidance in future research.

3. **Provide Aspects for Improvement**: Almost all the ten models analysed defined solely the status quo. Nevertheless, it is only when either general or specific recommendations for improvement are provided that the model's users are supported concretely in their efforts of scaling up telemedicine initiatives. || Therefore, the model needs to be prescriptive.
4. **Include Important Perspectives**: The perspectives analysed (see Table 3) are all important aspects needed to assess telemedicine maturity in different settings. Considering them all would provide a holistic view on the possible influencing factors when scaling up telemedicine.
   4.1 **Consider the Community/Public**: In eight out of the ten models, the community/public surrounding the individuals involved was not considered sufficiently. (The two exceptions are Jennett et al. (2003) and Jensen et al. (2015).) Neither core readiness nor patient readiness are considered enough. || Therefore, incorporating community readiness (Edwards et al., 2000) and adoption theories (e.g. Venkatesh, Thong, & Xu, 2012) should be included in a stronger way in future research, in order to close this identified gap. Community readiness refers to "the relative level of acceptance of a program, action or other form of decision-making activity that is locality-based" (Donnermeyer, Plested, Edwards, Oetting, & Littlethunder, 1997, p. 68). Even if telemedicine initiatives are not locality-based (as they aim to overcome distances through the use of ICT), the users of telemedicine are locality-dependent. This dependency results from the environment in which the user is embedded, whether this is the social, financial or legal (Ly et al., 2017). The community readiness model (CRM) of Edwards et al. (2000) can be used as a good starting point to fulfil this requirement as it incorporates levels and dimensions which can be adapted and it relies on the diffusion of innovations theory of Rogers (2003), which adds an additional layer of basic theory. The CRM's levels and dimensions have to be analysed regarding their suitability for describing telemedicine initiatives' scaling up, while including aspects of existing models to rely on available evidence (see requirement 1).
   4.2 **Include Core Readiness as Precondition**: Core readiness was the second perspective which was neglected in the majority of models analysed. However, it is a strictly necessary precondition for telemedicine implementation and therefore should not be ignored in a support model. || Adapting the CRM can also help in addressing this requirement, as the first three of the nine CRM levels follow this direction (i.e. vague awareness, preplanning, and preparation). Combining these three levels into the precondition of "core readiness needs to be fulfilled" would result in six remaining stages. The six stages could then potentially be adapted as they are as levels of the new telemedicine maturity model.
   4.3 **Consider Barriers and Success Factors**: The perspectives analysed in this chapter are quite broad. || To fill the perspectives identified, barriers and success factors can be helpful in describing the domain (De Bruin et al., 2005). All aspects in the ten existing telemedicine maturity models can serve as critical success factors since they were already incorporated in a maturity model and therefore identified as necessary to reach a higher maturity. Furthermore, barriers to the implementation of telemedicine need to be identified and matched with the success factors, to provide a holistic picture on the topic.

5. **Consider Mutability**: The majority of the authors (seven of the ten authors analysed) did not address the mutability of their models. Times are changing and so the maturity of telemedicine can also alter. To adjust the model to current needs and ensure the further applicability of the model, revising it could be necessary (Mettler et al., 2010). || While developing a new model, the mutability of both form and/or function have to be thought through and communicated clearly.

After Developing the Model

6. **Define Respondents**: A clear description of the model's respondents was not given in all of the ten models analysed. Nevertheless, it is only if the target users of the maturity model are defined that an appropriate usage can be ensured. || Possibly, the people who apply the maturity model and those who use the results obtained through the use of the maturity model can be different. This calls even more for a clear description of both groups.
7. **Evaluate the Model**: While some of the papers analysed did not provide any information regarding validity and reliability testing, these two types of testing are needed in order to show the model's possibilities to fulfil its intentions. Once the model is developed, it is crucial to undertake an evaluation of it in order to provide a sound tool for further use. Continuous evaluation is also required by Sonnenberg and vom Brocke (2012) in order to justify and evaluate the model developed. The authors propose various methods, which can be used for evaluation after different development steps. || Various activities are useful when developing a maturity model. They include: undertaking a literature review so as to show the research need/problem statement; applying logical reasoning to specify the design of the model; doing expert interviews so as to obtain feedback on the prototype; and examining case studies with experts who apply the model once it has been developed. Whenever experts are involved in the evaluation of the model, adding the "think aloud" method (Van Someren, Barnard, & Sandberg, 1994) can also be a supportive additional aid, as it helps to avoid bias and increases the interviewer's understanding as the experts express their thoughts and impressions.

Regarding the Presentation of the Model

8. **Think About the Availability**: Two of the latest four models to be made available are not available free-of-charge, which lowers the number of potential users. || Therefore, it is necessary to provide the maturity model free-of-charge. This lowers the barriers to usage and supports the development of a supportive community around the model.
9. **Provide a Clear Documentation**: Eight of the ten models analysed did not provide any form of additional support. However, having clear documentation is an essential step to provide an easy-to-use tool. || On the one hand, the model itself and its components need to be described clearly so as to be applicable without the model's developers being present. Each and every aspect of the model has to be explained in a written format in order to make sure that the users of the model understand its meaning and avoid bias. This could be possible in an extended version of the model, e.g. as a handbook or web tool. On the other hand, the application of the model needs to be clearly described so as to guide actual usage. This description should be done in the context of a research paper so as to make sure that when future literature analyses are undertaken in researching such

support tools, researchers can find a clear, condensed instruction of the model and its related use steps. An accompanying activity diagram could also be especially helpful.

Although the requirements are derived rigorously, there are still some limitations which need to be considered. First, the analysis was done based on a literature review, which generally – as a method – has a number of limits. However, counterbalancing steps needed to lower bias were taken to mitigate these limitations (Otto et al., 2019). Second, the requirements for a new maturity model were derived in an argumentative-deductive way. They were also placed in the context of prior research to lower bias. Overall, fundamentally, however, the requirements do mirror the results of the analysis.

CONCLUSIONS

Identifying existing maturity models for telemedicine and assessing them in a structured classification scheme (which can be re-used for classifying additional or newer maturity models) led to an overview of the state-of-the-art. The analysis helped in identifying the shortcomings of existing models that need to be addressed in the development of a new maturity model for telemedicine. To support future research and the development of this new supportive model, we have outlined nine requirements that can guide the development or update of new models for telemedicine maturity and provided different solutions to address the requirements. As a result, a support tool for telemedicine maturity can be developed which includes the incorporation of community and core readiness, the consideration of aspects in existing maturity models and barriers for telemedicine implementation, and guidance to be provided to users - through supportive recommendations and necessary documentation. When such a model is accompanied by an online tool, the readiness of sites to implement telemedicine initiatives could be achieved in a considerably faster way.

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REFERENCES

Abera, A. A., Mengesha, G. H., & Musa, P. F. (2014). Assessment of Ethiopian health facilities readiness for implementation of telemedicine. *Communications of the Association for Information Systems*, *34*(67), 1209–1234. doi:10.17705/1CAIS.03465

Becker, J., Knackstedt, R., & Pöppelbuß, J. (2009). Developing Maturity Models for IT Management. *Business & Information Systems Engineering*, *1*(3), 213–222. doi:10.100712599-009-0044-5

Boonstra, A., & van Offenbeek, M. (2010). Towards consistent modes of e-health implementation: Structurational analysis of a telecare programme's limited success. *Information Systems Journal*, *20*(6), 537–561. doi:10.1111/j.1365-2575.2010.00358.x

Broens, T. H. F., Huis in't Veld, R. M. H. A., Vollenbroek-Hutten, M. M. R., Hermens, H. J., van Halteren, A. T., & Nieuwenhuis, L. J. M. (2007). Determinants of successful telemedicine implementations: A literature study. *Journal of Telemedicine and Telecare*, *13*(6), 303–309. doi:10.1258/135763307781644951 PMID:17785027

Campbell, J. D., Harris, K. D., & Hodge, R. (2001). Introducing telemedicine technology to rural physicians and settings. *The Journal of Family Practice*, *50*(5), 419–424. PMID:11350706

Chipps, J., & Mars, M. (2012). Readiness of health-care institutions in KwaZulu-Natal to implement telepsychiatry. *Journal of Telemedicine and Telecare*, *18*(3), 133–137. doi:10.1258/jtt.2012.SFT103 PMID:22362834

De Bruin, T., Freeze, R., Kaulkarni, U., & Rosemann, M. (2005). Understanding the main phases of developing a maturity assessment model. In B. Campbell, J. Underwood, & D. Bunker (Eds.), *Proceedings of the ACIS 2005* (pp. 8–19). Retrieved from https://eprints.qut.edu.au/25152/

Donelly, B. (2017). *International code of practice for planning, commissioning and providing technology enabled care services: A quality framework for procurement and provision of services*. Buckinghamshire, UK: Community Equipment Solutions.

Donnermeyer, J. F., Plested, B. A., Edwards, R. W., Oetting, G., & Littlethunder, L. (1997). Community readiness and prevention programs. *Journal of the Community Development Society*, *28*(1), 65–83. doi:10.1080/15575339709489795

EC. (2015). *European scaling-up Strategy in Active & Healthy Ageing*. European Commission.

Edwards, R. W., Jumper-Thurman, P., Plested, B. A., Oetting, E. R., & Swanson, L. (2000). Community readiness: Research to practice. *Journal of Community Psychology*, *28*(3), 291–307. doi:10.1002/(SICI)1520-6629(200005)28:3<291::AID-JCOP5>3.0.CO;2-9

Fraser, P., Moultrie, J., & Gregory, M. (2002). The use of maturity models/grids as a tool in assessing product development capability. *IEEE International Engineering Management Conference*, *1*, 244–249. 10.1109/IEMC.2002.1038431

Gholamhosseini, L., & Ayatollahi, H. (2016). The design and application of an e-health readiness assessment tool. *The HIM Journal*, *46*(1), 32–41. doi:10.1177/1833358316661065 PMID:27486183

Hjelm, N. M. (2005). Benefits and drawbacks of telemedicine. *Journal of Telemedicine and Telecare*, *11*(2), 60–70. doi:10.1258/1357633053499886 PMID:15829049

iCOPS. (2017). *Commissioning Technology Enabled Care Services*. Retrieved November 15, 2018, from CECOPS & TECS Products | iCOPS® website: http://www.icops.co.uk/products/cecops-tecs-products/

Jennett, P., Jackson, A., Healy, T., Ho, K., Kazanjian, A., Woollard, R., ... Bates, J. (2003). A study of a rural community's readiness for telehealth. *Journal of Telemedicine and Telecare*, *9*(5), 259–263. doi:10.1258/135763303769211265 PMID:14599328

Jensen, L. K., Knarvik, U., Pedersen, C. D., Tangene, W., & Whitehouse, D. (2015). *Deliverable 3.4 Personalised Blueprint for telemedicine deployment: Validated and tested version*. Retrieved from http://www.telemedicine-momentum.eu/

Katuu, S. (2016). Transforming South Africa's health sector: The eHealth Strategy, the implementation of electronic document and records management systems (EDRMS) and the utility of maturity models. *Journal of Science and Technology Policy Management*, *7*(3), 330–345. doi:10.1108/JSTPM-02-2016-0001

Khoja, S., Durrani, H., Scott, R. E., Sajwani, A., & Piryani, U. (2013). Conceptual framework for development of comprehensive e-Health evaluation tool. *Telemedicine Journal and e-Health*, *19*(1), 48–53. doi:10.1089/tmj.2012.0073 PMID:22957502

Khoja, S., Scott, R. E., Casebeer, A. L., Mohsin, M., Ishaq, A. F. M., & Gilani, S. (2007). E-Health Readiness Assessment Tools for Healthcare Institutions in Developing Countries. *Telemedicine Journal and e-Health*, *13*(4), 425–431. doi:10.1089/tmj.2006.0064 PMID:17848110

Klimko, G., & Remenyi, D. (2001). Knowledge management and maturity models: Building common understanding. Academic Press.

Légaré, É., Vincent, C., Lehoux, P., Anderson, D., Kairy, D., Gagnon, M.-P., & Jennett, P. (2010). Developing and validating the French-Canadian version of the practitioner and organizational telehealth readiness assessment tools. *Journal of Telemedicine and Telecare*, *16*(3), 140–146. doi:10.1258/jtt.2009.090514 PMID:20386034

Ly, B. A., Labonté, R., Bourgeault, I. L., & Niang, M. N. (2017). The individual and contextual determinants of the use of telemedicine: A descriptive study of the perceptions of Senegal's physicians and telemedicine projects managers. *PLoS One*, *12*(7), e0181070. doi:10.1371/journal.pone.0181070 PMID:28732028

Mauco, K. L., Scott, R. E., & Mars, M. (2018). Critical analysis of e-health readiness assessment frameworks: Suitability for application in developing countries. *Journal of Telemedicine and Telecare*, *24*(2), 110–117. doi:10.1177/1357633X16686548 PMID:28008790

Mettler, T., Rohner, P., & Winter, R. (2010). Towards a classification of maturity models in information systems. In A. D'Atri, M. De Marco, A. M. Braccini, & F. Cabiddu (Eds.), *Management of the Interconnected World* (pp. 333–340). Physica-Verlag HD. doi:10.1007/978-3-7908-2404-9_39

Muigg, D., Kastner, P., Modre-Osprian, R., Haluza, D., & Duftschmid, G. (2018). Is Austria ready for telemonitoring? A readiness assessment among doctors and patients in the field of diabetes. *Studies in Health Technology and Informatics*, *248*, 322–329. doi:10.3233/978-1-61499-858-7-322 PMID:29726454

NSW Agency for Clinical Innovation. (2015). *Guidelines for the use of telehealth for clinical and non clinical settings in NSW*. Author.

Otto, L., Whitehouse, D., & Schlieter, H. (2019). On the road to telemedicine maturity: A systematic review and classification of telemedicine maturity models. *BLED 2019 Proceedings*, 485–506. doi:10.18690/978-961-286-280-0.26

Oxford Dictionaries. (n.d.). *Mature | Definition of mature in English by Oxford Dictionaries*. Retrieved November 7, 2018, from Oxford Dictionaries | English website: https://en.oxforddictionaries.com/definition/mature

Poeppelbuss, J., & Roeglinger, M. (2011). What makes a useful maturity model? A framework of general design principles for maturity models and its demonstration in business process management. *Proceedings of the ECIS 2011*. Retrieved from http://aisel.aisnet.org/ecis2011/28

Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). New York: Free Press.

Schwarz, F., Ward, J., & Willcock, S. (2014). E-Health readiness in outback communities: An exploratory study. *Rural and Remote Health*, *14*(3), 2871. PMID:25190566

Simmons, R., Fajans, P., & Ghiron, L. (2007). *Scaling up health service delivery: From pilot innovations to policies and programmes*. Geneva: World Health Organization.

Sokolovich, N., & Fera, B. (2015). *UPMC Telehealth Adoption Model—A HIMSS Case Study*. Retrieved from https://exhibitionfloor.himss.org/mhealth2015/Custom/Handout/Speaker0_Session529_2.pdf

Sonnenberg, C., & vom Brocke, J. (2012). Evaluations in the Science of the Artificial – Reconsidering the Build-Evaluate Pattern in Design Science Research. In K. Peffers, M. Rothenberger, & B. Kuechler (Eds.), *DESRIST 2012, LNCS 7286* (pp. 381–397). doi:10.1007/978-3-642-29863-9_28

Sood, S., Mbarika, V., Jugoo, S., Dookhy, R., Doarn, C. R., Prakash, N., & Merrell, R. C. (2007). What is telemedicine? A collection of 104 peer-reviewed perspectives and theoretical underpinnings. *Telemedicine Journal and e-Health*, *13*(5), 573–590. doi:10.1089/tmj.2006.0073 PMID:17999619

The Alliance for Building Capacity. (2002). Framework for rural and remote readiness in telehealth: Project report for CANARIE. Calgary, Canada: Author.

Tillett, S., & Newbold, E. (2006). Grey literature at The British Library: Revealing a hidden resource. *Interlending & Document Supply*, *34*(2), 70–73. doi:10.1108/02641610610669769

Uvin, P. (1995). Fighting hunger at the grassroots: Paths to scaling up. *World Development*, *23*(6), 927–939. doi:10.1016/0305-750X(95)00028-B

van Dyk, L. (2014). A Review of Telehealth Service Implementation Frameworks. *International Journal of Environmental Research and Public Health*, *11*(2), 1279–1298. doi:10.3390/ijerph110201279 PMID:24464237 van Dyk, L., & Schutte, C. S. L. (2012). Development of a maturity model for telemedicine. *South African Journal of Industrial Engineering, 23*(2), 61–72.

van Dyk, L., & Schutte, C. S. L. (2013). The Telemedicine Service Maturity Model: A framework for the measurement and improvement of telemedicine services. In R. Madhavan (Ed.), *Telemedicine* (pp. 217–238). InTech.

Van Someren, M. W., Barnard, Y. F., & Sandberg, J. A. C. (1994). *The think aloud method: A practical approach to modelling cognitive processes*. London: Academic Press.

Venkatesh, V., Thong, J. Y. L., & Xu, X. (2012). Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology. *Management Information Systems Quarterly*, *36*(1), 157–178. doi:10.2307/41410412

Walters, L. E. M., Mars, M., & Scott, R. E. (2016). A review and critique of teledermatology in the South African public health sector. *Studies in Health Technology and Informatics*, *231*, 143–151. PMID:27782026

WHO. (2009). *Practical guidance for scaling up health service innovations*. Geneva: World Health Organization.

Yusif, S., Hafeez-Baig, A., & Soar, J. (2017). e-Health readiness assessment factors and measuring tools: A systematic review. *International Journal of Medical Informatics*, *107*, 56–64. doi:10.1016/j.ijmedinf.2017.08.006 PMID:29029692

Zapka, J., Simpson, K., Hiott, L., Langston, L., Fakhry, S., & Ford, D. (2013). A mixed methods descriptive investigation of readiness to change in rural hospitals participating in a tele-critical care intervention. *BMC Health Services Research*, *13*(1), 1–11. doi:10.1186/1472-6963-13-33 PMID:23360332

Chapter 12
The E-Viewer Study:
Epworth Virtual Ward Round Study

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ABSTRACT

For patients undergoing surgery in a multi-day admission, standard care requires that their surgeon review the patient post-operatively to check on their progress. This is usually done by the specialist attending in person. However, in the Australian setting, most specialists work at multiple institutions. As a result, review ward rounds, especially of post-operative patients, can be delayed, which can delay management decisions and discharge, which in turn may lower patient satisfaction. A telemedicine solution is designed, and results from a pilot test are examined to assess the benefits of incorporating an electronic discharge capability into the current process.

INTRODUCTION

Standard care around discharge typically requires that the patient's surgeon will review the patient post-operatively to check on their progress before the patient may go home. This is usually done by the specialist attending in person. However, in the Australian setting, most specialists work at multiple institutions. As a result, review ward rounds, especially of post-operative patients for example, can be delayed, which can delay management decisions and discharge, which in turn may lower patient satisfaction. To prevent such delays, an often-used alternative is a "phone round", where the specialist checks their patient by speaking with the patient's nurse by phone. However, a phone round does not allow the

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specialist to perform the clinically important end-of-the-bed inspection, and does not provide the patient with the reassurance that they have been reviewed by their doctor. Especially, in today's Digital Age, a technology solution that can both enable more effective and efficient care delivery as well as ensure a higher level of patient satisfaction should be embraced (Haddad, Schaffer, & Wickramasinghe, 2015) .

Telemedicine, whereby doctors consult outpatients via internet video, has been successfully practised in Australia for several years, and is reimbursed by Medicare (Cadilhac et al., 2014; EIKELBOOMa'b, 2012; Thaker, Monypenny, Olver, & Sabesan, 2013). Internet video, using Skype, for example, allows patient and doctor to see and hear each other, as if they were in a consulting room together. The video enables the doctor to perform inspection, but telemedicine cannot currently enable any other part of the physical examination. We contend that this technology could also be used in the inpatient post-operative setting as an adjunct to the current in-person ward rounds. The following outlines the design and initial results from a pilot study to assess the potential benefits of such a solution.

BACKGROUND

To understand the opportunity this project affords for providing a better patient experience as well as supporting more effective and efficient healthcare delivery and addressing and thus support clinician needs, it is necessary to understand key aspects around Telemedicine as well as the Point-of-Care, bedside terminal that is currently in use. In particular, without the Point-of-Care system the proposed study would not have been possible. Hence, a key aspect of this study is also around leveraging existing technologies to provide a better patient and clinician experience.

1.1. Telemedicine

Due to rapid developments in health informatics ((André et al., 2008; Basch, 2005; DesRoches, Painter, & Jha, 2013; Liu, Shih, & Hayes, 2011; Protti, Johansen, & Perez-Torres, 2009; Trudel, 2008), Telemedicine is becoming an important part of healthcare services and care delivery in both public and private hospitals (Zanaboni & Wootton, 2012; Wootton, 1998). Telemedicine enables healthcare organizations to expand their boundaries by using integrated and collaborative IT solutions.

Telemedicine uses and adoption in hospitals is considered as a major development not only at the technological level, but also at sociotechnical and cultural levels (Bashshur, Reardon, & Shannon, 2000; Mahmoud & Lenz, 1995; Perednia & Allen, 1995);. According to Bangert et al. (2000), implementation and adoption of telehealth in hospitals represents a "paradigm shift" and is likely to impact all levels of healthcare organizations. One of the largest telemedicine networks is the Cleveland Clinics on-line second opinion system[1] that enables individuals anywhere in the world to access the Cleveland Clinic to get a second opinion consult.

1.2. The Point of Care System

The Point-of-Care (PoC) system is designed and developed by OneView. This system is a bedside computerized information system whose terminals provide patients with a range of entertainment, education and information services, and clinicians with a range of integrated clinical applications including electronic prescribing and administration, patient results, and electronic nurse rounding. In addition, the system also supports non-clinical functions to cover the food and environmental needs for patients. Given that the Point-of-Care system is already implemented in the private not-for-profit healthcare environment, it makes sense to develop a telemedicine system (e-Viewer) that leverages this existing technology solution. Critical to designing the e-Viewer is an assessment of its fit and viability.

THE EVIEWER STUDY

To answer the research question "how can we use telemedicine to assist in an electronic discharge process?" the following hypotheses were generated around the focus of using the video conferencing capabilities in conjunction with the PoC solutions as an adjunct method for surgeons to conduct inpatient post-operative reviews which will lead to:

i) Equivalent or higher patient satisfaction.
ii) Equivalent or higher VMO satisfaction.
iii) Equivalent or higher ward staff satisfaction.
iv) Greater efficiency of care delivery.
v) Cost savings.

In addition, the following six aims were developed to determine:

1) Feasibility, usability and validity of video conferencing capabilities in conjunction with the PoC as an adjunct for post-operative inpatient review.
2) If using video conferencing capabilities in conjunction with the PoC as an adjunct for post-operative inpatient review is associated with equal or less adverse events than current practice.
3) If using video conferencing capabilities in conjunction with the PoC as an adjunct for post-operative inpatient review will provide equivalent or improved patient, staff and surgeon satisfaction.
4) If using video conferencing capabilities in conjunction with the PoC as an adjunct for post-operative inpatient review will result in less delays in management decisions and patient discharge.
5) If using video conferencing capabilities in conjunction with the PoC as an adjunct for post-operative inpatient review will provide cost savings.
6) If using video conferencing capabilities in conjunction with the PoC as an adjunct for post-operative inpatient review will streamline co-ordination of care.

METHODOLOGY

This study consists of three key phases: design and development of the solution, pilot test of the designed solution and then the clinical trial of the final solution. This paper focuses on phase 2 of this study. The specific telemedicine solution was designed and developed by leveraging the existing OneView Point-of Care (PoC) solution (called the eViewer solution) to incorporate videoconferencing capabilities between the patient beside terminal and the doctor's consulting rooms. This included ensuring required levels of privacy and security were established, ensuring that resolution and audio were of an appropriate quality and to clinician satisfaction which included arranging for specific microphones. In order to design and develop the eViewer solution, Design Science Research Methodology coupled with user centred design principles and co-creation were embraced (A. Hevner & Wickramasinghe, 2018). On the securing of all necessary ethical approvals, an initial pilot study of 20 patients was conducted to assess the usability, feasibility and proof of concept of the designed telemedicine solution over approximately 8 months. Clinicians who have experience with Telehealth were selected to minimise any training issues from the clinicians' side for the pilot study. Clinicians selected patients suitable for the intervention arm using the following criteria:

Inclusion criteria:

- Post-operative patient.
- Patient progressing normally on pathway.

Pilot operations:

- TURP/ Greenlight laser.
- Radical prostatectomy (robotic and open).
- Ureteroscopy/pyeloscopy and laser for stones.

These procedures have been picked because 1) they are urological, 2) TURP and radical prostatectomy are always overnight stays or more (and stone operations commonly are), 3) they are the commonest overnight admission cases

Exclusion criteria:

- Patient requires physical examination beyond simple inspection.
- Impaired cognition of patient.
- New post-operative complication.

Specifically, the study included the video conference application set up on the PoC under biometric control. Surgeons wishing to perform a VWR (virtual ward rounding) call the ward in order to notify the ward clerk that they will video conference with their patient via PoC at the agreed time. To initiate the eViewer discharge scenario, the patient's nurse fingerprints into the patient's PoC and receives the surgeon's video conference call. The VWR takes place with the nurse in attendance. All VWR calls are logged. All patients who have had a VWR completed a self-administered satisfaction questionnaire immediately prior to discharge. In addition all clinicians (nurses and surgeons) complete a satisfaction questionnaire. Length of stay, discharge time of day and adverse events are recorded for all patients who have had a VWR during their admission. At the end of the pilot study period, all surgeons and nursing staff who have used VWR were also part of a focus group session to discuss benefits and challenges of the proposed solution as well as any future enhancements.

It is important to stress that this project is NOT being conducted with a view to have VWRs replacing in-person specialist ward rounds. Instead, it is hoped that this already widely-used technology will be used as an *adjunct* to in-person ward rounds, to improve efficiency of patient care, only on the condition that it is deemed acceptable by patients. In addition patients can opt out of the study at any time with no consequences to the care they will receive. Further, if any unexpected events occur and/or it is found that there is discomfort to a patient the study will be terminated.

Finally, the following benefits are expected; including discharge time to 70% by 10am, increasing patient satisfaction, staff satisfaction and VMO satisfaction. In addition, with the Geelong location going live soon it is expected that this capability will make VMOs more likely to operate in various locations since they can perform ward rounding virtually.

DISCUSSION

As noted, the small pilot consisted of 20 patients. Cleary these numbers at best give direction indications regarding the potential benefits of the designed eViewer solution but are by no means statistically significant. In particular, it was noted that all patients reported high levels of satisfaction with their discharge experience, although some patients did note that further modifications to the video conferencing would serve to enhance the experience further and these recommendations were taken on board. In no more than 2 instances a few minor technical issues made sound quality poor. Without exception all the surgeons in the study preferred the eViewer solution to conduct discharge over the standard care method. With regard to the nurses, while they were positive about the eViewer solution they also noted some process and technical aspects that if addressed would make the use of the eViewer system more seamless. These aspects included patients being changes to a different ward so the system was not set up to be used in the new ward, other nursing activities and unexpected demands on their time which served to interrupt the eViewer session and/or mean a nurse who was not familiar with the system had to conduct the eViewer session while the trained nurse needed to address a different pressing matter. This serves to identify a common aspect when introducing a technology solution into a specific clinical context that workflows and processes must also be examined to identify any unintended consequences and/or opportunities to streamline processes. It was also possible in the small pilot to reach the 70% by 10am discharge time but we note this is only for more than 7 patients in primarily 2 wards; when a result like this run across the whole hospital would be impactful.

Primarily, this study has had significant contributions to practice in the area of clinical discharge in acute care contexts and enabled the developed solution to be tested for usability, fidelity and to establish proof of concept. While we suggested that given the Australian healthcare context with VMOs stands to benefit from a telemedicine supported discharge solution, we do not think these results should be limited to Australia and can also show benefits in other countries for the discharge process and improve patient and clinical satisfaction around this process. The study also contributed to theory at multiple levels including the structuring and running of clinical trials of this nature and the use of design science research methodology, user-centred design principles and co-creation with regard to designing the eViewer solution

CONCLUSION

The proposed use of video conferencing capabilities as an adjunct method for surgeons to conduct in-patient post-operative reviews in the small pilot study did lead to a higher patient satisfaction, higher doctor satisfaction, higher ward staff satisfaction, greater efficiency of care delivery, and discharge time to 70% by 10am, which in turn translates into cost savings. Given these positive directional results a much larger study is now under way with 200 patients. In addition, some of the technical suggestions made by clinicians and patients have been incorporated.

Patient experience is important, and as the discharge process is the last encounter in the acute care facility having a positive discharge experience not only leads to a happy patient but also one who is more likely to comply with post-operative instructions and directions. In acute care facilities clinicians, both nurses and surgeons are very time poor; hence any/all opportunities to enable them to deliver quality care effectively, expeditiously, efficiently and efficaciously is highly desirable. We recognise that this was a small trial, which might be considered a limitation but is also a prudent strategy to follow when one is trying to also be fiscally responsible as well as considerate of clinician time and patient comfort; however, we believe the directional data is useful and does serve to suggest that the stated hypotheses:

i) Equivalent or higher patient satisfaction.
ii) Equivalent or higher VMO satisfaction.
iii) Equivalent or higher ward staff satisfaction.
iv) Greater efficiency of care delivery.
v) Cost savings.

Can be upheld. Again, notwithstanding the small sample size, we also contend that our aims:

1) Feasibility, usability and validity of video conferencing capabilities in conjunction with the PoC as an adjunct for post-operative inpatient review.
2) If using video conferencing capabilities in conjunction with the PoC as an adjunct for post-operative inpatient review is associated with equal or less adverse events than current practice.
3) If using video conferencing capabilities in conjunction with the PoC as an adjunct for post-operative inpatient review will provide improved patient, staff and surgeon satisfaction. 4) If using video conferencing capabilities in conjunction with the PoC as an adjunct for post-operative inpatient review will result in less delays in management decisions and patient discharge.
    5) If using video conferencing capabilities in conjunction with the PoC as an adjunct for post-operative inpatient review will provide cost savings.
    6) If using video conferencing capabilities in conjunction with the PoC as an adjunct for post-operative inpatient review will stream line co-ordination of care.

In closing, it is useful to underscore that this simple study has had many far reaching implications for both theory and practice. From the perspective of theory, it has extended our opportunities when considering telemedicine to focus on an instance in the acute care context around the discharge process and is one of the first such studies in this regard. From the perspective of practice it has highlighted opportunities to improve the patient and clinician experience simultaneously, streamline a key process and critical point; namely, the discharge process, and enable an existing technology solution to be leveraged to do so. In conjunction with these practical implications are also key lessons that can be generalised to any/all technology initiatives in healthcare including; addressing patient and clinician issues or pain points, design a simple and easy to use solution which leverages off existing systems so that one can maximise the return on investment.

REFERENCES

André, B., Inger Ringdal, G., Loge, J. H., Rannestad, T., Laerum, H., & Kaasa, S. (2008). Experiences with the Implementation of Computerized Tools in Health Care Units: A Review Article. *International Journal of Human-Computer Interaction*, *24*(8), 753–775. doi:10.1080/10447310802205768

Bangert, D. C., Doktor, R., Choi, M. H., Warren, J. S., Garshnek, V., & Logan, J. S. (2000). Enhancing medical decision-making through Telemedicine. *International Journal of Healthcare Technology and Management*, *2*(1/2/3/4), 255–270. doi:10.1504/IJHTM.2000.001069

Basch, P. (2005). Electronic health records and the national health information network: Affordable, adoptable, and ready for prime time? *Annals of Internal Medicine*, *143*(3), 227. doi:10.7326/0003-4819-143-3-200508020-00009 PMID:16061921

Bashshur, R. L., Reardon, T. G., & Shannon, G. W. (2000). Telemedicine: A new health care delivery system. *Annual Review of Public Health*, *21*(1), 613–637. doi:10.1146/annurev.publhealth.21.1.613 PMID:10884967

Cadilhac, D. A., Moloczij, N., Denisenko, S., Dewey, H., Disler, P., Winzar, B., ... Bladin, C. (2014). Establishment of an effective acute stroke telemedicine program for Australia: Protocol for the Victorian Stroke Telemedicine project. *International Journal of Stroke*, *9*(2), 252–258. doi:10.1111/ijs.12137 PMID:24148281

DesRoches, C. M., Painter, M. W., & Jha, A. K. (2013). *Health information technology in the United States: better information systems for better care, 2013*. Mathematica Policy Research.

Eikelbooma'b, R. H. (2012). The telegraph and the beginnings of telemedicine in Australia. *Global Telehealth 2012: Delivering Quality Healthcare Anywhere Through Telehealth: Selected Papers from Global Telehealth 2012 (GT2012), 182*, 67.

Haddad, P., Schaffer, J., & Wickramasinghe, N. (2015). Evaluating Business Value of IT in Healthcare: Three Clinical Practices from Australia and the US. *Proceedings of the 15th World Congress on Health and Biomedical Informatics*.

Hevner, A., & Wickramasinghe, N. (2018). *Design Science Research Methodology in Healthcare* (W. a. Schaffer, Ed.). New York: Springer.

Liu, L. S., Shih, P. C., & Hayes, G. R. (2011). Barriers to the adoption and use of personal health record systems. *Proceedings of the 2011 iConference*. 10.1145/1940761.1940811

Mahmud, K., & Lenz, J. (1995). The personal telemedicine system. A new tool for the delivery of health care. *Journal of Telemedicine and Telecare*, *1*(3), 173–177. doi:10.1177/1357633X9500100307 PMID:9375138

Perednia, D. A., & Allen, A. (1995). Telemedicine technology and clinical applications. *Journal of the American Medical Association*, *273*(6), 483–488. doi:10.1001/jama.1995.03520300057037 PMID:7837367

Protti, D., Johansen, I., & Perez-Torres, F. (2009). Comparing the application of Health Information Technology in primary care in Denmark and Andalucía, Spain. *International Journal of Medical Informatics, 78*(4), 270-283.

Thaker, D. A., Monypenny, R., Olver, I., & Sabesan, S. (2013). Cost savings from a telemedicine model of care in northern Queensland, Australia. *The Medical Journal of Australia*, *199*(6), 414–417. doi:10.5694/mja12.11781 PMID:24033216

Trudel, M.-C. (2008). *Challenges to personal information sharing in interorganizational settings: Learning from the Quebec Health Smart Card project*. School of Graduate and Postdoctoral Studies, University of Western Ontario.

Wootton, R. (1998). Telemedicine in the national health service. *Journal of the Royal Society of Medicine*, *91*(12), 614–621. doi:10.1177/014107689809101202 PMID:10730107

Zanaboni, P., & Wootton, R. (2012). Adoption of telemedicine: From pilot stage to routine delivery. *BMC Medical Informatics and Decision Making*, *12*(1), 1. doi:10.1186/1472-6947-12-1 PMID:22217121

ENDNOTE

[1] https://my.clevelandclinic.org/

Chapter 13
The Role of Crowdsourcing in the Healthcare Industry

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ABSTRACT

Crowdsourcing has a role to play in solving healthcare-based problems as it can tap into a vast pool of global medical knowledge. This chapter first categorizes the various problems in the healthcare industry. It then describes the differences in various medical traditions in solving medical problems. The chapter also discusses the challenges in identifying the ideal medical solution. It notes the various types of obstacles to adopting effective healthcare solutions and suggests crowdsourcing solutions that could build up an impetus for bringing about positive change. Finally, the chapter emphasizes the potential of crowdsourcing to disrupt old ideas and introduce new ones as well as 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 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.

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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 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 suggest recommended future paths of actions.

The chapter consists of six 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 second 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 next two sections discuss two different types of problems facing the health care industry. The third section discusses the various challenges facing the dissemination of knowledge in the health care industry. This section discusses possible solutions for overcoming problems specific to these knowledge-based deficiencies. The fourth section discusses an entirely different type of problem that also faces the health care industry. This problem emanates from the resistance to adopting more efficient health care solutions because of resistance from different sectors in society. These include various parties, perhaps inadvertently, resisting the adoption of new methods or systems of disseminating medicine within society. The next section summarizes the approach of some popular crowdsourcing sites for dealing with health care issues. This section suggests incorporating some of the existing approaches in crowdsourcing but also expanding the sources of inputs to include individuals from outside the frontiers of traditional Western medicine. The challenge is to aggregate these suggestions from myriad disciplines to a cogent whole using transparent methods. 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.

a. 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 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.

b. 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.

c. 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.

d. 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 contrasts with 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.

a. 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.

b. 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.

c. 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.

d. 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 contrasts with 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.

e. 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 IN SOLVING KNOWLEDGE BASED CHALLENGES

The Different Types of Failures related to Knowledge

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.

a. 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 home 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.

b. 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.

c. 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 piece of knowledge is the critical portion (Jensen & 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 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 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 try 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'S ROLE IN OVERCOMING OTHER CHALLENGES

While the health care professional's primary challenges are related to the discovery of effective medical solutions, there are cases, where a health care provider's work is frustrated by the inability to implement proven solutions. These are instances of what was earlier described as "known known" challenges. Two different types of impediments can inhibit the adoption of "known known" solutions. The first emanates from ignorance or misapprehension about a proven medical method. Often, this leads to public resistance to a medical program. The second type of resistance arises from vested interests who are focused on their own profit motives to the detriment of the provision of a broad-based cost-efficient solution. Crowd sourcing platforms manned by medical professionals can lower the resistance to the adoption of efficient solutions by providing information appropriate to each situation.

a. Public Misapprehension or Ignorance

Researchers suggest that the opposition to vaccination programs in the USA has its roots in the resistance to excessive government interference or misinformation about previous programs (Novak, 2018). Past programs which had defects in its implementation or wrong information about the contents of a vaccine sometimes increased public resistance to vaccination (Dartmouth College, 2019). In these types of situations, a slow and patient campaign, both in ensuring the quality of the final product as well as its delivery, should be developed. A crowd sourcing site available to the general public should be able to overcome public misapprehension and ignorance. This site should provide unbiased information and also enable certified health care professionals to respond to queries from concerned citizens. The success of these crowd sourcing sites will however be inextricably linked to the quality and delivery of the actual medical solution, as any potential defect will increase future resistance.

b. Resistance from Vested Interests

In many cases, various public bodies, including but not limited to pharmaceutical and insurance companies, medical retailers and health care professionals, could have a vested interest in the continuation of existing systems of providing health care. Unfortunately, these systems might not be cost effective in providing satisfactory medical solutions. Here, rather than only medical solutions, improvements in service delivery are also called for. This is because in addition to questions about the type of medication and the dosage, other elements of more cost-effective preventive schemes could come into play. In these cases, concerned health care professionals can play an important proactive role by starting a crowd sourcing service which solicits opinions and potential solutions about the key ingredients of an ideal health care system. Comparison of notes across a global body of experienced health care experts can over time build a “wish list” of the elements of an ideal health care delivery system. These experts should then solicit global support for the adoption of methods that have the promise of improving the status quo. The success of these type of crowdsourcing sites will be dependent on having a start-up group of dedicated and knowledgeable, health care professionals, not associated with groups with vested interests. This vanguard team must be willing to change the existing order of things. The crowd sourcing site should be seeded by a core group of such health care professionals. Gradually, this crowdsourcing service should be able to build up support for better health care delivery systems. Over time, the groundswell of this support should be able to overcome narrow, profit based vested interests.

EXISTING CROWDSOURCING SERVICES

With the increasing global influence of the internet, many healthcare professionals have already started different crowdsourcing sites to share knowledge within the medical community. Harper (2013) discusses the approaches of some popular healthcare crowdsourcing sites. An analysis of their diverse approaches provides an opportunity to evaluate the salient features that need to be incorporated by new entrants in the field. At the same time, an analysis of existing sites reveals gaps that need to be filled in the future.

Some of the sites discussed by Harper (2013) are: HealthMap, Sickweather, Global Public Health Intelligence Network (GPHIN) and CrowdMed. In addition to these sites, other crowdsourcing sites such as Patientslikeme, CureCrowd and SERMO also cater to health care problems. These sites have different approaches. For example, HealthMap monitors outbreaks of diseases around the world and tracks disease trends in real time. Sickweather and GPHIN also monitor social network sites to track the outbreak of diseases around the world. All these sites attempt to track the spread of diseases in real time and provide health care professionals with advance knowledge of the regions where specific diseases are likely to spread. In contrast to these sites, CrowdMed and Patientslikeme offer platforms to actual patients to discuss their personal stories and remedies that worked (or did not work) for them. CrowdMed also invites practitioners and the public at large to offer their insights about specific medical conditions. CureCrowd and SERMO are sites started by medical practitioners to discuss specific healthcare issues. Doctors can ask for advice from other doctors and also offer their own insights about questions posted by other health care professionals[1].

These sites show the potential of crowdsourcing sites to share knowledge among both healthcare professionals and patients. However, two unexplored areas need to be also brought into the scope of discussion. First, the "known known" problems alluded to in the last section call for the inclusion of opinions from professionals such as economists and managerial staff who have worked in the health care industry. Because of their experience in the health care industry, these individuals might be aware of the barriers that prevent the adoption of efficient health care delivery systems. At the same time, crowd sourcing systems must also make an effort to provide factual based evidence to overcome misinformation in the public domain about common diseases and their cures. Second, the potential crowdsourcing sites should make an attempt to widen their net to include the inputs of sectors of the population who are aware of cures and remedies from disciplines outside the scope of traditional Western medicine. This involves not only soliciting opinions from groups who have not been actively involved with mainstream crowdsourcing sites before, but also finding a middle ground which incorporates testing their suggestions using the "tried and tested" standards of modern Western medicine. This challenge of bringing individuals from different medical backgrounds to communicate with one another is daunting, but has the potential of uncovering many "unknown known" solutions for the future.

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 (Tepper, 2013). 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 has the potential to highlight the contributions of hitherto neglected pockets of the global population (Wallace, 2012). In addition to bringing to light neglected sources of remedies and discovering completely new medical solutions, crowdsourcing sites also have the potential to bring together health care professionals, who are dissatisfied with existing medical delivery systems. Dialogue between groups of such professionals can offer insights into possible routes to improving existing medical coverage schemes.

REFERENCES

Akst, J. (2013). *The elixir tragedy, 1937*. Retrieved June 29, 2015, from http://www.the-scientist.com/?articles.view/articleNo/35714/title/The-Elixir-Tragedy--1937/

American Cancer Society. (2014). *Can pancreatic cancer be found early?* Retrieved June 29, 2015, from http://www.cancer.org/cancer/pancreaticcancer/detailedguide/pancreatic-cancer-detection

Arnold, C. (2014). *NOVA Next: Can the Crowd solve medical mysteries?* Retrieved June 26, 2015, from http://www.pbs.org/wgbh/nova/next/body/crowdsourcing-medical-diagnoses

Budescu, D. V., & Chen, E. (2015). Identifying expertise to extract the wisdom of crowds. *Management Science*, *61*(2), 267–280. doi:10.1287/mnsc.2014.1909

Coulter, H. L. (1995). An update on the history of homeopathic and allopathic medicine. *Journal of the American Institute of Homeopathy*, *88*(3), 122–126.

CrowdMed.com. (2019). Retrieved September 6, 2019, from https://www.crowdmed.com/?utm_medium=cpc&utm_source=bing&utm_campaign=bing-brand&utm_keyword=crowdmed

CureCrowd.com. (2019). Retrieved September 6, 2019, from https://www.curecrowd.com/

Dartmouth College. (2019). Research explains public resistance to vaccination. *Science Daily*. Retrieved June 30, 2019, from https://www.sciencedaily.com/releases/2019/01/190109090933.htm

Finando, S., & Finando, D. (2012). Qi, acupuncture and the fascia: A reconsideration the fundamental principles of acupuncture. *Journal of Alternative and Complementary Medicine (New York, N.Y.)*, *18*(9), 880–886. doi:10.1089/acm.2011.0599 PMID:22874011

Global Public Health Intelligence Network (GPHIN). (2019). Retrieved September 6, 2019, from https://gphin.canada.ca/cepr/listarticles.jsp?language=en_CA

Harper, L. (2013). The top 5 sites crowdsourcing for your health. *Milken Institute School of Public Health*. Retrieved September 6, 2019, from https://publichealthonline.gwu.edu/top-5-sites-crowdsourcing-health/

Hayek, F. A. (1945). The use of knowledge in society. *The American Economic Review*, *35*(4), 519–530.

Healthmap.org. (2019). Retrieved September 7, 2019, from https://healthmap.org/en/

Jain, R. (2010, August). Investigation of Governance Mechanisms for Crowdsourcing Initiatives. In *Americas Conference for Information Systems Conference Proceedings* (p. 557). Academic Press.

Jensen, M. C., & Meckling, W. H. (1992). Specific and general knowledge, and organizational structure. In L. Werin & H. Wijkander (Eds.), *Contract Economics* (pp. 251–274). Oxford, UK: Blackwell.

More, D. (2014). *Sulfa drug allergy*. Retrieved June 29, 2015, from http://allergies.about.com/od/medicationallergies/a/sulfa.htm

Novak, S. (2018, Dec.). The long history of America's anti-vaccination movement. *Discover*.

Parker, S. (2013). Kill or cure: The illustrated history of medicine. London, UK: DK.

Patientslikeme.com. (2019). Retrieved September 6, 2019, from https://www.patientslikeme.com/

Peisl, T., Selen, W., Raeside, R., & Alber, T. (2014). Predictive crowding as a concept to support the assessment of disruptive ideas: A conceptual framework. *Journal of New Business Ideas and Trends*, *12*(2), 1–13.

Polanyi, M. (1966). *The Tacit dimension*. Chicago: University of Chicago Press.

Rumsfeld, D. (2002). *DOD News Briefing*. Retrieved June 29, 2015, from http://www.defense.gov/transcripts/transcript.aspx?transcriptid=2636

Schrotenboer, B. (2015). *How Soviet Union science helped American sports heroes*. Retrieved July 7, 2015, from http://www.usatoday.com/story/sports/2015/05/18/goride-howe-stem-cells-john-brodie-stemedica-soviet-union-fetal/27504019/

SERMO.com. (2019). Retrieved September 6, 2019, from https://www.sermo.com/

Sickweather.com. (2019). Retrieved September 7, 2019, from http://www.sickweather.com/index.php

Subbarayappa, B. V. (2001). The roots of ancient medicine. *Journal of Biosciences*, *26*(2), 135–144. doi:10.1007/BF02703637 PMID:11426049

ENDNOTE

1 The web addresses to these crowdsourcing sites are available in the References section.

Chapter 14
A Sentiment Analysis of the 2014–15 Ebola Outbreak in the Media and Social Media

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ABSTRACT

The negative and unbalanced nature of media and social media coverage has amplified anxieties and fears about the Ebola outbreak. The authors analyse news articles on the Ebola outbreak from two leading news outlets, together with comments on the articles from a well-known social media platform, from March 2014 to July 2015. The volume of news articles was greatest between August 2014 and January 2015, with a spike in October 2014, and was driven by the few cases of transmission in Europe and the USA. Sentiment analysis reveals coverage and commentary on the small number of Ebola cases in Europe and the USA were much more extensive than coverage and commentary on the outbreak in West Africa. Articles expressing negative sentiments were more common in the USA and also received more comments than those expressing positive sentiments. The negative sentiments expressed in the media and social media amplified fears about an Ebola outbreak outside West Africa, which increased pressure for unwarranted and wasteful precautionary measures.

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INTRODUCTION

The Ebola outbreak in West Africa began in late 2013, and was declared as an international public health emergency by the World Health Organization (WHO) on 8th August 2014 (WHO 2014). A total of 28,616 cases of Ebola virus disease (EVD) and 11,310 deaths were reported in Guinea, Liberia, and Sierra Leone (WHO, 2016). There were an additional 36 cases and 15 deaths that occurred when the outbreak spread outside of these three countries that include Italy, Mali, Nigeria, Senegal, Spain, United Kingdom and United States. By 7th October 2015, the WHO reported its first week with any new Ebola cases, and on 26 March 2016, it lifted the Public Health Emergencies of International Concern (PHEIC) status of West Africa.

In the 2014 – 2015 outbreak, coverage of Ebola was extensive in the media and social media but was also narrow, negative, and unbalanced (Funge et al., 2014). As mentioned in a Lancet editorial of November 2014, a "disproportionate airtime has been given to the nine confirmed American cases of Ebola compared with the massive human crisis unfolding in Liberia, Guinea, and Sierra Leone" (Lancet, 2014, pg 1). While Europe and the USA demonstrated preparedness by identifying cases, isolating them, treating and quarantining contacts, media coverage of the outbreak created a parallel epidemic of fear and fueled demand for additional, ineffective and unnecessary precautionary measures (Mira et al., 2015). These measures included temperature screening at airports, the cancellation of flights to West Africa, and the isolation and quarantining of asymptomatic health workers and other returning from the region (Mello et al., 2005).

However, evidence is missing on the role played by the social media in molding public perceptions about the risks of Ebola. The research problem addressed in this study is to determine how the attitudes of writers of news articles and comments on the Ebola outbreak influenced public perceptions towards it in Europe and America, thereby amplifying fears about an Ebola outbreak in the West. This paper employs sentiment analysis (Deng et al., 2018; Lak et al., 2017), a textual analysis method originating in the computational linguistics and natural language processing literature, to determine the attitudes of writers of news articles and comments toward the Ebola outbreak. We applied design science steps to plot and present the findings from the sentiment analysis based on the six activities of design science research (Baskerville et al., 2018). Thus, to analyse the research question, we collected coverage on the Ebola outbreak from two leading news services on either side of the Atlantic (the British Broadcasting Corporation (BBC) and the US-based Cable Network News (CNN), together with follow-up comments from a well-known social media platform (Reddit), and conducted an in-depth sentiment analysis. Our findings suggest that the negative and unbalanced nature of news coverage in Europe and the USA amplified public anxieties and fears about the Ebola outbreak outside West Africa.

Literature Review

From the start of Ebola in August 2014 till to its official end in March 2016, most studies focused on how to handle Ebola (Kruk, 2015; Gostin, 2015). The loss of life, social disruption, and failure of health-care systems demonstrate what happens when a crisis like Ebola hits the world (Peterson, 2015; Asamoah at al., 2015). Ebola is covered as an emerging social issue often led to rumors breeding and propagation in social media in various parts of the world (Ye et al., 2018). Guah (2017) presents the resilience during Liberia's Ebola epidemic while, Ding et al., (2016) investigates people's online prosocial microlending decision making after a natural disaster like Ebola in Africa. Chung et al., (2015) visualized Ebola outbreak discussions on Twitter by presenting an approach to social-media-based public health informatics by using 255,118 tweets posted by 210,900 users in January 2015. The Western media's coverage of the Ebola outbreak in West Africa in mid-2014 has been compared to their response to avian influenza, H1N1, SARS, and even the early years of the HIV-AIDS pandemic (Honigsbaum, 2017). Another study analyzed 2,276 unique tweets about Ebola in twitter and showed the use design science methodology that provides direct guidelines for better understanding the problem (Chatterjee et al., 2017).

Sentiment analysis is an area that is active in the field of information systems, computer science and media studies (Deng et al., 2018; Lak et al., 2017). Media and social media plays an important role in sentiment analysis of the content shared specially, due to the recent growth of social media platforms through numerous blogs, microblogs, forums, and social networks (Riloff et al., 2003; Yu & Hatzivassiloglou 2003). Sentiment analysis are important tools used today for understanding large amounts of social media data (Abbasi et al. 2008; Mohammad et al. 2013). Social media are increasingly important information sources for understanding public sentiments by identifying opinion leaders in discussion forums (Song et al. 2007) and visualizing networked relationships of infectious disease transmission. However, very little work is found in analyzing emotion to support public health policy decision making in situation like Ebola in Africa.

Design science is a new research paradigm in information systems (Gregor & Hevner, 2013). Design science is used to solve an identified problem by building socio-technical artefacts (Myers & Venable, 2014). Seven guidelines presented by Hevner et al. (2004) originated from information-systems design theory originally proposed by Walls et al. (1992). The six steps proposed by Peffers et al. (2007) are problem identification and motivation, definition of the objectives for a solution, design and development, demonstration, evaluation, and communication. The design science theory as a methodology needs to be incorporating these steps. There is also a need to give a minimal procedure and a mental model for offering and assessing the design science research (Peffers et al., 2007). As we propose sentiment analysis, the design science theory provides a groundwork for thoroughly specifying its design. Thus, this paper presents an instantiation of solving the problem of sentiment analysis of media and social media by developing a computational model for sentimental analysis. This is a classic example of computational genre of design science research (Rai, 2017).

Data and Methodology

To identify news coverage on Ebola outbreak, we used two leading news services, the BCC and CNN. This selection was based on Alexa's rankings of the top 15 news sites, in which BBC and CNN scored the top global ranks among reputable news outlets. We then downloaded all news headlines in 2014 and the first half of 2015 from these news services with the search term 'Ebola'. For BBC, we filtered to 'News' and for CNN, we filtered to 'Story and article' in English. This resulted in 889 unique news headlines from BBC and 486 unique news headlines from CNN.

To capture the perceptions and the sentiments generated in the social media by the news articles, we collected comments from Reddit.com. Reddit is the top news social media ranked by Alexa where registered members can submit content such as text posts or direct links. Reddit comments are the follow up discussions to news articles posted by users. We located 502 articles with the word 'Ebola' in the title that has been shared and discussed in Reddit, of which 276 were BBC articles and 226 from CNN. A total of 26,948 comments were made on these 502 articles.

Sentiment analysis involves calculating polarity scores—which show whether the opinions expressed in the text are positive, negative or neutral—for pieces of text (such as sentences or paragraphs) using an algorithm and sentiment dictionary (Pang & Lilian, 2005; Liu, 2015) This article employs the widely used R package qdap to code the algorithm for analyzing the sentiments of the articles together with the sentiment dictionary developed by Hu and Liu, 2004. Polarizing words, such as 'contagious' or 'epidemic' (negative) or 'recovery' and 'treatment' (positive), are identified in each sentence.

The cluster of neighboring words is then examined to see how valence shifters (such as 'highly',' partially', or 'never') act as amplifiers, deamplifier or negators of the polarized words. By identifying positive or negative words and weighting using the neighboring valence shifters, a polarity score between minus one and plus one is assigned to each sentence. For example, the sentence, 'If I contracted Ebola, I'd definitely kill myself.' has two negative words ('contracted' and 'kill'), one valence shifter ('definitely') and results in a polarity score of -0·458. In contrast the sentence, "This is good news for getting an effective vaccine for Ebola." has three positive words ('good', effective' and 'vaccine') and a polarity score of +0·424. The polarity scores assigned to each sentence are then summed and averaged over the number of sentences to give a total polarity score for the article or comment. Table 1 gives a list of the top twenty articles about Ebola based on the number of social media comments.

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We applied design science to plot and present the findings from the sentiment analysis based on the six activities of design science research as detailed by Peffers et al. (2007). These are:

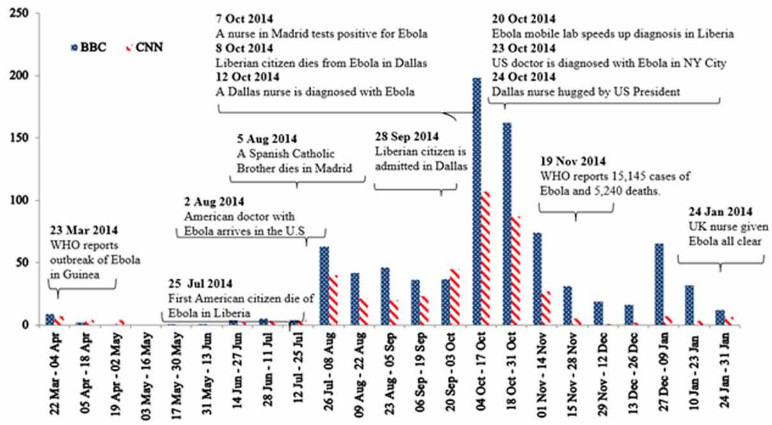
- Problem identification and motivation: The problem identified in this paper is to determine how the attitudes of writers of news articles and comments on the Ebola outbreak influenced public perceptions towards it in Europe and America, thereby amplifying fears about an Ebola outbreak in the West. The problem identified will help in understanding the linkage between the digital artefact designed for conducting sentiment analysis by embracing design thinking practices.
- Define the objective of a solution: Developing sentiment analysis and applying to the data collected from various news and social media defines the objective of the solution that result in a viable artefact.

Table 1: List of top twenty articles (2014 – 2015) about Ebola based on number of social media comments

Headline	Source	Date	Total Article Polarity Score	Number of Comments
A 2nd American has now tested positive for Ebola	CNN	27/07/2014	-0·17893	2356
People actively resisting Ebola Treatment	BBC	28/07/2014	-0·74212	213
Liberia closes borders. Trying to stop spread of the Ebola Virus	BBC	28/07/2014	-0·89686	425
Ebola 'spreading too fast' – WHO	BBC	1/08/2014	-0·75898	1426
Ebola is declared an international health emergency	BBC	8/08/2014	-1·22527	1249
A Spanish missionary who contracted the Ebola virus while working in West Africa has died in hospital in Madrid	BBC	12/08/2014	-1·45326	561
Blood-stained bedding looted from Ebola quarantine centre	BBC	17/08/2014	-3·05078	929
Ebola Doctor to be released from Atlanta hospital after tests show he has recovered	CNN	21/08/2014	1·756349	192
Ebola outbreak "threatens Liberia's national existence"	BBC	10/09/2014	-4·02918	171
Ebola Patients Buying Survivors' Blood from Black Market, WHO Warns	CNN	20/09/2014	-2·16222	377
Woman saves three relatives from Ebola. Her protection method is being taught to others in West Africa	CNN	29/09/2014	-0·27185	471
Ebola outbreak: '80 monitored' in Dallas, Texas	BBC	2/10/2014	-1·12334	341
Four People Still Living Inside Apartment of U.S. Ebola Patient	CNN	3/10/2014	0·960795	222
Nurse 'infected with Ebola' in Spain	BBC	6/10/2014	-2·46897	2548
Texas healthcare worker tests positive for Ebola	CNN	12/10/2014	-4·37207	4323
The Ebola epidemic threatens the "very survival" of societies and could lead to failed states	BBC	13/10/2014	-1·69021	165
Ebola cases now over 8900, death toll rises to 4,447, says WHO	BBC	14/10/2014	-1·25622	326
Spanish nurse who became first person to contract Ebola outside Africa tests negative for the virus	BBC	19/10/2014	-1·13586	164
Patient in NYC Tests Positive for Ebola	CNN	24/10/2014	-2·40009	5830
Quarantined nurse who tested negative twice for Ebola said that her human rights were violated	CNN	26/10/2014	0·30013	456

- Design and Development: The designed artefact in this paper is an instantiation of sentiment analysis as evidenced in the figure 2 and 3.
- Evaluation: We evaluated the artefact based on data collected from BBC, CNN and Reddit.com. The evaluation demonstrated clear evidence of improved precision of sentiment analysis.
- Communication: We published the findings and its applicability on media and social media. This study can be extended to apply and evaluate the sentiments of other types of content in social media, like tweets and comments in social media.

Figure 1. Number of BBC and CNN news articles concerning Ebola, 2014-15



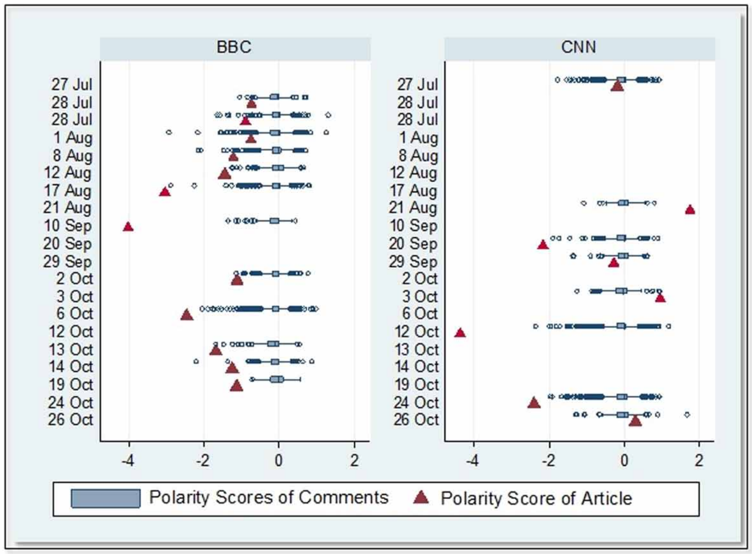
RESULTS

Figure 1 plots the number of news articles on Ebola on a fortnightly basis between January 2014 and July 2015. In the four months following the WHO's declaration of the Ebola outbreak in Guinea (23rd March 2014), there were just 47 articles published by the BBC and 32 articles published by the CNN. However, once an American doctor with Ebola virus diseases arrived in the USA and was confined in isolation at Atlanta (2nd August 2014), news coverage of Ebola increased more than tenfold. News coverage then spiked in October, when healthcare workers in Madrid and Dallas tested positive for Ebola, and a doctor was diagnosed with Ebola in New York. With no further cases recorded in Europe and the US, and declining rates of infection and improved survivals rates in West Africa, subsequent news coverage of Ebola was less extensive. However, a confirmed Ebola case in Glasgow led to a sudden increase in the number of BBC, though not CNN, articles in late December and mid-January. The declaration of end of the Ebola outbreak in April 2015 and a few new Ebola cases in Liberia in June/July 2015 generated very little news coverage.

Thus, Figure 1 provides strong evidence of a news 'bubble' generated by the four confirmed American and two confirmed European cases of Ebola in third and fourth quarters of 2014. This is the same period during which an 'epidemic of fear' concerning Ebola occurred in the USA, which led to the quarantining of asymptomatic health workers and travelers in at least eight US states plus the District of Colombia (Gonsalves et al., 2014). At this time, several European countries (including Belgium, France and the United Kingdom), introduced airport screening of travelers arriving from West Africa, despite disagreements among European Union health ministers about the need for such measures. An opinion poll in November 2014 revealed that the American public ranked Ebola as the third most urgent health problem in the country, after cost and access and above cancer and heart-diseases.

The sentiment analysis was performed on a total of 14,327 comments for 502 articles during the period of intense media interest concerning Ebola that occurred between July and November 2014. The sentiment analysis illustrates the flow of sentiments demonstrated by users in Reddit, with the average total polarity of the comments posted, reported on a daily basis. The average polarity score (-0·118) of the 6,403 comments on CNN articles were more negative than the average polarity score (-0·088) of the 7,924 comments on BBC articles. Social media sentiment started out as highly negative and remained

Figure 2: Polarity scores of articles and their comments



negative, with an average score of -0·1 until October but started to neutralize during November based on the recovery of healthcare workers in the US and Europe and the news of declining rates of infection in Guinea and Liberia. However, as can be seen from the analysis that, there was a wide variation in the average polarity scores on the daily comments, with 83% of days attracting negative comments on average.

To understand the relationship between the sentiments of the articles in the media and related discussion by the community in the social media, we selected the 20 articles with the highest number of social media comments. Table 1 gives the list of twenty articles sorted according to the chronological order. Among the twenty articles, twelve articles are from BBC and eight articles are from CNN. It is interesting to note that the article on "Patient in NYC tests positive for Ebola" (24th October 2014) received the highest number of comments (5830 comments), followed by "Texas healthcare worker tests positive for Ebola" (12th October 2014) with 4323 comments, and "Nurse infected with Ebola in Spain" (6th October 2014) with 2548 comments. It should be noted that articles with positive polarity are both rarer (3 articles among the top 20 articles) and attracted fewer comments (an average of 290 comments for positive articles compared to 1215 comments for negative articles).

Articles with the most negative or positive polarity scores did not receive the most comments. The article with the lowest negative polarity score is "Texas healthcare worker tests positive for Ebola" (CNN, 12th October 2014) which is the second most commented article with 4,323 comments. However, the article with the second most negative polarity score is "Ebola outbreak threatens Liberia's national existence" (BBC, 10th September 2014), and received just 171 comments and is one of the least commented articles among the top 20 articles. The two articles with the highest positive polarity scores are "Ebola Doctor to be released from Atlanta hospital (CNN, 21st August 2014) and "Four people still living inside apartment of U.S. Ebola patient" (CNN, 3rd October 2014). Both these articles received less than 225 comments.

Articles on the small number of Ebola cases in Europe and the USA received far more comments, and comments of a more negative nature, than those on the Ebola outbreak in West Africa. The ten top articles on Ebola in Europe and the USA received a total of 16,993 comments while the ten articles on the Ebola in West Africa received a total of 5,753 comments. Furthermore, the total polarity of all comments on the European and US articles was - 785·1 compared to -383·8 for comments on the outbreak in West Africa. This suggests it was fears of an Ebola outbreak outside Africa, in particular news that healthcare workers in Europe and the USA had contracted the disease, which drove the wave of negative sentiments in the Western social media.

Figure 2 compares the polarity scores of the original news articles and the social media comments they generated. The triangles show the polarity scores of the original articles. The box plots show the interquartile range, outer quartiles and outliers for the polarity scores of the comments on each news article. There is very low correlation between the polarity scores of the article and comments ($\rho<0.06$) with a slightly higher correlation found for the comments on CNN articles. It is interesting to note that the polarity of the comments on BBC articles were generally more positive than those for the original articles, while those for CNN articles were more one-sided. This may indicate a more optimistic and independent stance among commentators of the BBC articles. The BBC articles were also generally reporting on different events than the CNN's and contained more detailed coverage of the situation in West Africa. Figure 3 gives the sentiments of the comments for the top 20 most commented articles. It is evident that the comments were negative.

CONCLUSION

In this paper, we have conducted a sentiment analysis of BBC and CNN news articles and social media comments during the Ebola outbreak in West Africa from 2014-15. By using a sentiment analysis combined with a design science approach, we show that the volume of news articles and comments peaked between August 2014 and January 2015, with a marked spike in October 2014. Both news articles and comments were heavily biased towards the few cases of Ebola transmission in Europe and the USA (Peterson, 2015). While there was a wide variation of polarity scores of comments on these articles, more than four-fifths were dominated by negative comments. This is similar to the Western Media's response to avian influenza, H1N1, SARS, and even the early years of the HIV-AIDS pandemic (Honigsbaum, 2017). Articles expressing positive sentiments about Ebola received substantially fewer comments than articles expressing negative sentiments, with the commentary on BBC news articles being generally more positive than those on CNN articles.

Thus, largely unwarranted public fears about an Ebola outbreak outside West Africa appear to have been amplified by negative sentiments in the media and social media, especially in the United States. In the absence of prompt and effective communication by public health agencies, this led to a series of unwarranted and wasteful preventative measures being implemented at the state and national levels. To add on, as reported on 7th April 2019, in the recent outbreak, the number of Ebola virus disease (EVD) cases in the North Kivu provinces of the Democratic Republic of the Congo is 1156 cases and 731 deaths (WHO, 2019). However, the recent outbreak is well handled when compared to the earlier outbreak. As part of future work, there is a need to examine the second Ebola outbreak in the Democratic Republic of the Congo, in media and in social media and how the lessons learnt from 2014-2015 Ebola outbreak improved the situation.

REFERENCES

Abbasi, A., Chen, H., Thoms, S., & Fu, T. (2008). Affect analysis of web forums and blogs using correlation ensembles. *IEEE Transactions on Knowledge and Data Engineering*, *20*(9), 1168-1180.

Asamoah, D., Sharda, R., & Thandapani Kumarasamy, A. (2015). Can Social Media Support Public Health? Demonstrating Disease Surveillance using Big Data Analytics. *Proceedings of the Twenty-first Americas Conference on Information Systems*.

Baskerville, R., Baiyere, A., Gregor, S., Hevner, A., & Rossi, M. (2018). Design science research contributions: finding a balance between artifact and theory. *Journal of the Association for Information Systems, 19*(5), 358-376.

Chatterjee, S., Deng, S., & Liu, J. (2017). Improving Opinion Mining by Classifying Facts and Opinions in Twitter. *Proceedings of the American Conference on Information Systems*, 2017

Chung, W., He, S., & Zeng, D. (2015). emood: Modeling emotion for social media analytics on Ebola disease outbreak. *Proceedings of the International Conference on Information Systems.*

Dempsey, L. A. (2018). *Targeting Ebola*. Nature Microbiology.

Deng, S., Huang, Z., Sinha, AP, & Zhao, H. (2018). The Interaction Between Microblog Sentiment and Stock Returns: An Empirical Examination. *MIS Quarterly*, *42*(3), 895-918.

Ding, Y., Xu, H., Yang, L., & Tan, B. C. (2016). Online Prosocial Microlending Decision Making: A Natural Experiment of Ebola Outbreak. *Proceedings of the International Conference on Information Systems*.

Funge, I., Zion, T., Chi-Ngai, C., Adriana, S., & King-Wa, F. (2014). Ebola and the social media. *Lancet*, *384*, 207.

Gonsalves, G., & Staley, P. (2014, December). Panic, Paranoia, and Public Health— The AIDS Epidemic's Lessons for Ebola. *The New England Journal of Medicine*, *371*(25), 2348–2349. doi:10.1056/NEJMp1413425 PMID:25372947

Gostin, L.O., & Friedman, E.A. (2015). A retrospective and prospective analysis of the west African Ebola virus disease epidemic: robust national health systems at the foundation and an empowered WHO at the apex. *Lancet*, *385*(9980), 1902-1909.

Gregor, S., & Hevner, A. R. (2013). Positioning and presenting design science research for maximum impact. *Management Information Systems Quarterly*, *37*(2), 337–355. doi:10.25300/MISQ/2013/37.2.01

Guah, M. W. (2017). Resilience in the Gaze of Ebola: Analysis from a Developing Country. *Proceedings of the 50th Hawaii International Conference on System Sciences.* 10.24251/HICSS.2017.304

Hevner, A., March, S.T., Park, J., & Ram, S. (2004). Design science research in information systems. *MIS Quarterly, 28*(1), 75-105.

Honigsbaum, M. (2017). Between securitisation and neglect: managing Ebola at the borders of global health. *Medical History*, *61*(2), 270-294.

Hu, M., & Liu. (2004). *Mining and summarizing customer reviews*. Paper presented at the ACM SIGKDD International Conference on Knowledge Discovery and Data Mining, Seattle, WA.

Kruk, M.E., Myers, M., Varpilah, S.T., & Dahn, B.T. (2015). What is a resilient health system? Lessons from Ebola. *Lancet*, *385*(9980), 1910-1912.

Lak, P., & Turetken, O. (2017). The Impact of Sentiment Analysis Output on Decision Outcomes: An Empirical Evaluation. *AIS Transactions on Human-Computer Interaction*, *1*(9), 1–22. doi:10.17705/1thci.00086

Liu, B. (2015). Sentiment analysis and subjectivity. In N. Indurkhya & F. Dameraua (Eds.), *Handbook of Natural Language Processing* (2nd ed.; pp. 627–666). Boca Raton, FL: CRC.

Mello, M., Merritt, M., & Halpern, S. (2015). Supporting those who go to fight Ebola. *PLOS Medicine*, *12*(1).

Mira, J.J., Susana, L., María, T.G., Jesús, A., & Carlos, A. (2015). Ebola's media outbreak: lessons for the future. *European Journal of Public Health*, *25*(2), 188-189.

Mohammad, S. M., Kiritchenko, S., & Zhu, X. (2013). NRC-Canada: Building the state-of-the-art in sentiment analysis of tweets. *Proceedings of the seventh international workshop on Semantic Evaluation Exercises*.

Myers, M.D., & Venable, J.R. (2014). A set of ethical principles for design science research in information systems. *Information & Management, 51*(6), 801-809.

Pang, B., & Lilian, L. (2005). Seeing stars: Exploring class relationships for sentiment categorization with respect to rating scales. *Proceedings of the Association for Computational Lingustics*, *2005*, 417–424.

Peffers, K., Tuunanen, T., Rothenberger, M.A., & Chatterjee, S. (2007). A design science research methodology for information systems research. *Journal of Management Information Systems*, *24*(3), 45-77.

Peterson, A. T. (2015). Good and bad news about Ebola. *PLoS Neglected Tropical Diseases*, *9*(3), e0003509. doi:10.1371/journal.pntd.0003509 PMID:25764305

Rai, A. (2017). Editor's comments: Diversity of Design Science Research. *Management Information Systems Quarterly*, *41*, 1.

Riloff, E., Wiebe, J., & Wilson, T. (2003). Learning Subjective Nouns Using Extraction Pattern Bootstrapping. in *Proceedings of the seventh conference on Natural language learning at HLTNAACL 2003.* Association for Computational Linguistics. 10.3115/1119176.1119180

Song, X., Chi, Y., Hino, K., & Tseng, B. (2007, November). Identifying opinion leaders in the blogosphere. In *Proceedings of the sixteenth ACM conference on Conference on information and knowledge management* (pp. 971-974). ACM.

The medium and the message of Ebola. (2014). *Lancet*, *2014*, 384–9955.

Timen, A., Sprenger, M., Edelstein, M., Martin-Moreno, J., & McKee, M. (2015). The Ebola crisis: Perspectives from European Public Health. *European Journal of Public Health*, *25*(2), 187–188. doi:10.1093/eurpub/cku236 PMID:25583039

Walls, J.G., Widmeyer, G.R., & El Sawy, O.A. (1992). Building an information system design theory for vigilant EIS. *Information Systems Research*, *3*(1), 36-59.

WHO. (2014). *Statement on the meeting of the international health regulations emergency committee regarding the 2014 Ebola outbreak in West Africa*. Geneva: World Health Organization. Retrieved from http://www.who.int/mediacentre/news/statements/2014/ebola-20140808/en/

WHO. (2016b). *Ebola data and statistics – 11 May 2016*. Retrieved from http://apps.who.int/gho/data/node.ebola-sitrep.quick-downloads?lang=en

WHO. (2019). *Ebola situation report - 24 April 2019*. Retrieved from https://www.who.int/ebola/situation-reports/drc-2018/en/

Ye, X., Li, S., Yang, X., Lee, J., & Wu, L. (2018). The fear of Ebola: A tale of two cities in China. In *Big data support of urban planning and management* (pp. 113–132). Cham: Springer. doi:10.1007/978-3-319-51929-6_7

Yu, H., & Hatzivassiloglou, V. (2003). Towards answering opinion questions: Separating facts from opinions and identifying the polarity of opinion sentences. In *Proceedings of the 2003 conference on Empirical methods in natural language processing*. Association for Computational Linguistics. 10.3115/1119355.1119372

Chapter 15
Blockchain in Healthcare:
A Primer

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ABSTRACT

Blockchain is a decentralized, digital ledger that keeps a permanent, unalterable record of transactions between users. One of the greatest advantages of Blockchain is that it is much more secure than other data storage platforms, and thus particularly relevant for healthcare. The chapter serves to outline areas and opportunities for deploying this technology into key healthcare contexts to support effective and efficient operations as well as heightened transparency and trust around activities between and within stakeholders.

BACKGROUND

The healthcare sector is one of the globe's largest industries. It consumes over 10% of the Gross Domestic Product of the most industrialized states. Simply, this sector includes generalization as well as commercialization of products and services to treat patients with preventive, palliative care, curative, and rehabilitative care. Being a multifaceted system of interconnected institutes under heavy regulatory boundaries, patient information is highly fragmented, and the expense of healthcare delivery is constantly increasing because of ineffectiveness in the system and dependence on various intermediaries. Moreover, transparency on the whole process on enhancing data sharing between many parties, even though supposedly important to the patient, is still inefficient on full transparency and control from the patient's outlook. This inadequacy in the system has heightened the need for Information Technology (IT) systems that can eliminate the middle steps, improve efficiencies and cut costs while cultivating trust and transparency. The blockchain is a technology which can aid in solving these healthcare challenges by offering decentralized trust and the establishment of a trust architecture. It enables decentralization which promises to reduce the issue of vendor lock-in that has plagued the medical care industry.

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INTRODUCTION

Patient data dispersed across varying institutes in the value of the medical care sector known as the data silos and sharing of data is susceptible to a multi-level practice of permission control (Gordon & Catalini, 2018). As a result of this, most often, critical data is inaccessible and unavailable at the time when they are needed urgently (Gordon & Catalini, 2018). Dimitrov (2019) claims that Blockchain can address this challenge with health data exchange by serving as a foundation for a reliable decentralized database. It can enhance one-stop access to the entire health history of an individual across all the medical physicians Dimitrov (2019) . Access control systems that are built using trust in blockchain places patients in control of their information Dimitrov (2019) . They can gain consent and access rights to external parties such as scientists to have access to all or even a subset of their health records Dimitrov (2019) . This element of the blockchain fits nicely with the patient-centric structure of the medical sector where the blockchain can act as a catalyst encouraging trust (Gordon, & Catalini, 2018).

The records stored in the blockchain technology are absolute and cannot be altered or even deleted (Gordon, & Catalini, 2018). According to Delgado-Mohatar, Fierrez, Tolosana, & Vera-Rodriguez, (2019), this feature of blockchain offers primitives such as provenance and data reliability which can be utilized in building solutions to mitigate drug counterfeiting and clinical fraud. For example, deceitful results and removal of information in medical investigations which fail to align with the scientist's bias or the funding source can be controlled by strengthening the integrity of information in blockchain (Frandsen & Joynt, 2015). Additionally, it enhances the storing of the indisputable log of subject's consent in a healthcare trial (Frandsen & Joynt, 2015). In terms of financial views, blockchain helps in saving hundreds of billions of dollars, especially for the pharmaceutical sector as it helps in defining a chain of custody in the supply chain (Frandsen & Joynt, 2015).

With the blockchain technology, it is possible to write custom laws and regulations hence forming contracts on the blockchain (Frandsen & Joynt, 2015). This process is similar to that of the real world contracts and is majorly legally binding (Frandsen & Joynt, 2015). These types of contracts in blockchain are known as smart contracts (Frandsen & Joynt, 2015) and can be used in various processes within medical care including insurance and billing which aids in automating the whole process and minimizing the expenses.

FOCUS AREAS AND FACILITATORS FOR BLOCKCHAIN IN HEALTHCARE

Pharmaceuticals are one of the promising capacities for blockchain (Gordon & Catalini, 2018). One key area of use is in drug traceability (Gordon & Catalini, 2018). Blockchain could thus not only be used in prescription traceability but also in tracing counterfeit drugs (ibid). All the information entered into the system is complete and time stamped (Gordon & Catalini, 2018). The time-stamped permanent records could possibly eliminate the expense of medical trials and data management and promote interoperability as well as (Gordon & Catalini, 2018). Significant resources are currently being wasted on drugs because of non-conformation to consumer genetics and the incapacity to offer a conventional health solution (Gordon & Catalini, 2018). Therefore, Blockchain can minimize the leeway for counterfeit drugs to hit the black market as well as reduce prescription mishandling (Gordon & Catalini, 2018). Blockchain technology's security could aid in restructuring patient-centric drug improvement for future targeted therapies by better smoothing of the exchange of personalized data and direct medical sources for studies or investigations (Gordon, & Catalini, 2018). The resulting improvement in collaboration amongst industry participants, researchers, scholars, and patients could increase progress in health research, and population-based genomic research to encourage precision medicine (Gordon & Catalini, 2018).

The financial facet of healthcare is fundamental in today's medical landscape. This area of the financial element in medical care however, is rife with inadequacies, mostly related to integrity and transparency, which can potentially be addressed by the use of blockchain. In particular, the technology offers a mechanism for direct links between individuals who make the claims, and the bearers as there is trust inbuilt (Frandsen & Joynt, 2015).

Cybersecurity threats are a critical concern for healthcare technology and device firms (Frandsen & Joynt, 2015). The medical systems, drug manufacturers, as well as supplies require safe and sound health IT ecosystem to manage the medical value chain, information, and patient records (Frandsen & Joynt, 2015). The present growth of linked health devices will be challenging for the Internet of Medical things (IoMT) as the current infrastructure will be unable to maintain the developing IoMT ecosystem (Kuo, Kim, & Ohno-Machado, 2017). Blockchain technology is seen as a feasible solution to bridge the gaps of device data interoperability while making certain that security and trustworthiness around IoMT use scenarios (Kuo, Kim, & Ohno-Machado, 2017).

In addition, blockchain can also be used chronic care coordination area (Kuo, Kim, & Ohno-Machado, 2017). The changeability in chronic disease management, commonly referred to as fragmented care, is a common issue throughout the healthcare system and has been found to bring about suboptimal care and higher expenses (Kuo, Kim, & Ohno-Machado, 2017). In a study as stated by Frandsen & Joynt (2015), findings indicate that the patients of primary medical care providers with the higher division of care had a 7% to about 9% higher rates of preventable hospitalizations, and a mean of $4,542 in higher medical expenditure. For instance, a chronic illness state with challenging care breakup issues is managing kidney transplant patients, who need complex long-term care that encompasses various care transitions and hand-offs amongst a number of health providers as well as health experts (Gill, Wright, Delmonico, & Newell, 2017). However, with blockchain technology, the patients' medical records could be centralized in a care management network, with health providers and care teams of patients working in collaboration among separate amenities, sharing information from varying points along that patient's continuum of care, connecting hometown primary care physicians with distant specialists when needed (Gill, Wright, Delmonico, & Newell, 2017).

Furthermore, blockchain technology is increasingly being used in the area of personalized healthcare (Gill, Wright, Delmonico, & Newell, 2017). Today, more and more patients are increasingly getting involved in their healthcare delivery (Gill, Wright, Delmonico, & Newell, 2017). Digital healthcare solutions are enhancing this by creating personalized medical data, and a sense of consumerism in individuals (Gill, Wright, Delmonico, & Newell, 2017). Patients are starting to track their condition symptoms and demand news feeds on related medical issues. Some will change their doctors if they are unable to access their records (Kuo, Kim, & Ohno-Machado, 2017). Mostly, patients want to know their health state before the physician is called and access the information on their health history (Kuo, Kim, & Ohno-Machado, 2017). The existing healthcare system fails to offer this and raises a question on information ownership and the integrity of health workers (Kuo, Kim, & Ohno-Machado, 2017). Blockchain technology with its peer to peer data exchange network models provides identity management frameworks with predefined consumer access rules (Kuo, Kim, & Ohno-Machado, 2017). This will make certain that patients have more control over their medical data, and will also support patient engagement programs (Kuo, Kim, & Ohno-Machado, 2017). In addition, it enables the permanent storage of encrypted patient-generated information on the entire blockchain systems (Kuo, Kim, & Ohno-Machado, 2017). This could offer a single, unified standpoint of patient data (Kuo, Kim, & Ohno-Machado, 2017). Hence, patients will be empowered to talk about their anonymized personal medical data for research selectivity and mostly receive incentive payments for sharing from the research institute or some incentives from insurers for resulting betterment in health behavior (Gordon, & Catalini, 2018).

BARRIERS

Existing systems is one of the main barriers in implementing the blockchain technology in the healthcare system (Gordon, & Catalini, 2018). Blockchains are unable to manage data as it is already being managed by existing systems (Gordon, & Catalini, 2018). A large sum of time and money has been spent into establishing these architectures and implementing a novel technology would require rebuilding some aspects of the platforms (Gordon, & Catalini, 2018). The current systems store information in local databases with a fewer likelihood of sharing it between several firms (Kuo, Kim, & Ohno-Machado, 2017). On the contrary, Blockchain technology would imply a total change, going from centralized as well as small-scale technologies to diverse and worldwide systems (Kuo, Kim, & Ohno-Machado, 2017). Though it is a proof that it would bring corporation and interoperability between health and scientific societies, some view it as not worthy of the money and the time (Kuo, Kim, & Ohno-Machado, 2017).

In addition, blockchain technologies are affected by negative image following the security breaches in the prominent Bitcoin blockchain (Kuo, Kim, & Ohno-Machado, 2017). Thus, using such technology to manage health information could look as inappropriate (Kuo, Kim, & Ohno-Machado, 2017). In fact, from a larger perspective, the core concern when dealing with the storage and utilization of health data is security (Kuo, Kim, & Ohno-Machado, 2017). Such data is extremely valuable and sensitive while the number of medical data being hacked every day is increasing exponentially 9ibid). According to Kuo, Kim, & Ohno-Machado (2017), the Break Level Index findings indicate that nearly 554 million records were lost while others were stolen in the first half of the year 2016. Moreover, whether healthcare systems consider either on-chain or off-chain mix, most of the data would not be put in the safekeeping of the blockchain technology, but rather on the traditional databases as well as the cloud (Kuo, Kim, & Ohno-Machado, 2017). Hence, the adoption of the blockchain technology will not be the aspect that will help in solving the security issues (Vazirani et al, 2019). Other systems will need to be built to make certain that the databases or the cloud structures are safe (Kuo, Kim, & Ohno-Machado, 2017).

Another inherent challenge is that the healthcare industry lacks the important structures to collect, exchange, and analyze data results in the absence of interoperability (Kuo, Kim, & Ohno-Machado, 2017). The existing systems are controlled in an off-line architecture, with central, local databases, while blockchain technology is decentralized and operates in the cloud (Vazirani et al., 2019). Directing the healthcare systems in this move and implementing the blockchain technology will be impossible in without having an effective HER system proficient of promoting collaboration as well as interoperability among medical and researchers' communities (Vazirani et al., 2019).

The absence of universal standards Acts is also another barrier for the merging of Blockchain and the healthcare industry 9 (Vazirani et al., 2019). For stowed data to be standardized in the map, a large number of firms will need to collaborate (Vazirani et al., 2019). Intermediaries in the medical care sector will also be mandated to the interface (Vazirani et al., 2019). Most of these firm changes will need to happen in order for the health sector to fully adopt the blockchain technology (Vazirani et al, 2019).

ADVANTAGES AND DISADVANTAGES

One of the main aims of the Federal Health IT focus in the US is to spur confidence and trust in the healthcare sector and to offer better-quality care. It also seeks to improve the population health and minimizes healthcare expenditures through the use of health IT (Vazirani et al., 2019). In this case, blockchain could help in attaining this Federal health IT aims (Vazirani et al., 2019).

By the fact that blockchain is a distributed ledger that is often updated and synched in real time, it builds an absolute, spread out, and transparent record of all the transactions using a peer network (Vazirani et al., 2019). In a statement by Forbes, blockchain is able to securely and privately track the health records of patients. Presently, a patient's health history is distributed between various EMRs by a number of physicians and organizations, most of which is inaccessible by the patient (Gordon, & Catalini, 2018).

Notably, blockchain has the capacity to bring all of the health records together in one source that is a complete and present record which illustrates any alterations made and by the person who has made those changes (Gordon, & Catalini, 2018). Essentially, blockchain could empower patients with a whole set of information in relation to their own healthcare (Agbo, Mahmoud, & Eklund, 2019). This absolute dispersed ledger can better make sure that resilience and origin, traceability, and management of medical data are achieved (Agbo, Mahmoud, & Eklund, 2019).

Despite the numerous advantages that the blockchain would bring in the healthcare sector, the notion is controversial due to the fine line between right and wrong access to health care histories (Agbo, Mahmoud, & Eklund, 2019). In America, breaches of privacy in the medical system are happening at an alarming rate (Agbo, Mahmoud, & Eklund, 2019). While blockchain technology ought to normally serve to enhance data security, about 40% of the medical breaches apparently yield from inside actors (Vazirani et al, 2019). This is to mean that the higher levels of accessibility enhanced by blockchain technology might bolster higher rates of inside privacy breaches (Vazirani et al, 2019).

To add to those challenges, there exist limitations as of the present state of the blockchain (Vazirani et al, 2019). Presently, every node in the blockchain network that processes transactions makes the blockchain very slow and unsuitable to deal with in the transactions in the real world which range in 10,000 transactions per second (Agbo, Mahmoud, & Eklund, 2019). This inconsistency highlights the scaling challenge that the blockchain technology has to overcome for wider adoption across all the sectors (Agbo, Mahmoud, & Eklund, 2019). In addition, with the increase in use, the size of the blockchain is growing exponentially, making it hard for normal users to maintain the full copy of it (Agbo, Mahmoud, & Eklund, 2019).

It is important to note that blockchain is not at a level of optimal maturity (Agbo, Mahmoud, & Eklund, 2019). Its implementation needs a decent infrastructure and interconnectivity (Agbo, Mahmoud, & Eklund, 2019). Hence, there are highly technical challenges that can slow down it's leaking into healthcare (Agbo, Mahmoud, & Eklund, 2019). Blockchain networks use nodes to run (Agbo, Mahmoud, & Eklund, 2019). However, most of the networks are novel and they lack the number of nodes to assist in extensive usage (Agbo, Mahmoud, & Eklund, 2019). According to Vazirani et al (2019), this inadequacy of resource manifests itself in the higher expenses as nodes look for higher compensations for completing transactions in a supply and demand cases. It also manifests itself in the slower transactions where the nodes priorities transactions with greater recompenses, the buildup of transactions.

DISCUSSION AND CONCLUSION

Data sharing across health stakeholders and even within healthcare organizations is fragmented and inefficient (Vazirani et al., 2019), This leads to medical records often becoming inaccurate as they are passed between providers, potentially leading to duplicate or unnecessary treatment (Vazirani et al., 2019). Enabling interoperability would allow information from appointments, wearable devices, and demographics to be shared among providers, giving them a more accurate and complete patient medical history and thus enabling them to provide a higher quality of care. This is important for healthcare delivery at multiple levels because the lack of interoperability in healthcare is one of the most common pain points that providers report. Through utilization of Blockchain technology we have the potential to ameliorate this problem.

This chapter has set out to bring awareness to the potential benefits for Blockchain in healthcare and as such serve as a primer. As discussed above, it is evident that blockchain technology has the capability to solve several challenges afflicting the healthcare sector today. As a trustworthy technology, it can enhance new healthcare solutions. Also, as an incentive device, it can enhance new business models that may result in a novel dynamic among several healthcare shareholders such as patients and medical practitioners. It is true that there are a number of barriers as discussed above, but the relevant stakeholder needs to work together and to overcome these barriers for blockchain technology to go mainstream in the medical care industry. As blockchain is in its infancy, there is much that needs to be done in relation to exploring and learning about technology. However, this aligns to the responsibilities of the healthcare organizations and regulators. Nevertheless, the opportunities in medical care are obvious and thus it is time for a change in the medical care industry. Considering the need for transparency and the establishment of a trusted architecture so that all healthcare stakeholders can share data in confidence efficiently and effectively, blockchain technology appears to offer a promise of an appropriate environment with multiple benefits to enable such a future to be realized and thus, is likely to develop into a needed technology for enabling prudent health data exchange management at various levels in the healthcare sector.

REFERENCES

Agbo, C. C., Mahmoud, Q. H., & Eklund, J. M. (2019, June). Blockchain Technology in Healthcare: A Systematic Review. In Healthcare (Vol. 7, No. 2, p. 56). Multidisciplinary Digital Publishing Institute. doi:10.3390/healthcare7020056

Delgado-Mohatar, O., Fierrez, J., Tolosana, R., & Vera-Rodriguez, R. (2019). *Blockchain and Biometrics: A First Look into Opportunities and Challenges*. arXiv preprint arXiv:1903.05496

Dimitrov, D. V. (2019). Blockchain Applications for Healthcare Data Management. *Healthcare Informatics Research*, *25*(1), 51–56. doi:10.4258/hir.2019.25.1.51 PMID:30788182

Frandsen, B. R., & Joynt, K. E. (2015). Care fragmentation, quality, and costs among chronically ill patients. *The American Journal of Managed Care*, *21*(5), 355–362. PMID:26167702

Gill, J. S., Wright, A. J., Delmonico, F. L., & Newell, K. A. (2017). Towards improving the transfer of care of kidney transplant recipients. *American Journal of Transplantation*, *17*(1), 54–59. doi:10.1111/ajt.13997 PMID:27495956

Gordon, W. J., & Catalini, C. (2018). Blockchain Technology for Healthcare: Facilitating the Transition to Patient-Driven Interoperability. *Computational and Structural Biotechnology Journal*, *16*, 224–230. doi:10.1016/j.csbj.2018.06.003 PMID:30069284

Kuo, T. T., Kim, H. E., & Ohno-Machado, L. (2017). Blockchain distributed ledger technologies for biomedical and health care applications. *Journal of the American Medical Informatics Association*, *24*(6), 1211–1220. doi:10.1093/jamia/ocx068 PMID:29016974

Vazirani, A. A., O'Donoghue, O., Brindley, D., & Meinert, E. (2019). Implementing Blockchains for Efficient Health Care: Systematic Review. *Journal of Medical Internet Research*, *21*(2), e12439. doi:10.2196/12439 PMID:30747714

Chapter 16
3D Printing in Healthcare:
Opportunities, Benefits, Barriers, and Facilitators

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ABSTRACT

3D printing has developed as a modification of an old injection printer. Today, it is rapidly expanding offering novel possibilities as well as new exciting applications for various sectors including healthcare, automotive, aerospace, and defense industries. This chapter presents key application areas within the healthcare sector. In medicine, 3D printing is revolutionizing the way operations are carried out, disrupting prosthesis and implant markets as well as dentistry. The relatively new field of bioprinting has come to be because of advances with this technology. As will be discussed, numerous applications of 3D printing in healthcare relate to personalized medicine. For instance, implants or prostheses are 3D printed for a specific user's body, optimizing the technology to work for an individual, not an average user as with most mass-produced products. In addition, 3D printing has applications on the nanoscale with printing of drugs and other smaller items. Hence, 3D printing represents a disruptive technology for healthcare delivery.

INTRODUCTION

Chuck Hall is credited with the invention of 3D printing (Valchanov, 2017); he made the first 3D printer and used it to print a tiny cup. These were the first steps towards a revolution that would see major changes in the health sector over the years. Technology has played a key role in ensuring that the medical field continues to thrive. It therefore means that with the increasing needs in the market, engineers and other stakeholders have a sole responsibility of ensuring that more products are invented for better healthcare. The use of 3D printers has been one of the ways in which revolution has occurred in the healthcare system. 3D printing enables medical professionals to provide treatment for their patients

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in different ways depending on their ailments. 3D printing is used to create replicas of organs, blood vessels, and bones to specific patients' specifications (Valchanov, 2017). In addition, it is important for developing new surgical cutting and drill guides, and prosthetics. Recently, inventions in 3D has contributed to stronger, lighter, and safer products. This in turn has lowered the overall costs and the amount of time spent during treatment. Benefits have been accrued as the parts are tailored to fit each individual's requirements. As such, patients are comfortable with their medical personnel interactions as they are assured of products that fit their anatomies (Wen & Korakianitis, 2018). Research has been conducted on 3D printing inventions with many scholars making several conclusions. In this literature review, the chapter will focus on the opportunities, benefits, challenges, and facilitators in 3D printing, an evolving area in supporting superior healthcare delivery.

BACKGROUND

3D printing is also known as additive manufacturing and has developed from rapid prototyping techniques of the 1980s (Gibson et al., 2015). The drivers to change the design and manufacturing process are around new requirements such as a better integration on production line, a larger series of manufacturing and/or the need to reduce weight of products due to heavy costs of machines and materials (ibid). The ability to produce complex geometries allows proposing of design and manufacturing solutions in the industrial field in order to be even more effective (Gibson et al., 2015). The additive manufacturing (AM) technology has thus, developed rapidly with new solutions and markets which sometimes need to demonstrate their reliability. One developing market is the healthcare sector.

3D APPLICATIONS

Additive manufacturing, also referred to as 3D printing, has been used by different industries since its inception. Medical technology has however applied it extensively and this is an excellent opportunity to help patients with speciifc needs. Medical imaging techniques including computed tomography (CT) scans, X-rays, ultrasounds, and magnetic resonance imaging (MRI) scans are used in the production of the original digital model (Barrow, 2018). The produced model is then fed into the 3D printer which manufactures an excellent replica of the organ (ibid). The growth of additive manufacturing has been forecasted to increase in the future since the medical field comprises of numerous cases that need more inventions (Wen & Korakianitis, 2018). However, 3D printing offers opportunities in four core areas in the medical field that are important. These areas are the leading cause of its introduction into the medical field.

ORGANOIDS AND BIOPRINTING TISSUES

Bioprinting is one of the readily available types of 3D printing used in the medical field (Wen & Korakianitis, 2018). Bioprinters use computer-guided pipettes which layer living cells, known as bio-ink, on one another's top, thus creating an artificial tissue (Wen & Korakianitis, 2018). The tissues made, known as organoids, are extensively used in healthcare research since they mimic organs but on a miniature scale. Recently, there have been trials to have them as cheaper alternatives to human organ transplants since they would function the same (Wen & Korakianitis, 2018). In the United States of America, a company known as Organovo, is currently researching and experimenting on how printed liver and intestinal tissue can be utilized in studying human organs (Valchanov, 2017). In addition, the company is using the same technique to see whether they can develop drugs for treating certain diseases (Valchanov, 2017). The company's efforts have been succeeding since in May 2018, they presented pre-clinical information showing the functioning of its 3D printed liver tissue (Valchanov, 2017). The organ was developed in a program targeting type 1 tyrosinemia, which is a condition that impedes the metabolic ability of a body when handling tyrosine, an amino acid due to lack of a crucial enzyme (Valchanov, 2017).

Research has also been conducted at the Wake Forest Institute in North Carolina, where they adopted a 3D brain organoid (Valchanov, 2017). This has potential applications incorporating discovery of drugs and disease modelling (Valchanov, 2017). In May 2018, the university announced they had made significant progresses having acquired a fully cell-based brain with functioning blood which is a mimicry of the normal human brain (Valchanov, 2017). The university has also been working hard to mimic skin grafts that would play a significant role in assisting burn victims (Valchanov, 2017).

SURGERY PREPARATION USING 3D PRINTING

Prior to undertaking comprehensive surgical operations, there is always a need to practice with similar organs. 3D printing makes this possible by allowing the creation of patient-specific replicas which the surgeons can use in undertaking the processes. Such procedures have been carried out over the years and they are slowly becoming routine. Spinal procedures and complete face transplant are some of the specific areas that have seen 3D printing undertaken and great successes have been realized (Valchanov, 2017). In Dubai for instance, hospitals are at liberty to apply 3D printing when they are carrying out different operations (Valchanov, 2017). Recently, doctors operated on an individual that had cerebral aneurysm occurring in four veins (Valchanov, 2017). They used a replica of the arteries and this assisted them greatly in navigating the complicated parts of the patient and the operation was fully successful (Valchanov, 2017).

Kidney transplant has also been a candidate, with doctors taking crucial operations using 3D prior to the main operation (Valchanov, 2017). Such happened in Belfast, whereby doctors operated on a 22-year old woman but developed complications later (Valchanov, 2017). The problem was that her father had an incompatible blood group and they discovered a cyst in the donated kidney (Valchanov, 2017). The doctors however, used 3D printing to determine the size and location of the cyst (Valchanov, 2017).

Clearly, 3D printing is making milestones in easing operations (Vander & Stocksman, 2017). Previously, doctors did not have clear knowledge on the patients that they would be operating on and this made it more difficult. As a result, more people would die because of challenges resulting from human error performed during the operations. With 3D printing being in place, doctors are able to determine the exact procedures that they are going to undertake and have it in their mind. When they undertake operations therefore, it is always easier. 3D printing has therefore proved to be a great way of carrying major and complex operations.

SURGICAL INSTRUMENTS PRINTING USING ADDITIVE MANUFACTURING

In a research conducted on 3D printing, Valchanov (2017) discovered that they have the ability to produce haemostats, forceps, scalpel handles, and clamps. Not only does 3D printing have the ability to make these sterile surgical tools but it also uses a traditional Japanese practice known as origami, where they can be made extremely small (Valchanov, 2017). The instruments created in this instance can be used to carry out operations in tiny areas without causing unnecessary damage to the patient (Valchanov, 2017). However, working with such instruments needs a high-level concentration to avoid leaving them in the body of the patient (Valchanov, 2017). There has been reported cases where patients have suffered long after their operations ended (Vander & Stocksman, 2017). Therefore, the discovery of 3D printing has made it possible for better and more minimally invasive operations to take place (Vander & Stocksman, 2017).

CUSTOM MADE PROSTHETICS USING ADDITIVE MANUFACTURING

Additive manufacturing can be utilized in the making of prosthetic limbs that suit the individual wearing them (Vander & Stocksman, 2017). Traditionally, people with amputated limbs have had to wait for long periods of time before they could get their limbs but with 3D printing, the process has been sped up (Vander & Stocksman, 2017). The process is also cheaper since the materials used are better and they offer the same functionality as the traditional forms of manufactured limbs (Vander & Stocksman, 2017). Dodziuk (2016) notes that the lowered prices are most appropriate especially for children who naturally would outgrow the limbs and might need replacement which in the traditional forms would be expensive (Dodziuk, 2016). Consequently, with 3D printing, the patient gets the chance to choose the one that suits his or her needs (McDaniel, 2017). Body Labs has created a system where patients can get to design their limbs in ways that suits them (McDaniel, 2017). Research is also ongoing at Massachusetts Institute of Technology to design better limbs sockets (McDaniel, 2017).

3D printing is not a new technology (McDaniel, 2017). It is slowly entering into high dynamism with wide range of advancements and increased adoption levels (McDaniel, 2017). There are more clinical applications and researches are ongoing to introduce more forms of additive manufacturing (McDaniel, 2017). Radiologists and other stakeholders are positioned to spearhead this revolution in the medical field (Dodziuk, 2016). Such people have the opportunity to engage key challenges taking place in the medical field. Undertaking such moves will take imaging into greater heights and help to solve clinical problems.

BARRIERS TO 3D PRINTING

Despite the successes enjoyed by 3D printing, it is clear that there are numerous challenges that the medical advancement faces. Manufacturing blood vessels in the bioartificial graft is a great challenge even now. In his research, Valchanov (2017) notes that the manufactured vessels can develop necrotic core due to inadequacy in oxygen and nutrients supply (Valchanov, 2017). Therefore, the only solution is the manufacture of simple organs that do not experience such complexities (Valchanov, 2017).

In addition, carrying out these printing requires a high-level knowledge. Most of the engineers in the industry might not have the knowledge required to manufacture these complex printers (Valchanov, 2017). The lack of such engineers makes it difficult for greater progress to be made in the long run. Consequently, Valchanov (2017) states that the most excellent height required for extrusion-based printers is in most cases 10 micro-meters. However, this is only achievable by some high-end machines and most of the low and middle-end machines can only go up to 50 micro-meters at most (Valchanov, 2017). Therefore, the manufacturing of complex structures including liver lobes or kidney glomerulus is not achievable for now.

LACK OF REIMBURSEMENT

In a detailed study carried out in 2018, Bryant (2018) discovered that deficiency in reimbursement is a major blow to hospitals planning to establish 3D printing labs. In some cases, a joint 3D printed implant or bone fixator may have been reimbursed (Bryant, 2018) However, the 3D model of an individual patient's anatomy and the professional fees are not paid in most cases (Bryant, 2018). This is a great barrier since some of the patients may not be able to afford these treatments as it might be too expensive for them (Bryant, 2018). The key is that professionals have to be paid for their services since they undertake their work seriously (Bryant, 2018). Any individual willing to have an implant or any other product must pay the professional fees and many researches have cited this as a great challenge for this form of treatment (McDaniel, 2017).

ETHICAL CONCERNS

In addition, there are ethical concerns in regards to using 3D printing in human treatment (McDaniel, 2017). A key issue is whether it is ethical to use human stem cells, implant biomechanical devices into human bodies, and the complications that might arise from undertaking such measures (Valchanov, 2017). For some people, they think that inasmuch as these practices help humans, they are not favourable owing to the structure that God made man and hence there is the notion that adding anything new is not ethical (Valchanov, 2017). Such remain unresolved concerns that stakeholders have to encounter while advancing the processes (Valchanov, 2017).

REGULATIONS

The future of 3D printing is dependent on the numerous regulations that have been introduced into this field (Valchanov, 2017). In the United States, medical devices have to be regulated by the Food and Drug Administration (FDA) (Wang, 2019). The FDA has been tracking the 3D printing industry and flagged several devices for use made from imaging data. Moreover, such regulations have been a challenge since high experience and expertise has to be applied if the devices have to pass (Wang, 2019). However, the growth of technology is fast and regulations have to keep changing based on what is being manufactured. For better devices and products, regulation plays a fundamental role overall (Wang, 2019).

BENEFITS

The medical field is one that is directly impacted by advancements in technology. The incorporation of 3D printing into the medical field has helped in improving health for numerous people. Doctors can now work faster since the new technology shortens theatre time and improves operation results (Jones et al., 2016). Specialists are using 3D printing in various ways and this has contributed to faster advances (Jones et al., 2016). Prosthetics and implants enable patients to experience improved care (Jones et al., 2016). Other advances such as the use of 3D printing pens also play a key role when carrying out orthopaedic surgery (Jones et al., 2016).

Consequently, the low cost prosthetics created makes it possible to treat people especially in war torn countries. In such nations, it is impossible to afford advanced prosthetics and the cheaper ones come in handy (Jones et al., 2016). In addition, the waiting time is drastically reduced as the manufacture of these products does not take time (Barrow, 2018). Low income or hard to access areas can therefore benefit from the products made from 3D printing (Barrow, 2018). In addition, customization is also another benefit that patients can get from using 3D printed products (Barrow, 2018). The traditional way of making prosthetics is extremely expensive since they involve personalization (Jones et al., 2016). 3D printers give the patients an opportunity to choose the size, colour, design, and form of their prostheses (Jones et al., 2016). Thus, patients are able to have a prosthetic which suits him or her at an affordable price (Jones et al., 2016).

FACILITATION OF 3D PRINTING

According to research, there are no universities and colleges in the United States that are currently teaching on ways to handle 3D printing. Therefore, it is more of a mentor/mentee relationship in this advanced field of medicine. Hence, people have to learn on their own or reach out to colleagues with better ways of handling 3D printing price (Jones et al., 2016). Experience is vital when teaching this kind of practice as the person receiving it has to understand and know how to apply the same (Matsumoto et al., 2015). However, this has caused concerns on craftsmanship. For instance, compensation has to be offered when melted metals cool down (Matsumoto et al., 2015). Trial and error is a huge risk in this field and hospitals seeking to undertake it need to have better personnel to handle (Matsumoto et al., 2015). Thus, the hospitals avoid losing money to trial and error (Matsumoto et al., 2015).

DISCUSSION AND CONCLUSION

It is clear that 3D printing is a revolution to the medical field. Many of the complications that have occurred in the past, for example around joint surgery, are being addressed with the introduction of this technology. As outlined, 3D printing has numerous opportunities where applications have played a fundamental role in helping patients. In particular, key areas include: 1) bioprinting and tissue engineering to ensure implants e.g.; artificial lung are personalised and specifically designed, 2) pharmacology, where it could be possible to 3D print drugs, 3) surgical rehearsal, 4) customised prosthetics, so that knee replacements, hip replacement or spin vertebrae replacements can be tailored and more effective, 5) especially in very complex cases it is possible to practice using 3D printed models of the real person, and 6) it is even possible to envisage distribution of production so that joints and models can be printed as need in the local hospital or clinic.

In addition, there many accrued benefits such as cost reduction, faster treatment and better healing. However, this does not come without experiencing problems. Doctors have been facing the challenge of manufacturing blood vessels and other complexities that patients may need. Comparing this advancement to the previous medical milestones, it is clear that it has changed numerous things (Matsumoto et al., 2015). The facilitators which include the radiologists, face the training challenge but they need to undertake the human anatomy of the victim before carrying out any major operation in them. Ethically, 3D printing has been challenged with people being concerned whether it is appropriate to have foreign material in someone's body. However, with these advancements and more developments, it is without a doubt that 3D printing has been fundamental in providing changes to healthcare delivery and a better patient experience and opportunities for medical practitioners worldwide.

REFERENCES

Barrow, M. (2018). How 3D printing is transforming healthcare. *Raconteur*. Retrieved from https://www.raconteur.net/healthcare/3d-printing-transforming-healthcare

Bryant, M. (2018). 3D printing poised to disrupt healthcare. *MEDTECHDIVE*. Retrieved from https://www.medtechdive.com/news/3d-printing-poised-to-disrupt-healthcare/541540/

Dodziuk H. (2016). Applications of 3D printing in healthcare. *Kardiochirurgia i torakochirurgia polska, 13*(3), 283–293. doi:10.5114/kitp.2016.62625

Gibson, I., Rosen, D., & Stucker, B. (2015). *Additive Manufacturing Technologies*. New York: Springer. doi:10.1007/978-1-4939-2113-3

Jones, D. B., Sung, C., Weinberg, C., Korelitz, T., & Andrews, R. (2016). Three-dimensional modeling may improve surgical education and clinical practice. *Surgical Innovation*, *23*(2), 189–195. doi:10.1177/1553350615607641 PMID:26423911

Matsumoto, J. S., Morris, J. M., Foley, T. A., & Williamson, E. E. (2015). Three-dimensional Physical Modeling: Applications and Experience at Mayo Clinic. *RadioGraphics*. Retrieved from https://pubs.rsna.org/doi/full/10.1148/rg.2015140260

McDaniel, L. (2017). 3D Printing in Medicine: Challenges Beyond Technology. *Design of Medical Devices Conference*.

Valchanov, P. (2017). 3D Printing In Medicine – Principles, Applications And Challenges. Department of Anatomy and Cell Biology, Faculty of Medicine, Medical University of Varna, Bulgaria, 1(1), 18-22.

Vander S. J., & Stocksman. (2017). *Building Evidence for 3D Printing Applications in Medicine*. . doi:10.13140/RG.2.2.14182.11846

Wang, K. (2019). Clinical 3D Printing: Status, Challenges and Opportunities. *RSCNA*. Retrieved from https://www.rsna.org/en/news/2019/January/Clinical-3D-Printing-Status-Challenges-and-Opportunities

Wen, P., & Korakianitis, T. (2018). Medical Applications for 3D Printing: Recent Developments. *Science of Medicine, 115*(1).

Chapter 17
Comparative Study of Oncology Information Systems for Better Patient and Provider Outcomes

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ABSTRACT

Cancer is among the top three chronic diseases both in developed countries as well as underdeveloped countries. The diagnosis, medication, and treatment for cancer is extremely costly. Typically, cancer treatment involves surgery, radiotherapy, and chemotherapy. Owing to the extremely high price of medicine and treatment along with cytotoxicity of medication, cancer treatment warrants extraordinary care in treating cancer patients. Oncology information systems (OIS) provide an all-in-one solution for such problems. The OIS can integrate different treatment protocols and update change in dose and treatment in real time.

BACKGROUND

Cancer is considered as one of the leading causes of death among other chronic diseases (AIHW, 2017, Torre et al., 2016, Pesec and Sherertz, 2015, Torre et al., 2015). In Australia, it was found that by the age of eighty five, one in two Australians is detected with cancer whereas cancer will be the cause of death for 20% of population (1 out of 5) . Cancer is affecting more males (approximately 53.8%) than females (approximately 45.6%) (AIHW, 2017). Around 33% of males while 20% of females are diagnosed with cancer by the age of 75 (2017). It was estimated that in 2017 around 134,174 people were identified as cancer sufferers and it appears that by the year 2020 there will be 150,000 people suffering from cancer (AIHW, 2017).

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Figure 1.
Source: Australian Institute of Health and Welfare

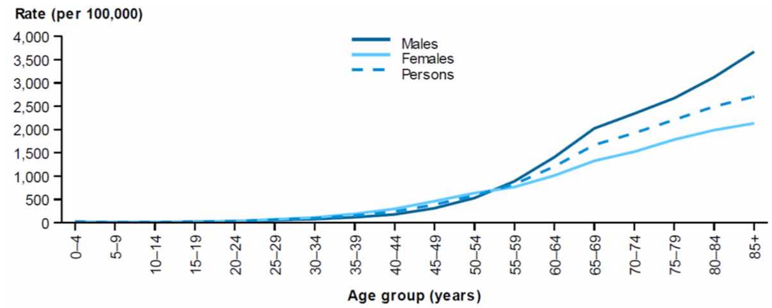

Figure 1, shows the age specific pattern in the Australian population (Connell, 2017). As can be easily seen, below the age of 30, the pattern is almost the same in both males and females while it shows a change in pattern over 30 (ibid), more females are found to suffer than males until it reverses around 54, where the male population seems to suffer from cancer more prominently than females ibid). In general, people living in Australia have a better chance of survival than people living in other parts of the world (2017). This is attributed to better awareness and improved clinical care (Crawford, 2013). The overall reduction in cancer incidences in Australia is primarily due to decreased number of cases in prostrate cancer in men (2013). This decline in cancer trends could be associated to increased awareness and prostrate specific antigen (PSA) testing in males (2017). For a cancer patient surgery, radiation and chemotherapy are considered as a generalized treatment (Crawford, 2013), which are expensive treatments (Paul et al., 2017, Paul et al., 2016); fortunately, for Australians, the healthcare system pays most of the cost which is estimated around $4.5 billion (AIHW, 2017). As cancer treatments involve utilization of radiation and cytotoxic doses, critical control over the amount and time duration for procedure is very critical so as to avoid any damage to the healthy cells (Wickramasinghe et al., 2015).

What is OIS (Oncology Information System)?

Thanks to new innovative technologies and their non-traditional employment in disease detection and treatment, we have better health outcomes and improved survivor rates (AIHW, 2017). We are living in the age of information technology and have effortless access to new research findings being conducted in any corner of the world. This influx of information through electronic and print media serves to improve health and wellbeing (Duckett and Willcox, 2015). In general, people are living longer and demand better disease management, which stretches the overall healthcare budget of global healthcare systems (Nutbeam, 2008). This situation becomes critical when we are dealing with cancer treatment which is already expensive and can lead to fatal consequences with tiny mistakes in treatment, records or failing to get to a scheduled appointment, consequently wasting resources and time for such a costly treatment in already stretched healthcare system is a key problem (Berwick, 2003).

To increase the efficiency and usefulness of healthcare, providers have started using medical information systems which reduce errors and keep up to date information regarding patients' medication, electronic health records and their test results all in one place (Sulaiman and Wickramasinghe, 2014, Wickramasinghe and Schaffer, 2010). These electronic healthcare records (EHR) aid in better management of records thus avoiding duplication of records, eliminating repetition of tests /imaging and treatment (Duncan et al., 2010, Hillestad et al., 2005). The need to use information systems for cancer patient has become very important, as it uses toxic medicine and radiation to control the malignant tissues, thus oncology information systems were developed to aid healthcare providers and enable an all in one solution (Evans et al., 2014, Fasola et al., 2008). The oncology information system (OIS) can coordinate different treatments from multiple sites and multiple users. Many oncology information systems (OISs) are capable of instant access and update records in real time and can convey change throughout the treatment chain to keep surgeon, physician, pharmacist and nurse up to date regarding the state of tumour/ disease progress as well as help in supporting informed decision making drawing on cancer registry data (Duncan et al., 2010). Each patient has its own journey of recovery and recurrence of cancer thus each patient requires a unique pathway for treatment as their treatment plan and recovery vastly differ owing to a variety of factors (2018d, Štambuk et al., 2010). To achieve better and faster results for each patient, the entire journey to recovery needs to be customised and personalised (2018c), and thus we are seeing the adoption of precision medicine techniques.

Oncology information systems can not only integrate all treatment plans e.g., surgery, radio or chemo therapy but also control and update pharmacists to prepare for reorder or cancel further ordering saving cost on inventory and time for reordering all through one single system (Crawford, 2013, Herre and Heller, 2004). The oncology information system (OIS) is also capable of integration within a single facility or across different healthcare providers giving access only to authorized personnel to data regarding radiation oncology, particle therapy and medical data database (Janssen et al., 2017, Wickramasinghe et al., 2015). OIS also acts as an agent for quality control and creating disease specific clinical protocols through managing standardized and coherent care (Krayenbuehl et al., 2015). OIS helps clinicians observe and attach images in single files and supervise the dose quantity and later review progress in treatment through images without leaving the single system to establish if a dosing plan needs to be changed or kept to the same pathway (Cheng et al., 2011).

METHODOLOGY

This study was conducted with a focus to analyse the oncology information systems (OISs) to evaluate and compare their suitability and operability within the Australian healthcare system. We selected 3 leading Oncology information solutions which were developed and are already being used in the United States or Europe. A Comparative analysis was done from data and information available from electronic and print media. Moreover, we visited different healthcare sites (both in the public and private sectors) to conduct focus group discussions with patients, clinicians and healthcare management to gain in depth understanding of their point of views and desired features they would like to see in OIS and how these features might help in making these OISs a better choice. Appropriate ethic clearances were secured. The preliminary comparison is presented in Table 1 and described in discussion section.

Oncology Information Systems and their Evaluation in the Australian Context

In the current study, we reviewed 3 different leading international oncology information systems. Our main focus was to determine their relevancy and valuable features and find missing and mismatched components for the Australian Healthcare system. In particular, we searched for the oncology (cancer) treatment and information system features to integrate them into Australian healthcare system. Overall a brief and to the point summary is reported in Table 1. The overall review of these systems as relevant to oncology patients, clinicians & healthcare managements was then discussed further with the different focus groups. From a comparative point of view, most of the systems have been designed either in the US, Europe or other advanced countries, these countries and regions have different healthcare systems to that of the Australia, which has a two tier complementary public and private system. The Australian public healthcare system is unique in providing healthcare services which is substantially supported by Government agencies, augmented by private insurance, while there is also a parallel system of private healthcare providers which includes VMOs (visiting medical officers). Thus, any system designed for overseas healthcare system needs to be customized or adopted to make full utilization of the system and improve the patient experience and satisfaction in the Australian context.

Almost all the systems have in common inclusion of billing system, image visualization & management, paperless communication and fast data transfer while all of them lack the inclusion of Pharmaceutical Benefits Scheme (PBS)/Medicare Benefits Schedule (MBS) and insurance share calculation. Pharmaceutical Benefits Scheme started in 1948 to provide free medication to pensioners and a limited life-saving and disease prevention listed medicine free to general public. Now PBS provides subsidized medication for most of the diseases for eligible persons (2018a), whereas MBS helps in managing subsidised medical services (2018b).

The OIS -1 has some features which distinguish it from other including review dosimetric images for IMRT, ability of scheduling appointment, remote image review, customisation of forms & questionnaire, ability to attach images/files/photographs to documents and continuous data protection while ensuring minimal data loss and immediate data recovery through HARRP system. Whereas prominent features for OIS -2 are 3D viewer, RTP, XVI, iView GT integration, stereoscopic & volume registration and elimination of error-prone work through tight integration that enables transition of seamless data between different tools. In OIS – 3, along with other features, the most intriguing feature is estimation and comparison of cost, complications, toxic analysis and even analysis between different practice centres and clinics.

DISCUSSION AND INFERENCEX FROM COMPARISON OF OISS

Table 1 gives the major comparative details of the OISs under consideration. On examination, it is obvious that these OISs have been designed to provide a unique solution for oncology clinicians and healthcare providers to access data regarding patient history, treatment plan, amount of dose, tracking improvement, image visualisation, medication prescription, and other relevant information but they overlooked the main character in whole story “the patient”. It is completely understandable that the clinicians and healthcare providers have a key responsibility in determining which OIS suits best for treatment and their existing infrastructure but they altogether miss the patient and their care and only focus on the provider’s point of view. Consequently, the patient was not at the centre of treatment rather the clinicians were (Saletti et al., 2018).

In the modern era, the focus is shifting from clinicians and hospitals to the patient, family members and care givers. From the patients, family members and care providers' point of view, it was found that the person who suffers the most is the cancer patient and family members. However, patient and family members' needs and desires tend to be the most ignored during the treatment and recovery phases and hence the patient experience is less than satisfactory. For many clinicians, nurses and healthcare providers, the patient is just another subject and one more case study for different treatments. The patients were desirous of more empowerment and access to information and data through psychological surveys, awareness/training, visual treatment and booking/cancelling/rescheduling their appointments. Further, having the capacity to participate in patient reported outcomes and self-reporting pain and progress of recovery on a daily and hourly basis was key for them to improve their patient experience. Many patients also wanted the ability to log their medication e.g., missing and on-time or ordering for repeats.

To summarise, the key factors from Australian patients' point of view include:

- Pain time/date, duration grading and registering
- User friendly interface, graphical icons and ease of interpretation
- Automatic concession and payments through PBS/ MBS and private insurance
- Personal and individualized psychological, emotional and social support or stories
- Up to date knowledge on their disease, new treatments and ongoing research in the field
- Visual experiences and training for clinics, treatments, therapies and location/parking
- Making sure for privacy and confidentiality of patient data while making it anonymously accessible for researchers to compare similar cases for implications and treatment.

Clinician and healthcare provider's highlighted that the different healthcare providers of the variety of systems for patient data registering. Most of the systems are unable to communicate with each other which creates hurdles for clinicians who must work with multiple systems. With the mergers and collaborations, hospitals and healthcare providers are forming alliance to better utilize resources. Therefore, the alliance of healthcare providers warrant the integration of isolated old operating systems and machines to get patient data access from within and across multiple sites. Once this challenge of integration is overcome through OIS, variation in already existing infrastructure and their versions; poor integration, disrupted work flow is expected to be resolved.

After discussions with oncology clinicians and managers at different healthcare organisations, critical factors were identified to improve the overall performance of OIS include:

- Compatibility with international, Australian, states and regional standards
- Ability to operate and transfer of data with already present assets and future provision
- Inclusion of Australian/Victorian healthcare system e.g., VMOs (visiting medical officer) and nurses for calculation of share and payments by patients after Medicare.
- Capability of billing and applying concession through PBS, MBS and insurance systems
- Communication of change in plan in real time with access to data from multiple sites/users
- Highly secure communication by encryption and safe from cyber security issues
- Capability of auto initiating and notification for change in plan in medication or radiation to the related doctor, radiologist, pharmacist and patient.
- Keeping track of treatments across the facilities for consistency, timelines and cost

Table 1. Comparison of different leading international oncology information systems (OIS) in Australian context

	OIS – 1	*OIS – 2*	*OIS – 3*
Therapies (Chemo & radiation)	Yes	• Yes	• Yes
Payment	• Billing • Calculation for missed-procedure billing • Export billed items to billing software	Billing and other third-party systems	Claims and billing data from financial systems
Image management	• Comprehensive review of clinical images • Optimized image-guided treatment techniques • Review images remotely and send set-up instructions to the treatment machine • Review dosimetric images for IMRT pre-treatment quality assurance • Compare images using automatic, manual or fiducial marker-matching algorithms • Attach images, files or patient photographs to documents	• Sophisticated image visualization & distribution • 3D viewers: RTP, XVI, & iView GT™ integration, adding and synchronizing tools, 2D image registration, volume image viewing • External image registration • Stereoscopic & volume image registration • Setup details, immobilization devices and reference images entered into treatment chart	Present complex, personalized analytics on individual patients based on clinical, molecular, and other relevant data in a clinically actionable format
Clinician led & patient-centric	• Appointment scheduling, review images remotely, customisable data collection forms and questionnaires • Attach images, files or patient photographs to documents	• Electronic patient management allows users to achieve a paperless, filmless working environment; treatment setup workflow management	• Configure CARE reports to contain personalized analytic content and historical patient content formatted to your institution's & clinician's specific needs
Information & analytics	Pain scoring to identify trends	Trend analysis	Integration, aggregation & personalized analytics on highly complex, disparate, multi-institutional data sources
Adherence to agreed standards and interoperability & leveraging existing assets and capabilities	• Automates patient-data transfer with external hospital systems using standard communication protocols	• Seamless connectivity to virtually any linear accelerator & treatment planning system from any vendor, providing unmatched integration, freedom and flexibility	IT team, data and network security resulting in very fast time-to-value.
PBS / MBS	—	—	—
Robust privacy, security and data protection	• Built-in EDI (electronic data interchange) for secure online claim submissions • High Availability and Rapid Recovery Protection (HARRP) continuous data protection and ensures minimal data loss and immediate recovery	• Eliminate error-prone work through tight integration that enables the seamless transition of data between tools	—
Safety and Quality	• Facilitates compliance with the Work Health and Safety (WHS) Act	• Manual, barcode and biometric patient identification and verification options provide multilevel safety checkpoints	Quality and safety reporting.
Comparison of cost, complications, toxicity and practice	—	—	Comparison of cost, complications, toxicity and even comparison between different practice centres or clinics

From the healthcare provider perspective, the existing assets are equally important and their utilization/integration in the OIS and future features needs to be considered to make the OIS more attractive to healthcare providers. Similarly, calculation of payment share for VMOs and nurses, integration of PBS/MBS and private insurance benefits are missing and it also makes it difficult for OISs incorporation and implementation. Healthcare providers also had a desire to add safety and quality control related forms and protocols to avoid any legal or ethical issues. The need for web-based login was also a point to be considered as specialists work in different organizations as independent and they need to access data/images of patients and treatment equipment and not all the organizations have same solutions and licensing issues restrict access. Consequently, the patients suffer delays and missing of appointments and procedures.

- The new system being introduced should create value in terms of money and productiveness
- The OIS should be able to Integrate with existing assets and must have capabilities with future equipment and easy to upgrade
- Calculation and distribution of share for PBS/ MBS, specialists and nurses should be available
- To make it more attractive to VMOs, there should not be any licensing issues within and among different healthcare providers, better if its web-based with login access from anywhere
- There should be protocols and registering system to track safety and quality issues in treatment dose, cost and scheduling of appointments.
- Compatible data format for real time data accessing, updating, storing and transferring of change in plan from multi sites/users without compromising on patient privacy.

CONCLUSION

Cancer has already became a significant global health issue and has caused substantial disruption to the budgets of the general public and governments around the world because of expensive medicine and treatments. Using oncology information systems can help in providing more effective and efficient care for patients. OIS can also help in bringing imaging data, medication, radiation, recovery, progress and change in plan all in one place giving multiple users and multiple sites access. A comparison of 3 leading international OISs followed by focus group discussions with patients, clinicians and healthcare service providers was conducted. The key points have been summed up in Table 1. It is evident that as most of the leading international OIS are developed either in the US or Europe, they are not aligned with the Australian context and cannot be adopted as is into Australian healthcare system but must be suitably tailored first if their true potential is to be realised. Patients indicated the need for these systems to also support their needs such as access for making/ modifying appointment, having literature regarding their symptoms, disease and possible pathways related to treatment, its protocols, out of pocket costs, connecting with survivors, support for family members, recording of pain time, its duration, rating & and last but not least the missing or overdose logging of medicine. While clinicians and healthcare providers highlighted the need for web based omni login from anywhere, easy transmission of data & operability between existing systems and assets along with provision of inclusion of future equipment, access to visiting medical officer (VMOs) and government agencies (PBS/MBS) for up to date data monitoring and for subsidised treatment through Medicare (PBS/MBS) need to be considered with respect to designing such systems of these key factors into any oncology information system will make such system more likely to gain strong clinician and healthcare providers' support and better patient satisfaction for the Australian healthcare environment.. Hence, our study serves to highlight key areas that must be attended if these systems are to be actually beneficial in the Australian healthcare context.

REFERENCES

About the PBS. (2018). Available: http://www.pbs.gov.au/info/about-the-pbs

AIHW. (2017). *Cancer in Australia*. Available: https://www.cancer.org.au/about-cancer/what-is-cancer/facts-and-figures.html

Berwick, D. M. (2003). Disseminating innovations in health care. *Journal of the American Medical Association*, *289*(15), 1969–1975. doi:10.1001/jama.289.15.1969 PMID:12697800

Cancer in Australia. (2017). Canberra: Australian Institute of Health and Welfare.

Cheng, H. C., Wu, V. W., Liu, E. S. & Kwong, D. L. (2011). Evaluation of radiation dose and image quality for the Varian cone beam computed tomography system. *International Journal of Radiation Oncology, Biology, Physics, 80*, 291-300.

Connell, Martin, Bartlett, & Harvey. (2017). Cancer in Australia 2017. Canberra: Australian Institute of Health and Welfare Canberra Cat.

Crawford, S. (2013). Is it time for a new paradigm for systemic cancer treatment? Lessons from a century of cancer chemotherapy. *Frontiers in Pharmacology*, *4*, 68. doi:10.3389/fphar.2013.00068 PMID:23805101

Duckett, S., & Willcox, S. (2015). *The Australian health care system*. Oxford University Press.

Duncan, L. D., Gray, K., Lewis, J. M., Bell, J. L., Bigge, J., & Mckinney, J. M. (2010). Clinical integration of picture archiving and communication systems with pathology and hospital information system in oncology. *The American Surgeon*, *76*, 982–986. PMID:20836348

Evans, W., Ashbury, F. D., Hogue, G., Smith, A., & Pun, J. (2014). Implementing a regional oncology information system: Approach and lessons learned. *Current Oncology (Toronto, Ont.)*, *21*(5), 224. doi:10.3747/co.21.1923 PMID:25302031

Fasola, G., Aita, M., Marini, L., Follador, A., Tosolini, M., Mattioni, L., ... Aprile, G. (2008). Drug waste minimisation and cost-containment in medical oncology: Two-year results of a feasibility study. *BMC Health Services Research*, *8*(1), 70. doi:10.1186/1472-6963-8-70 PMID:18380901

Herre, H., & Heller, B. (2004). Ontological foundations of medical information systems. *New Trends in Software Methodologies, Tools and Techniques: Proceedings of the Third SoMeT_W04, 111*.

Hillestad, R., Bigelow, J., Bower, A., Girosi, F., Meili, R., Scoville, R., & Taylor, R. (2005). Can electronic medical record systems transform health care? Potential health benefits, savings, and costs. *Health Affairs*, *24*(5), 1103–1117. doi:10.1377/hlthaff.24.5.1103 PMID:16162551

Janssen, A., Brunner, M., Keep, M., Hines, M., Nagarajan, S. V., Kielly-Carroll, C., ... Shaw, T. (2017). Interdisciplinary eHealth Practice in Cancer Care: A Review of the Literature. *International Journal of Environmental Research and Public Health*, *14*(11), 1289. doi:10.3390/ijerph14111289 PMID:29068377

Krayenbuehl, J., Norton, I., Studer, G., & Guckenberger, M. (2015). Evaluation of an automated knowledge based treatment planning system for head and neck. *Radiation Oncology (London, England)*, *10*(1), 226. doi:10.118613014-015-0533-2 PMID:26555303

MBS Online. (2018). Available: http://www.mbsonline.gov.au/internet/mbsonline/publishing.nsf/Content/Home

No two breast cancer patients are the same and treatment should be tailored. (2018). Available: http://www.totalhealth.co.uk/blog/no-two-breast-cancer-patients-are-same-and-treatment-should-be-tailored

Nutbeam, D. (2008). The evolving concept of health literacy. *Social Science & Medicine*, *67*(12), 2072–2078. doi:10.1016/j.socscimed.2008.09.050 PMID:18952344

Paul, C. L., Boyes, A., Searles, A., Carey, M., & Turon, H. (2016). The impact of loss of income and medicine costs on the financial burden for cancer patients in Australia. *The Journal of Community and Supportive Oncology*, *14*(7), 307–313. doi:10.12788/jcso.0273

Paul, C. L., Fradgley, E. A., Roach, D., & Baird, H. (2017). Impact of financial costs of cancer on patients-the Australian experience. In *Cancer Forum, 2017*. The Cancer Council Australia.

Pesec, M., & Sherertz, T. (2015). Global health from a cancer care perspective. *Future Oncology (London, England)*, *11*(15), 2235–2245. doi:10.2217/fon.15.142 PMID:26235185

Prostate cancer in Australia. (2013). Australian Institute of Health and Welfare.

Saletti, P., Sanna, P., Gabutti, L., & Ghielmini, M. (2018). Choosing wisely in oncology: Necessity and obstacles. *ESMO Open*, *3*(5), e000382. doi:10.1136/esmoopen-2018-000382 PMID:30018817

Štambuk, S., Šundov, D., Kuret, S., Beljan, R., & Anđelinović, Š. (2010). Future perspectives of personalized oncology. *Collegium Antropologicum*, *34*, 763–769. PMID:20698168

Sulaiman, H., & Wickramasinghe, N. (2014). Assimilating Healthcare Information Systems in a Malaysian Hospital. CAIS, 34, 77.

Torre, L. A., Bray, F., Siegel, R. L., Ferlay, J., Lortet-Tieulent, J., & Jemal, A. (2015). Global cancer statistics, 2012. *CA: a Cancer Journal for Clinicians*, *65*(2), 87–108. doi:10.3322/caac.21262 PMID:25651787

Torre, L. A., Siegel, R. L., Ward, E. M., & Jemal, A. (2016). Global cancer incidence and mortality rates and trends—An update. *Cancer Epidemiology and Prevention Biomarkers*, *25*(1), 16–27. doi:10.1158/1055-9965.EPI-15-0578 PMID:26667886

Twitter graphic cancer in Aust 2017. (n.d.). Available: https://www.aihw.gov.au/getmedia/96aa3854-ceb0-40c5-8d25-27d4b1098490/twitter-graphic-cancer-in-aust-2017.pdf.aspx

Understanding Cancer. (2018). Available: https://www.mesotheliomagroup.com/our-mission/resources/understanding-cancer/

Wickramasinghe, N., Haddad, P., Vaughan, S., Han-Lin, C., & Moghimi, H. (2015). Identifying key success factors for the adoption and implementation of a chemotherapy ordering system: A case study from the Australian private healthcare sector. In *21st Americas Conference on Information Systems, AMCIS 2015*. Americas Conference on Information Systems.

Wickramasinghe, N., & Schaffer, J. (2010). *Realizing value driven e-health solutions.* Washington, DC: Report for IBM.

Chapter 18
Fast Track to Reduce Patient Lead Time:
A Discrete Event Simulation Analysis

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ABSTRACT

Patient lead time in emergency units is a critical factor for quality of care and patient safety. The objective of the chapter is a public emergency care hospital of a Brazilian city, important for its localization in the second more populated area of the city. Green risk patients constitute more than half of attendances and represent the largest volume of out-of-goal attendances in the hospital. Considering this analysis, it was conducted the process modelling in order to understand patient pathway and the main related problems. A list of undesirable effects was subsequently composed, allowing the construction of the current reality tree (CRT). With the root causes identified, the literature suggested fast track as an alternative to reduce the average waiting time in queue until the medical care. The method used for testing scenarios of fast track was discrete events simulation.

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INTRODUCTION

In the last few decades, hospitals across the world have faced economic pressure (Capkun et al., 2012). Modernization of hospital structures has a two-fold objective: improving quality of care and reducing healthcare costs. The demand for productivity and quality in service recognized in the past still an issue now a day (Sundbo, 1994; Vahatlo & Kallio, 2015; Spiegel & Assad, 2018).

In Brazil, as a constitutional principle, people have the right to health, which is a State duty (Brasil, 1988). However, pragmatic differences and difficulties arise when the resources needed to support this right are restricted (Tieghi, 2013). As defined by Hollnagel et al. (2013, p. 59), healthcare is "an open, extensive and widely effective system characterized by large numbers of people, emerging and adaptive behaviors over time."

In this context, designing healthcare operations refers to a complex object, which includes making decisions about the size of the health unit and its location, which healthcare flows will be available, what is the policy of hospital materials management, which IT system should be implemented according to the regulatory apparatus, among others (Spiegel & Cameira, 2016). The healthcare operations management refers to decisions and actions that occur within the limits defined by the operating system design. It includes activities such as the implementation of policies, procedures and strategies, contingent decision-making, process coordination, problem identification and resolution, response to uncertainty and unforeseen problems, and rewarding people (Spiegel et al, 2016). Improving the system refers to experimentation and learning activities aimed to improve operational performance over time (Gino & Pisano, 2008, p. 6).

In healthcare delivery systems, the problem of long waiting times is complex and highly variable (La & Jewkes, 2013). In some particular cases, such as emergency hospital units, the system is subject to demand peaks triggered by external and therefore uncontrollable events, where each patient presents a unique set of needs (Smith et al., 2007). Thus, this system needs to be designed to deal with variability in a scenario where there is an incompatibility between the investments and their potential demand (Hall, 2013).

The inefficiencies from wastes in the health service management also constitute a problem. To obtain efficiency gains in health services means reconciling different dimensions, such as quality, reliability, speed, availability and cost compatibility (Spiegel & Assad, 2016). Within the service operations strategy literature, there is a small but growing body of work that explores the links between operations strategy and healthcare performance (Silva et al., 2015). As discussed, this link is now even more important considering healthcare costs, the increasing importance of quality in healthcare, and current demographic patterns. Operations strategy has flourished as a field, yet there is still much to be learned regarding how this knowledge can be effectively applied within the healthcare setting. Specifically, how transferable are these manufacturing-derived principles to a setting where quality and costs take on a very different meaning (Spiegel & Cameira, 2016)?

La & Jewkes (2013) suggested that operations research (OR) techniques provide healthcare administrators a method of applying advanced analytical methods to facilitate better decision making. From this perspective, simulation and process modeling are essential tools for understanding resource allocation and utilization, as well the assessment of current and proposed system workflows.

In this sense, this research aims to use Process management tools and Discrete event simulation to reduce the average waiting time until the medical care process in an emergency unit. It contributes for both the healthcare area and the literature.

BACKGROUND

Emergency Departments Operations Management

According to Hall (2013), in emergency departments, depending on the nature of the disease, patient can be referred to an outpatient clinic or to a doctor and nurse in treatment rooms. This referral must be specialized by the level of urgency or disease type (orthopedics, for instance). It is conducted in risk classification phase by nurses whose associated functions are the patient's prioritization and stabilization. However, the emergency department proposal for resolution also involves patient's ability to provide resources, which are necessary for patient treatment and diagnosis.

Emergency department (ED) provides services to patients carrying various clinical conditions, who demand instant and efficient medical operations at any time (every day and 24 h per day). Planning an efficient medical operations leads to dealing with a great challenge: patients who do not need appointments to come to an ED, while managers efficiently try to allocate professionals to fill all ED attendance phases (e.g., registration, risk classification, and consultation). This effort is done in order to provide timely treatment to patients within limited financial budgets (Guo et al., 2017).

ED plays an important role in the whole healthcare system and regardless of hospital sizes, it is an area with complex interactions and multiple actors who are involved in interrelated processes. These interactions must occur in an orchestrated way in order to provide optimal patient care. In terms of volume, it is estimated that emergency department accounts for 40% to 70% of all hospital care (Strauss, 2014).

Sometimes the demand of emergency department exceeds capacity (overcrowding) (Hopp & Lovejoy, 2013) due to demand characteristics, which are described above. ED overcrowding is considered to be a serious problem and it has a critical impact on patient's safety. It could reduce survival chances of severe patients caused by the long waiting time (Nahhas et al., 2017).

EDs face, worldwide, an ever-increasing arrival of patients. Patients average in waiting to be evaluated by an ED physician in the USA has increased from 46.5 to 58.1min between 2003 and 2009. In Canada median risk classification-to-physician time has increased from around 40 min to nearly 120 min between 2000 and 2007. This increase in waiting time has lead to adverse clinical outcomes and a more stressful environment at ED. Evidence suggests that mitigation of crowding in EDs is associated with better clinical outcomes (Barak-Corren et al., 2017).

According to Litvak (2009), hospital flow can be affected by natural and artificial variability. Natural variability is the one where parameters are not measurable, such as, professional variability (knowledge asymmetry, experience and skills among the professionals that provide service), clinical variability (patients come with different diseases, different clinical conditions and different responses even when they undergo the same treatment) and flow variability (patients do not arrive with certain rate, they come when need medical attention).

Table 1. Optimizing hospital processes models: classifications and categories.

Classifications	Categories
Type of model	Computer simulation
	Descriptive
	Analytical
Type of problem	Process Design
	Capacity problem
	Scheduling problem
Kind of department	Operating room
	Inpatient
	Outpatient
	Imaging diagnosis
	Other
Objective of study	Designing a model
	Comparing models
	Using a model
	Critiquing/ proposing a model
Outcome measures	Waiting times
	Needed capacity
	Cost
	Utilization
	others
Validated in practice	Yes/no
Generic	Yes/no

Source: adapted from Van Sambeek et al., 2010.

Therefore, natural variability occurs randomly and must be managed on a daily basis. On the other hand, in artificial variability, parameters are measurable. Such as those associated with scheduling practices (a schedule that seeks to maximize resource utilization can, for instance, generate conflict with emergency patient care, leading to cancellation of one or more elective surgeries); patient flow management (treating hospital patient flow on an aggregate basis instead of distinguishing patients with more severe conditions, those who must be seen faster than others) and resources availability (ICU beds or nursing ward, equipment, human resources are, among others, unavailable and can increase queues, leading to surgeries cancellations and, in some cases, increase death rates). So, they are non-random variability and must be eliminated.

Discrete Event Simulation

Van Sambeek et al. (2010) categorize decision-making models related to design and control processes that involve patient flows in hospitals. The authors' objective is to map out how hospitals try to achieve the goals of higher quality and higher resource allocation efficiency in the field of operations management (OM) and operational research (OR). The synthesis of this categorization is presented in Table 1.

Shannon (1975) defines simulation as "process of elaborating a model of a real (or hypothetical) system and conducting experiments with the purpose of understanding the behavior of a system or evaluating its operation".

Discrete Event Simulation (DES) consists in a model that, according to Law and Kelton (2000), can be defined as "a set of assumptions about how a system works, to try to gain some understanding of how the system behaves".

According to Sakurada and Miyake (2009), Discrete Event Simulation covers the study of simulation models whose variables change state instantaneously at specific points of time, in contrast to what happens with continuous models, whose variables may change the state continuously along the time.

Günal & Pidd (2010) concluded that even after 25 years of Wilson (1981) review, there are still many barriers to the successful implementation of simulation to some degree in all domains, including health care and expose reasons:

1. A simulation project is often initiated by decision-makers who seek urgent solutions to their particular problems, having already carried out a thorough analysis of the situation. As the timing is crucial for the decision-makers, simulation analysts are expected to generate quick solutions, which they failed to do so, due to the time spent in collecting and analyzing data.
2. The simulation process is expensive (this may have changed due to better software).
3. When quick solutions are expected, modelers tend to oversimplify the models, which can cause decision-makers lack of confidence.

Despite the high efforts for data collection and development and validation time, a simulation model, according to Chwif (1999), has as advantages:

1. **Reduced risk of accidents:** in case there is any problem with the control Logic, it will be detected in the simulation, avoiding problems or material damage;
2. **Reduction of problems that may occur in the field:** since before testing the control logic in field, it is tested in the "laboratory", the possibility of still encountering logic errors is minimized;
3. **Extensive Tests:** With the simulation, a wide range of situations can be generated to test the control logic, making it "stronger", since it may work either for common situations as for uncommon ones, which may occur;
4. **The cost of each simulation round/set-ups, in the simulation model is despicable:** once the simulation model was built and customized, the time cost of assembling new configurations is minimal (just some simulation in the keyboard). In practice to test logic in a new system configuration may generate costs since there is all the time real time and costs set-ups.

Many authors have proposed new approaches to define general rules/configurations in order to deals with uncertainties about patient arrival and resource utilization.

For instance, Elalouf and Wachtel (2016) proposes sending patients, if possible, to receive treatment in other hospital departments (instead of in the ED) in order to reduce waiting time for examinations and treatment and in the same way Gasmi, Marcon, and Chakroun (2014) proposes a patient flow control that limits a maximum amount of non-urgent patients that could be accepted when the ED is overwhelmed.

In another direction for a given ED capacity (resource allocation) and patient prioritization criteria He, Lei, and Kremer (2014) compared several ED workflow strategies (first-in-first-out (FIFO) with priority, fast-track, physician triage and team triage) to conclude, in their case, which strategy provide the best ED performance.

An alternative way is proposed by Ashour and Kremer (2016) by softening the patient prioritization criteria using a dynamic grouping and prioritization (DGP) algorithm in order to identify appropriate patient groups and prioritize them according to the benefits to patients and to the system. Using a discrete event simulation (DES) they provide statistical evidence that the DGP system outperforms alternative (and traditional) prioritization methods in terms of all performance measures.

In addition, although many researches state the ED overwhelmed problem and strategies to reduce ED patients waiting time only Huang, Carmeli, and Mandel-baum (2015) evaluated the trade-off between a relevant and a little explored question: how to schedule patients that need to see a doctor again if new patients came from triage and cannot wait a lot.

Fast Track

The high volume of people arriving at the emergency department is one of the most relevant issues in healthcare management (Mazier et al., 2010) and there is a peculiar characteristic: patients simply "appear" with a unique set of needs (Smith et al., 2007). As they need no appointments, variation range of patient demand in emergency care is an old issue that has been studied for almost five decades. According to La and Jewkes (2013) previous simulation studies in healthcare systems have been used to make improvements in operational efficiencies and reducing wait times.

According to Hopp and Lovejoy (2013), fast track units are separate units to diagnose and treat patients with minor conditions that do not require as much emergency resources and are likely to be released after treatment. Based on La and Jewkes (2013) the introduction of fast track systems aims to reduce waiting times within EDs. Reducing patient waiting times allows an increase in the number of low-complexity patients that can be treated and discharged, thus increasing the effective capacity of the ED.

Welch and Savitz (2012) highlight that the concept of fast track is one of the most successful strategies used in medical emergencies to improve patient flow. Based on Considine *et al.* (2012), previous studies on fast track show a reduction in the patient's permanence in the emergency unit. Many examples investigated the implementation of fast track in a variety of settings, such as rural and urban areas, pediatric centers, international EDs and with care supplied by either a physician or mid-level provider (La & Jewkes, 2013).

Furthermore, Considine *et al.* (2012) looks at the disruptions and reallocations of staff that have an impact on the effectiveness of rapid assessment and initiation of treatment, as well as the fact that clinicians spend up to 28% of their time on activities which do not add value to the patient. This indicates that a study of the practices in the hospital is necessary so that the time of service is optimized. However, increasing the resources of the fast track was not always accompanied by an increase in the general flow of patients, sometimes leaving these resources underutilized. For Yoon (2003), fast track is an organizational approach that evaluates and treats acute or minimally ill outpatients in parallel in an emergency. Common elements of an emergency fast track system include selecting patients with low severity determined in a classification system, a separate physical space dedicated to patients fast track, dedicated medical and nursing staff and attached to a major emergency.

The Ministry of Health has identified that hospital overcrowding is an in-hospital flow problem. As a result, brought to the Brazilian Unified Health System the lean methodology which translates into lean production, rationalizing resources, which optimizes space and inputs. The use of fast track is one of the ideas driven by methodology lean (Bonelli & Souza, 2018a). The Municipal Hospital Odilon Behrens (HOB), located in the city of Belo Horizonte, Minas Gerais, was one of the six Brazilian public hospitals pioneering the implementation of the methodology lean started at this hospital in August 2017. Of the 12 thousand patients attended in May 2018 in this hospital, 63.8% were classified in green risk and have an average waiting time of 1.5 hours, comparatively lower than 5 hours of waiting time before the system's implementation (Bonelli & Souza, 2018b).

The manager of the studied Public Hospital is a public health company that is also pioneer in the use of lean in health care area, implementing this philosophy since 2014. The central idea is that in order to operate efficiently it is necessary to eliminate unnecessary activities of companies.

THE RESEARCH

Contextualization: Emergency Network in Brazil

The public health system is characterized in Brazil by the Brazilian Unified Health System, which is based on the 1988 Constitution and the Organic Health Law (8,080 / 1990). According to article 197, "health actions and services are of public relevance, and it is a Government responsibility to provide, under the terms of the law, its regulation, supervision and control". In this way, the Brazilian Unified Health System is based on the health context as a right of everyone and the duty of the State, "ensuring political and economic measures aimed at reducing the risk of disease and other diseases and universal and equal access to actions and services for its promotion, protection and recovery" (article 196 of the 1988 Constitution).

The emergency network of Rio de Janeiro in Brazil is made up of three different types of units: Emergency Care Unit (UPA), Regional Emergency Coordination (CER) and Emergency Hospitals. This segmentation is necessary to distribute the patients according to the degree of complexity, thus avoiding overloading, reducing the waiting time and allowing hospitals to dedicate themselves to cases of greater severity and trauma. Emergency hospitals are dedicated to the most serious emergencies, surgical cases and hospitalizations (Municipal Health Secretary, 2012).

The emergency network works with the policy of reception and risk classification and attends patients according to their specific disease profile. At the entrance of each unit, the patient is evaluated by professionals who analyze the individual cases: those who are in a more serious condition are cared for before the least serious, regardless of the order of arrival. The risk classification is based on situation / complaint / duration (SQD), history, use of medications, vital signs check, physical examination and so on. The risk classification is given at the following levels: emergent - immediate risk to life (red), very urgent - imminent risk of life (orange), urgent - potential life threatening potential / potential for serious complications (yellow), little or less urgent (green) and non-urgent (blue) (Municipal Health Secretary, 2012).

Each color is assigned a maximum limit of waiting time for the patient to be attended, determined as a goal by the Municipal Health Secretary (SMS). Patients classified as red should be treated immediately, orange in up to 10 minutes, yellow in up to 30 minutes, green in up to 1 hour and blue in up to 2 hours or redirected to the primary care network (Municipal Health Secretary, 2002).

Research Method

The research methods are the basis for the creation of knowledge, being the tools that lend themselves to understand the reality (Pinsonneault & Kraemer, 1993). Following the classification proposed by Eisenhardt (1989) and Yin (2005), this research is an exploratory single case study. Its objective is to deepen the comprehension regarding a problem that is not yet sufficiently studied, to suggest hypotheses and questions, or to develop the theory.

Green risk patients constitute more than a half of attendances at the studied Hospital, and that they represent the largest volume of out-of-goal attendances. Considering this analysis, it was conducted the process modelling through semi-structured interviews at the Hospital with nurses, administrative assistants and physicians, in order to understand patient pathway and the main related problems. Afterwards a list of undesirable effects (Dettmer, 1997) was created through field observation, which were organized according to the Current Reality Tree (CRT) following Noreen et al. (1995) steps. A prioritization matrix was used to prioritize the root causes, which will be the focus of proposition of improvements.

Considering the findings, this article proposes testing a fast track solution, indicated by literature as an alternative to reduce the average waiting time until the medical care (La & Jewkes, 2013). The method used is discrete events simulation (Shannon, 1975) using real data analysis, considering the creation of a fast track service for this profile of patients.

Then, the simulation technique in ARENA software were conducted to test the scenarios previously proposed. These scenarios aim to improve the time of service. This lead time reduction aims to reach the service level defined in the management agreement with the Municipal Health Secretary. The consequences are increasing quality of care and population satisfaction that uses the Hospital and also its employees satisfaction (Considine et al., 2008), when subjected to less pressure of the environment.

Object of Analysis

Benbasat and Weber (1996) 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 object of the article is the public emergency care hospital of a Brazilian city. It is an important health care emergency unit considering its localization in the second more populated area of the city. It is inserted in a network of 10 large scale emergency hospitals of Municipal Health Secretary. In addition to emergency care for adult patients, it also offers pediatric and pregnant emergency services. Emergency care of pregnant women occurs in a specific and isolated area of the hospital. Despite pediatric emergency care initiates at the same location of adults, the consultations with pediatric physicians occur in an separated area, no longer consuming the same resources of the main flow.

Therefore, the focus of the study are the non-pediatric and non-pregnant patients classified as green risk awaiting the first medical care that are referred to specialized medical care. The hospital offers general, orthopedics and surgery evaluation.

Description of the Current Situation

This section address the description of the hospital layout, the human resources organization, the characteristics of the risk classification and the process details.

Hospital Layout

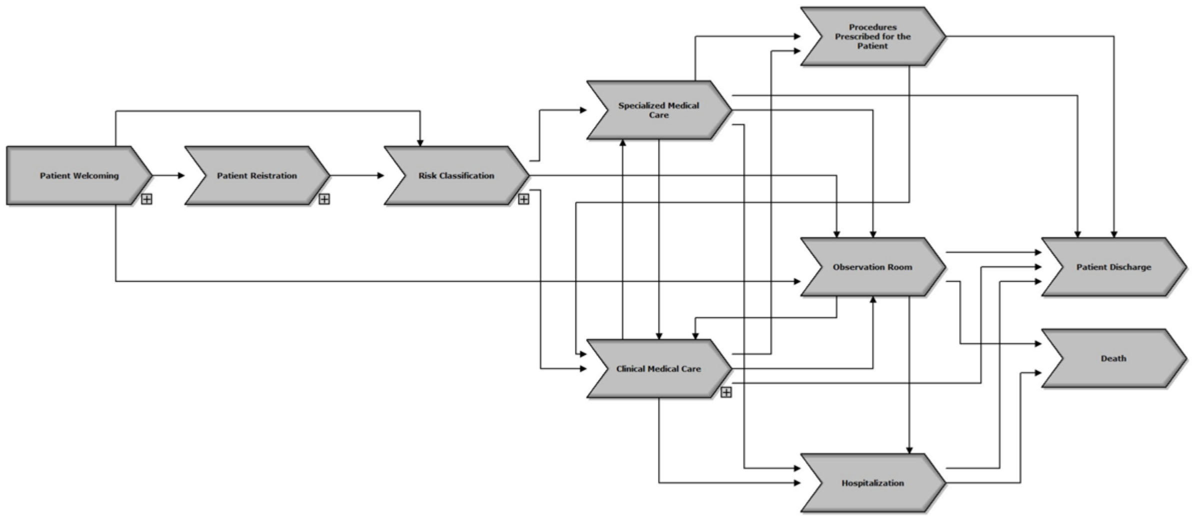
The hospital offers 3 main services that are organized in different layout structures, such as emergency care, hospitalization and surgical procedures. The layout description is is focused on the attendance until the first medical appointment.

1. Patient reception and registration workstation: it is located at the entrance of the emergency unit. The reception is conducted by a nurse that collect the first patient complaint and may refer this patient for any service if it is necessary. For the registration, patients are organized on a first-come, first-served basis. Sometimes service tickets are manually distributed in order to organize the queue. It occurs when there are more than 20 waiting patients in queue.
2. Risk classification workstation: there are 2 rooms available for the patient risk classification. Patients are organized on a first-come, first-served basis and there is a call manager screen (visual and sound signal) that allows the communication between nurses and patients in queue. A life sign measurement equipment integrated to the classification information system (a decision tree n algorithm) is available in each classification room, so that the nurses can complete the risk classification on average in 3 minutes.
3. Medication room: this area is near the classification risk workstation to allow fast patient referrals. There are 4 workstation in this room and a isolated area where electrocardiogram is conducted. It is also in this room where blood collection occurs when a laboratory analysis is necessary.
4. Medical offices: in this emergency units there are 2 general medical offices, 2 orthopedic medical offices and 1 office where surgeon evaluates specific cases. There is a hall separating the risk classification workstation and these medical offices. Each physician must record patients information on the information system.
5. Waiting area: there is one central area where patients must wait each step. They are called through a call management screen. There are specific waiting areas for each service, to allow a visual management of patient in queue.

Risk Classification Protocol

This emergency unit uses an adaptation of Manchester Protocol. The codes of risk classification are red, orange, yellow, green and blue according to patient risk of death. The maximum waiting time allowed for each classification is immediately attendance for the red classification, and 15, 30, 60 e 1440 minutes for the following respectively. According to the hospital management reports, patients in green classification often are not evaluated by the physician in established time.

Figure 1. Emergency Patient VAC.
Source: The authors, 2019.



Processes Description

Patient care begins in reception process where nurse hear the first patient complaint and may refer this patient for any service if it is necessary. If it is a patient without a serious health condition, he is referred to the registration queue. This registration process is an important step for the information workflow. It is in this process where patient receives the bar code that will organize and track all his attendance.

After registration, he is referred to risk classification process. From this process until the end of patient stay in hospital, patient flow is supported by the information system and organized by the call manager screen. The priority of care defined in risk classification will determine patient position in queues and also change his care rout by hospital services. The classification is a standardized process performed by a nurse using life sign measurement equipment integrated to the classification information system.

Patients classified as red risk is immediately referred to medical care or to observation room, depending on his health situation. The other risk codes are referred to clinical or specialized medical care and may after be addressed to observation, hospitalization or surgical processes. The physicians of medical care process may also prescribe some procedures such as exams or medication.

After having crossed the appropriated processes, patient must be evaluated by the physician before the discharging process. The model in figure 1 represents the Value-Added Chain (VAC) of the emergency care in the studied hospital. It was elaborated using the ARPO modeling tool, using ARIS notation.

The field observation and interviews to construct process modeling allowed the identification of problems, or undesirable effects (Goldratt & Cox, 1984). These problems were reported and organized in a list used as an input to construct the CRT. According to Bornia and Neto (2001), CRT can be conceptualized as being basically a cause-effect relationship that seeks to identify which undesirable effects occur and objectifying the location of the cause of these undesirable effects, the so-called root problem. Dettmer (1997) defined a CRT as a logical structure that depicts the state of reality as it currently exists in a given system. According to Dettmer (1997) constructing a current reality tree is the first and most critical step on the path to improvement, because it makes us verbalize the symptoms and the underlying causes.

Figure 2. Current Reality Tree (CRT) with undesirable effects.
Source: The authors, 2019.

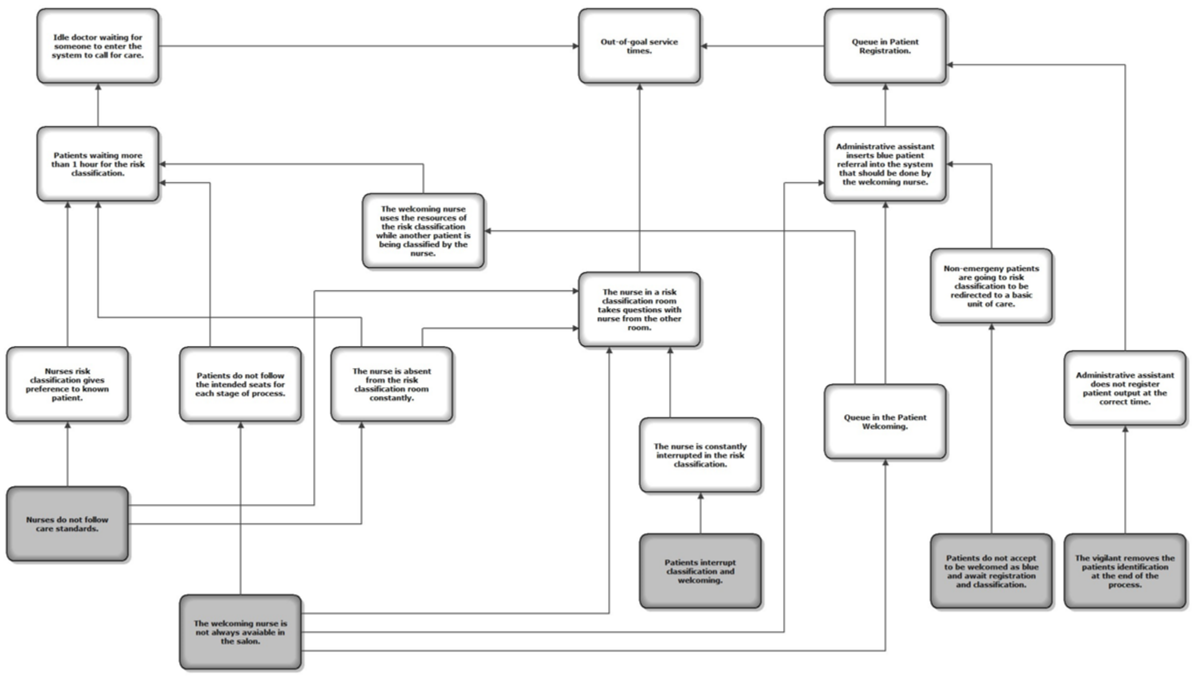


Table 2. Prioritization matrix.

Criteria	Ease of Intervention	Impact on risk classification time	Impact on green patient care time	Impact on return patient time	Impact on patient crossing time	
Weights	**1**	**4**	**3**	**3**	**2**	**TOTAL**
Patients do not accept to be welcomed as blue and await registration and classification	1	4	2	3	3	38
The reception nurse is not always available in the salon	3	4	3	0	3	34
Nurses do not follow the care standards	3	4	1	1	3	31
Patients interrupt classification and welcoming	1	4	1	1	3	29
The vigilant removes the patient's identification at the end of the process	1	0	0	0	4	9

Subtitle: 0 (little) until 5 (very)
Source: The authors, 2019.

The CRT identifies cause and effect relationships in a system. It is constructed from the top-down by identifying undesirable effects, and depicting probable causes for those effects (effect-cause). It is however, read from bottom-up (cause-effect), when the construction is complete (Goldratt & Cox, 1984; Goldratt, 1990; Goldratt, 1994). The Figure 2 was constructed following Noreen et al. (1995, p.156) steps to develop CRT.

Table 3. Number of patient attendance in April 2019.

Patients Served	Average time of attendance	Green			Yellow			Red	
		Average time	In the goal	Out of the goal	Average time	In the goal	Out of the goal	In the goal	Out of the goal
14502	81	83	5092	2524	57	3281	1150	353	0

Source: The authors, 2019.

It is important to highlight that the CRT allows to identify the root causes from all the undesirable effects (Dettmer, 1997). Through this analysis, the project must solve/propose alternatives to this root causes and not to its effects. Figure 2 shows that contrasted gray problems causes the white one, so that solving any white one means a wasting of resources, because the root cause will make the white one occur again. From this point of view, the focus is to analyze and discuss how to solve this gray root causes.

The prioritization matrix shown in Table 2 was constructed to identify from the five root causes in the Current Reality Tree, which will be the focus of the proposed improvements.

Data Analysis

According to the Current Reality Tree and the prioritization matrix, root causes are directly related to the patient's total waiting time, mainly for the green risk. Usually, the nurse of the reception process is not available in this process and the waiting time for registration and classification increase, especially because of constant interruption of these processes by patients asking for some information. Observing Municipal Hospital statistics in Tables 2 and 3, we can see that the classified patients are not being attended within the limit established by the Municipal Health Department.

Once green patients make up the largest percentage of patients served outside the established goal, the present study focus on reducing their waiting time.

The current situation process was implemented in ARENA® software. The parameters used were obtained from company's information management system and three alternative scenarios were simulated in order to evaluate which hospital configuration could reduce green patient waiting time.

The following assumptions were adopted in simulation:

- Only physician care process was considered in the model (2 physicians consultation rooms).
- The registration process was considered constant, estimated in forty seconds, because this process is the patient's data collection.

Table 4. Number of patient attendance in May 2019.

Patients Served	Average time of attendance	Green			Yellow			Red	
		Average time	In the goal	Out of the goal	Average time	In the goal	Out of the goal	In the goal	Out of the goal
15425	94	68	5739	2284	44	3656	1240	383	0

Source: The authors, 2019.

Table 5. Distribution of patients' arrival time.

Interval	Limits	Distribution	Expression	Patient's sample
09:00 – 11:59	0-21	Gamma	-0.5 + GAMM(0.937, 2.38)	3976
12:00 – 12:59	0-15	Beta	-0.5 + 16 * BETA(4.22, 22.4)	1084
13:00 – 15:59	0-16	Gamma	-0.5 + GAMM(0.953, 2.41)	3817
16:00 – 17:59	0-23	Beta	-0.5 + 24 * BETA(3.47, 28.2)	2128

Source: The authors, 2019.

Table 6. Distribution of other processes.

Process	Limits (minutes)	Distribution	Expression	Patient's sample
Total rating time	0-15	Logarithm	-0.5 + LOGN(2.96, 2.08)	3985
Total Time of Medical Care	0-20	Logarithm	-0.5 + LOGN(4.12, 2.83)	4420

Source: The authors, 2019.

Table 7. Data considered constant.

Constant Average	
Reception process	6.67 sec
Registration	40 sec

Source: The authors, 2019.

- Reception process of non-emergency patients was estimated in five seconds as they are referred to the Registration queue. Critical patients are processed within one minute and thirty seconds, due to the need to gauge the vital signs of the patient. As these patients are rarer among the total, it is estimated a probability of one in fifty (1/50) of five-second patients.
- The time of referral to the primary care unit was considered as one second, since these patients will not be considered in the analysis.
- There are two possible pathways that the patient makes when arriving at the hospital depending on their arrival time (from 9 am to 6 pm there is a nurse who performs the Reception process). Through database analysis it is observed that the weekday with higher number patient admission is Monday. For better adapting the model to the reality of the higher number of attendances, the data collected from 9 am to 5:59 p.m. on Mondays will be used for the model.
- Due to the distribution of patient arrivals varies according to the day period, the distributions were calculated creating blocks of patient entries (time intervals), in order to make the model more realistic. The distribution and ranges considered are expressed in Table 4.

The data collected from the Hospital database were inserted in the Input Analyzer tool (provided by ARENA software) to verify the best distribution of each process. These results are shown in Tables 5 and 6.

Table 8. Classified patients.

Classification	Amount	Percentage
Red	96	1.4%
Orange	368	5.37%
Yellow	1,809	26.40%
Green	3,086	45.03%
Blue	1,494	21.80%

Source: The authors, 2019.

Table 9. Patients attended.

Classification	Amount	Percentage
Red	14	0.31%
Orange	334	7.35%
Yellow	1,569	34.51%
Green	2,572	56.58%
Blue	57	1.25%

Source: The authors, 2019.

Considering that patients identified as red risk in the Reception process have their names registered in the information system, the number of patients that doesn't consume the classification and medical care processes is 74 of 11,161 patients from the base data, which is equivalent to 0.66%.

Besides that, patients classified as blue risk at the time of the Reception process (1,887, 17.02%) are referred to primary care. Therefore, these patients should also not occupy the hospital's medical care resource that is analyzed in this article. However, some patients refuse to go to the primary care unit, choosing to stay in the Hospital and consumes the resources of Classification process. In the analysis, only 393 accepted to be referred to the primary care unit, leaving 1,494 non-emergency (blue) patients who chose to wait the attendance in the Hospital. After being attended by the risk classification nurse and being referred to primary care again, 1,437 accepted this referral, leaving only 57 patients classified as blue who opted to wait for the doctor's care. Thus, in Registration process 9,200 patients (82.98%) are considered in emergency situation and must be processed in hospital service.

It should be noted that some patients change their emergency status (risk classification) in queue, during the waiting time. In addition, some patients may give up the attendance after Registration process or the red risk can be verified at the moment of waiting in queue and patient can be referred directly to observation process, without occupying the classification and medical care processes that will be analyzed in that article.

Because of this, the number of patients classified differ from those recorded in Registration process. The classification occurs according to Table 7, out of the total of 6,853 classified patients.

The data collected from the information system shows the quantities of each classification risk in Table 8, out of a total of 4,546 attendances. These values were used to calculate the percentage of each

Table 10. Current scenario results in minutes all over 1000 replications.

Queue	Average	Minimum Average	Maximum Average
Patients classified as orange	1.25627	0.153681	3.116258
Patients classified as yellow	1.643544	0.453636	5.994
Patients classified as green	7.068	1.130989	125.94
Patients classified as blue	23.298	0	339.546

Source: The authors, 2019.

risk in the model, which will be object of study in order to test scenarios to verify the best configuration that the Hospital can provide to allow reduction in waiting time within the limits established by the Ministry of Health.

It was observed that the Risk classification process often becomes the bottleneck, while medical care is idle, the first scenario is to withdraw patients from Classification when the queue in that process exceeds 20 patients and releasing them directly to the doctor in order of arrival. The Reception process remains to direct patients who would be in red risk to immediate care and direct non-emergency patients to primary health care units.

The second scenario proposed considers that as there are two medical care rooms available in the Hospital, one consultation room will be available for patients classified as green, leaving the other for orange, yellow and blue patients. This fast track would work full time.

In the third scenario, as there are two consultation room available in the Hospital, one of them would be available for green patients when there were more than 20 patients waiting in queue. At these times, the other consultation room would work with patients with orange, yellow and blue risk classification.

SOLUTIONS AND RECOMMENDATIONS

We retrieved the data collection from hospital database system and implemented the simulation model in ARENA® simulator in order to:

1. Evaluate outputs from current ED configuration (following current patient ordering rules);
2. Propose and implement in the simulation model alternative strategies to ED configuration in order to decrease patient crossing time.

In addition, we analyze in all sceneries (including in current one) if the waiting times queues for each kind of patient can be lesser or equal to maximum waiting time limit defined by Health Secretary of Rio de Janeiro. These limits are defined according patient's risk classification as follows: patients classified as orange should be treated in up to 10 minutes, yellow in up to 30 minutes, green in up to 1 hour and blue in up to 2 hours or redirected to the primary care network.

In current scenario patient ordering rules are:

1. Green, yellow and orange patients must pass to registration, triage and consultation room;
2. Blue patients must pass to registration, triage and redirection to the primary care network;

Table 11. Scenario 1 results in minutes all over 1000 replications.

Queue	Average	Minimum Average	Maximum Average
Patients classified as orange	0.917806	0	3.31301
Patients classified as yellow	1.139873	0.287397	3.920343
Patients classified as green	3.479675	0.40732	13.782
Patients classified as blue	8.532	0	120.558

Source: The authors, 2019.

3. In registration and triage processes all patients will be served following first in first out rule (FIFO);
4. In medical consultation process patients will be served following highest classification risk (red, orange, yellow, green and blue, respectively) and after, in the same classification risk by first in first out rule (FIFO);

Table 10 summarizes the results obtained throughout 1000 replications showing the average waiting time by patient classification risk color.

In Table 10 the results match the reality observed in ED. The waiting time of patients classified as green and blue in some moments exceeds the stipulated limit, with a mean maximum time of 125 and 339 minutes respectively, although the average time is 7 and 23 minutes.

A report extracted from the simulation showed that the common ED overcrowding between 09:00 – 11:59 throughout 10 replications and all over sceneries proposed the main objective is to reduce that level and peaks for the same process time and patient arrival parameters presented in tables 5, 6 and 7.

In order to reduce the patient crossing time, we propose the first scenario, in which patient's pathway are based on the following rules:

1. Green, yellow and orange patients must pass to registration, triage and consultation room;
   a. If the queue in triage step exceeds 20 patients all patients will be load in consultation room queue where patient will be served in FIFO order;
   b. If the queue in triage step is lesser or equal to 20 than patients the sequence of steps remains the same of current scenario (registration, triage and consultation room);
2. Blue patients must pass to registration, triage and redirection to the primary care network;
3. In registration process all patients will be served following first in first out rule (FIFO);
4. If the number of patients waiting for triage step do not exceed 20 patients the triage processes all patients will be served following first in first out rule (FIFO) else this step only load patients to consultation room queue, in other words, there is no triage process;
5. In medical consultation process patients will be served following highest classification risk (red, orange, yellow, green and blue, respectively) if exists and after by first in first out rule FIFO;

Table 11 summarizes the results obtained throughout 1000 replications showing the average waiting time by patient classification risk color is presented.

In this scenario a several reductions of the maximum average time of the 1000 replications is observed. The maximum waiting time for patients classified as green reduced from approximately 2 hours to 13 minutes, and the classified as blue reduced from more than 5 hours to the exact 2 hours, time limit for the goal. Thus, the first scenario is viable.

Table 12. Scenario 2 results in minutes all over 1000 replications.

Queue	Average	Minimum Average	Maximum Average
Patients classified as orange	2.104798	0	10.482
Patients classified as yellow	4.33228	0.751118	26.64
Patients classified as green	10.692	1.478288	77.598
Patients classified as blue	9.804	0	161.682

Source: The authors, 2019.

Besides feasibility ensured by Table 11, according to data extracted from the simulation is possible to use this rules to decrease in 2:30 hours the maximum waiting time of green patient and in 1:00 hour the maximum waiting time of yellow patient.

Seeking better results and taking into account the patient classification proportion the second scenario consists of allocating a specific consultation room to green patient and, therefore, leaving the other for orange, yellow and blue patients. In other words, the difference between current scenario and scenario 2 is an exclusive consultation room for green patients while the other consultation room serves all other patients classification risk.

Table 12 summarize the results obtained all over 1000 replications. In Table 12 the average waiting time by patient classification risk color is presented.

For the second scenario tested, it is observed that although the mean maximum queuing time of patients classified as green and blue also reduced significantly, they still remain outside the 60 and 120 minute goal, respectively. In addition, the mean maximum queue time of patients classified as orange, who was within the goal in the scenario that represents reality, increased from 3.1 to 10 minutes, remaining at the limit of the target for certain patients, which is not desirable, although its average waiting time is only 2 minutes. So, the second scenario is not feasible.

Table 12 shows that a single consultation room is not able to process all green patients and including could increase their waiting time. The waiting time of yellow patients remains near to the first scenario and decrease yellow patients waiting time in 1 hour comparing to current scenario. So, although that is a current solution adopted in other researchers presented in previous section, in our case this solution is worse than the current ED configuration. The purpose of test and present a worse scenario than the current adopted by the company is to show a concrete contribution of discrete event simulation importance to refuse even some "state of art" solutions.

Finally, the third scenario, merges the two scenarios previously presented in order to evaluate the viability of changing the current scenario with the following patient ordering rules:

1. Green, yellow and orange patients must pass to registration, triage and consultation room;
    a. If the green patient queue exceeds 4 patients the ED will serve green patients in a specific consultation room and that green queue can be served by both consultation rooms.
    b. If the green patient queue does not exceed 4 patients the ED sequence of steps remains the same of current scenario (registration, triage and consultation room);
2. Blue patients must pass to registration, triage and redirection to the primary care network;
3. In registration process all patients will be served following first in first out rule (FIFO);
4. In medical consultation process patients will be:

Table 13. Scenario 3 results in minutes all over 1000 replications.

Queue	Average	Minimum Average	Maximum Average
Patients classified as orange	0.941677	0	3.341217
Patients classified as yellow	1.146686	0.287397	3.71496
Patients classified as green	3.248477	0.40732	11.298
Patients classified as blue	8.508	0	120.558

Source: The authors, 2019.

a. Served following highest classification risk (red, orange, yellow, green and blue, respectively) and after by first in first out rule FIFO if ED configuration in that moment share consultation rooms for all patients (see scenario 3 first rule);
b. Served following highest classification risk (red, orange, yellow, green and blue, respectively) and after by first in first out rule FIFO if ED configuration in that moment share consultation rooms for all patients in one consultation room and serve only green patients in the other (see scenario 3 first rule);

Table 13 summarize the results obtained all over 1000 replications. In Table 13 the average waiting time by patient classification risk color is presented.

In this scenario it is observed that the average time of all the queues reduced compared to the current scenario, as well as the average maximum waiting time for patients classified as yellow, green and blue. The average maximum waiting times are below the stipulated target, except for the blue-labeled patient who is within 120 minutes, although the average time is 8 minutes. The result found is similar to the one obtained in the first scenario tested.

Table 13 shows that using this merge rule proposed is possible to decrease in 45 minutes the maximum waiting time of green patient comparing it to scenario 1 and in 3 hours from current scenario. The waiting time of yellow patients remains near to all scenarios tested and decrease yellow patients waiting time in 1 hour comparing to current scenario.

So, if these settings parameters presented in Tables 4 to 9 do not radically change the merge rule proposed and evaluated in scenario 3 should be adopted.

FUTURE RESEARCH DIRECTIONS

An interesting scenario to be approached that was not possible in the present study is the compulsory attendance of one green patient for every four attendances of a patient in the order stipulated by the classification of risk (including green patients). The idea is that this configuration occurs in both offices and full time.

Another interesting work to be approached is to use the return patient as the focus of the study. It is now known that returning patients are waiting in line for a long time, since their waiting time does not have a goal. A proposed scenario for future work is to attend in one of the offices, full time, one patient returns to every two patients. This is possible because, according to the collection in the hospital database, it is verified that the patients who return are only 1.98% of all the attendances.

Another proposed scenario is that of attending a patient to return to each three attendances in each of the offices, configured in this way full time.

CONCLUSION

This chapter sought to discuss a fast track solution to reduce patient crossing time in the hospital. In the first stage, the process modelling was carried out with structured interviews in the hospital with the main process actors. After the data collection, ARPO modelling tool using the ARIS notation was adopted to represent the current patient flow in the emergency unit.

This step of modelling the current situation and identifying problems allowed the construction of a list of undesirable effects. The list was an input to Current Reality Tree (CRT). The CRT was used to identify the root causes. Later, the problems were prioritized in a matrix according to criteria such as facility of intervention, impact on the time of risk classification, impact on the time of care of the green patient, impact on the time of patient care of return and impact on patient crossing time.

The next step was to collect data about the processes in the hospital to use the discrete event simulation tool. Some premises were established to adequate the use of these data in ARENA and to test the scenarios proposed. Three scenarios were tested: withdraw patients from risk classification when the queue in that process exceeds 20 patients and releasing them directly to the doctor in order of arrival; two consultation room available in the Hospital, one consultation room will be available for patients classified as green risk, leaving the other for orange, yellow and blue risk patients and an office will be available for green risk patients at determined times when the demand is more than 20 patients waiting to be evaluated by a doctor (in queue).

The first scenario allows a several reductions of the maximum average time, the maximum waiting time for patients classified as green reduced and the classified as blue reduced to limit for the goal. In the second scenario, although the mean maximum queuing time of patients classified as green and blue also have reduced too much, they still remain out-of-goal and the mean maximum queue time of patients classified as orange, who was within the goal in the scenario that represents reality, increased. In the third scenario the average time of all the queues reduced compared to the current scenario, as well as the average of the maximum wait time for patients classified as yellow, green and blue. The average maximum waiting times are below the stipulated goal, except for the patient classified as blue. The result found is similar to the one obtained in the first scenario tested.

It is possible to conclude from the simulation of the scenarios tested that the first and third scenarios have similar results, that is, by evaluating the question of time of service and queues for the patients, the two scenarios are equally efficient.

But according to the concepts presented in the paper, it was taken into account that as the first scenario considers the risk classification as a bottleneck releasing patients when the queue is larger than 20 people and the third scenario focuses on the issue of the patient classified as green, proposing a temporary fast track clinic to help in times where the queue of this type of patient is larger, the third scenario is better suited to the initial objective of the work, being chosen as the best scenario to be put into practice by the hospital.

REFERENCES

Barak-Corren, Y., Israelit, S. H., & Reis, B. Y. (2017). Progressive prediction of hospitalisation in the emergency department: Uncovering hidden patterns to improve patient flow. *Emergency Medicine Journal*, *34*(5), 308–314. doi:10.1136/emermed-2014-203819 PMID:28188202

Benbasat, I., & Weber, R. (1996). Research commentary: Rethinking "diversity" in information systems research. *Information Systems Research*, *7*(4), 389–399. doi:10.1287/isre.7.4.389

Bonelli, B., & Souza, T. (2018a, June 13). *MS implanta excelência operacional nas emergências do SUS em Tocantins*. Brasília: Ministério da Saúde. Retrieved from http://portalms.saude.gov.br/noticias/sas/43552-ms-implanta-excelencia-operacional-nas-emergencias-do-sus-em-tocantins

Bonelli, B., & Souza, T. (2018b, June 13). *MS implanta excelência operacional nas emergências do SUS em Minas Gerais*. Brasília: Ministério da Saúde. Retrieved from http://portalms.saude.gov.br/noticias/sas/43548-ms-implanta-excelencia-operacional-nas-emergencias-do-sus-em-minas-gerais

Bornia, A., & Rocha Neto, A. (2001). *A utilização da ferramenta árvore da realidade atual para a identificação do problema raiz em uma instituição de ensino superior*. Salvador, BA, Brasil: Anais do Encontro Nacional de Engenharia De Produção.

Brasil. Ministério da Saúde. (2002). *Tempo de espera na urgência e emergência.* Retrieved from http://www.ans.gov.br/images/stories/prestadores/E-ACE-02.pdf

Brasil. Ministério da Saúde. Pesquisa para saúde: por que pesquisa em saúde? Textos para tomada de decisão. (2007). *Council on Health Research for Development and Global Forum for Health Research.* Secretaria de Ciência, Tecnologia e Insumos Estratégicos Departamento de Ciência e Tecnologia, Brasília.

Capkun, V., Messner, M., & Rissbacher, C. (2012). Service specialization and operational performance in hospitals. *International Journal of Operations & Production Management*, *32*(4), 468–495. doi:10.1108/01443571211223103

Chwif, L. (1999). Redução de modelos de simulação de eventos discretos na sua concepção: uma abordagem causal. São Paulo: Academic Press.

Considine, J., Kropman, M., Kelly, E., & Winter, C. (2008). Effect of emergency department fast track on emergency department length of stay: A case–control study. *Emergency Medicine Journal*, *25*(12), 815–819. doi:10.1136/emj.2008.057919 PMID:19033498

Considine, J., Lucas, E., Martin, R., Stergiou, H., Kropman, M., & Chiu, H. (2012, January 18). Rapid intervention and treatment zone: Redesigning nursing services to meet increasing emergency department demand. *International Journal of Nursing Practice*, *18*(1), 60–67. doi:10.1111/j.1440-172X.2011.01986.x PMID:22257332

Dettmer, H. W. (1997). *Goldratt's Theory of Constraints: a systems approach to continuous improvement*. Milwaukee, WI: ASQC Quality Press.

do Brasil, S. F. (1988). *Constituição da república federativa do Brasil*. Brasília: Senado Federal, Centro Gráfico.

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review*, *14*(4), 532–550. doi:10.5465/amr.1989.4308385

Fanjiang, G., Grossman, J. H., Compton, W. D., & Reid, P. P. (Eds.). (2005). *Building a better delivery system: a new engineering/health care partnership*. National Academies Press.

Gino, F., & Pisano, G. (2008). Toward a theory of behavioral operations. *Manufacturing & Service Operations Management: M & SOM*, *10*(4), 676–691. doi:10.1287/msom.1070.0205

Goldratt, E. M. (1990). *What is This Thing Called Theory of Constraints and How Should it be Implemented?* New York, NY: North River Press.

Goldratt, E. M. (1994). *It's Not Luck*. Gower.

Goldratt, E. M., & Cox, J. (1984). *The Goal: An Ongoing Improvement Process*. Aldershot, UK: Gower.

Günal, M. M., & Pidd, M. (2010). Discrete event simulation for performance modelling in health care: A review of the literature. *Journal of Simulation*, *4*(1), 42–51. doi:10.1057/jos.2009.25

Guo, H., Gao, S., Tsui, K. L., & Niu, T. (2017). Simulation optimization for medical staff configuration at emergency department in Hong Kong. *IEEE Transactions on Automation Science and Engineering*, *14*(4), 1655–1665. doi:10.1109/TASE.2017.2697899

Hall, R. (2013). *Patient flow: reducing delay in healthcare delivery*. Berlin: Springer Science & Business Media. doi:10.1007/978-1-4614-9512-3

Hollnagel, E., Braithwaite, J., & Wears, R. L. (2013). *Resilient health care*. Surrey, UK: Ashgate Publishing Limited.

Hopp, W. J., & Lovejoy, W. S. (2013). *Hospital operations: principles of high efficiency health care*. FT Press.

La, J., & Jewkes, E. M. (2013). Defining an optimal ED fast track strategy using simulation. *Journal of Enterprise Information Management*, *26*(1), 109–118. doi:10.1108/17410391311289578

Law, A. M., & Kelton, W. D. (2000). *Simulation modeling and analysis*. Singapore: McGraw-Hill.

Litvak, E. (2009). *Managing patient flow in hospitals: strategies and solutions* (2nd ed.). Oakbrook Terrace, IL: Illinois Joint Commission Resources.

Mazier, A., Xie, X., & Sarazin, M. (2010, August). Scheduling inpatient admission under high demand of emergency patients. In *Automation Science and Engineering (CASE), 2010 IEEE Conference on* (pp. 792-797). IEEE. 10.1109/COASE.2010.5584679

Nahhas, A., Awaldi, A., & Reggelin, T. (2017). Simulation and the Emergency Department Overcrowding Problem. *Procedia Engineering*, *178*, 368–376. doi:10.1016/j.proeng.2017.01.068

National Academy of Engineering of the National Academies. (2003). *The impact of academic research on industrial performance*. National Academy of Engineering of the National Academies Press.

Noreen, E., Smith, D., & Mackey, J. (1995). *The Theory of Constraints and Its Implications for Management Accounting* North River Press.

Patton, M. Q. (2002). *Qualitative Research & Evalutation Methods* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Peck, J., & Kim, S. (2008). 147: Improving emergency department patient flow through optimal fast track usage. *Annals of Emergency Medicine*, *52*(4), S88. doi:10.1016/j.annemergmed.2008.06.061

Pinsonneault, A., & Kraemer, K. L. (1993). Survey research methodology in a management information systems: An assessment. *Journal of Management Information Systems*, *10*(2), 75–105. doi:10.1080/07421222.1993.11518001

Rosenberg, N., Gelijns, A. C., & Dawkins, H. (Eds.). (1995). *Sources of medical technology: universities and industry*. National Academies Press.

Sakurada, N., & Miyake, D. I. (2009). Aplicação de simuladores de eventos discretos no processo de modelagem de sistemas de operações de serviços. *Gestão & Produção*, *16*(1), 25–43. doi:10.1590/S0104-530X2009000100004

Secretary, M. H. (2012). *Unidades de saúde: urgência e emergência*. Rio de Janeiro, RJ: Prefeitura do Rio de Janeiro. Retrieved from http://www.rio.rj.gov.br/web/sms/urgencia-e-emergencia

Shannon, R. E. (1975). *Systems Simulation: The Art and Science*. Upper Saddle River, NJ: Prentice-Hall.

Silva, S. B., Caulliraux, H. M., & Spiegel, T. (2015). Modelo de simulação para auxílio em planejamento e gestão de serviços de saúde. *Sistemas & Gestão*, *10*(4), 608–616. doi:10.20985/1980-5160.2015.v10n4.616

Smith, C. A., Barry, R., & Brubaker, C. E. (2007). *Going lean: busting barriers to patient flow.* Chicago, IL: Health Administration Press.

Spiegel, T., & Assad, D. B. (2018). Operations model for trauma centers: Multiple case study. *International Journal of Public Health Management and Ethics*, *3*(1), 1–13. doi:10.4018/IJPHME.2018010101

Spiegel, T., & Assad, D. B. N. (2016). Operations project and management in trauma centers: the case of brazilian units. In *Handbook of Research on Healthcare Administration and Management* (pp. 104–119). Hershey, PA: IGI Global.

Spiegel, T., & Cameira, R. F. (2016). The processing chain of sterilized material from the health units of Rio de Janeiro county: analysis and proposition of scenarios. In *Supply chain management: applications for manufacturing and service industries* (pp. 245–263). New York, NY: Nova Science Publishers.

Spiegel, T., Caulliraux, H. M., Treistman, F. E., Guimaraes, G. E., Vaccaro, G. L. R., Amorim, L. G., ... Azzam, S. M. (2016). Projeto e Gestão de Operações em Saúde. In V. Cavenaghi & V. F. Oliveira (Eds.), *Tópicos emergentes e desafio metodológicos em engenharia de produção: casos, experiências e proposições* (pp. 15–72). Rio de Janeiro, RJ: Associação Brasileira de Engenharia de Produção.

Strauss, R. W. (Ed.). (2014). Strauss and Mayer's emergency department management. New York, NY: McGraw-Hill Education Medical.

Sundbo, J. (1994). Modulization of service production and a thesis of convergence between service and manufacturing organizations. *Scandinavian Journal of Management, 10*(3), 245-266.

Tieghi, A. L. (2013, November). A saúde brasileira tem cura? *Revista Espaço Aberto, 155*. São Paulo, SP: Universidade de São Paulo.

Vähätalo, M., & Kallio, T. J. (2015). Organising health services through modularity. *International Journal of Operations & Production Management*, *35*(6), 925–945. doi:10.1108/IJOPM-12-2013-0523

Van Sambeek, J. R. C., Cornelissen, F. A., Bakker, P. J. M., & Krabbendam, J. J. (2010). Models as instruments for optimizing hospital processes: A systematic review. *International Journal of Health Care Quality Assurance*, *23*(4), 356–377. doi:10.1108/09526861011037434 PMID:20535906

Welch, S., & Savitz, L. (2012). Exploring strategies to improve emergency department intake. *The Journal of Emergency Medicine*, *43*(1), 149–158. doi:10.1016/j.jemermed.2011.03.007 PMID:21621363

Yin, R. K. (2005). *Case study research: design and methods*. New York, NY: Sage Publications.

Yoon, P. (2003). *Emergency department fast-track system. Alberta Heritage Foundation for Medical Research*. Edmonton, Canada: AHFMR.

KEY TERMS AND DEFINITIONS

Discrete Event Simulation: A model that set of assumptions about how a system works, to try to gain some understanding of how the system behaves.

Emergency Department: The structure that aim to solve most of the emergencies (intermediate severity injuries), such as high blood pressure and fever, fractures, cuts, heart attack and stroke. They help to reduce queues in the hospital's emergency department.

Fast Track: Operational model of care used to expedite emergency care of low complexity. The goal for this group of patients is the rapid accomplishment of care by a clinical team. This care model is designed to reduce the time and length of stay for a defined group of patients.

Healthcare Operations Management: The decisions and actions that occur within the limits defined by the operating system design. These include activities such as the implementation of policies, procedures and strategies, contingent decision-making, process coordination, problem identification and resolution, response to uncertainty and unforeseen problems and rewarding people.

Lead Time: Total time of patient crossing within the health unit, from when it arrives at the hospital until it is discharged.

Operations Management: A multidisciplinary field that investigates the design, management and improvement of processes aimed at the development, production, distribution and delivery of products and services.

Simulation: Process of elaborating a model of a real (or hypothetical) system and conducting experiments with the purpose of understanding the behavior of a system or evaluating its operation.

Chapter 19
Digital Systems Innovation for Health Data Analytics

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ABSTRACT

Digital innovation for health data analytics has faced obstacles in systems implementation and consumer acceptance. Research suggests that digital health innovation has been a challenge and a slow process for acceptance. At the same time it offers tremendous opportunities in health data analytics for consumers of health services and service providers, such as health information portability, personalization of health information by consumers, easy access and usefulness of health information, better management of data records by institutions and government, and management of information by healthcare staff for patients' engagement and care. Health data analytics is the key for driving digital systems for health innovation. This research seeks to identify the digital health innovation opportunities and obstacles, develop a framework and a conceptual model for digital health innovation that empowers consumer of digital health to use the information to make informed decisions and choices.

INTRODUCTION

Digital Systems Innovation for Health Data Analytics have faced obstacles in systems implementation & consumer acceptance. Research suggests that digital health innovation has been a challenge and a slow process for acceptance. At the same time it offers tremendous opportunities in Health Data Analytics for consumers of health services & service providers, such as health information portability, personalization of health information by consumers, easy access and usefulness of health information, better management of data records by institutions & government, and management of information by healthcare staff for patients' engagement and care. Health Data Analytics is the key for driving a Digital Systems for Health Innovation. This research seeks to identify the digital health innovation opportunities and obstacles, develop a framework & a conceptual model for digital health innovation, that empowers consumer of digital health to use the information to make informed decisions and choices.

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Table 1. Comparison of Digital Systems with Paper-based Systems

Digital Systems	Level of Customer Engagement & Managerial Implications: Digital Systems	Paper-based Systems	Level of Customer Engagement & Managerial Implications: Paper-based Systems
Digital Health Systems	High Engagement	Paper-based Health Systems	Low Engagement
Digital Health Records	Easy to use & useful, Fast access, Quick records, High Data Portability, Better Decisions, Highly Cost effective	Paper-based Health Records	Not easy to use, less useful, Slow access, Slow record, No Data portability, Slow Decisions, Least cost effective

DIGITAL SYSTEMS INNOVATION FOR HEALTH DATA ANALYTICS

Researchers have long argued that the adoption rate of Electronic Health Record (EHR) systems is an important indicator of the degree of national e-health (Bonomi 2016). This is also a measurement in the success of creating, sharing, distribution, of data analytics. Health Data is essential for digital innovation systems to function. Hambleton and Aloizos (2019) argue that the health care industry is one of the last industries to be disrupted by digital technologies. It arguably has the most to gain, particularly from timely, accurate communication and clinical improvements, especially medication safety. At a time when governments of different countries willing to provide quality healthcare to their citizens on a digital platform. For example: Singapore government have made digital health a top priority for their citizens (RIE2020). Jha et al. (2008) state that health information technology in general and EHRs in particular, are tools for improving the quality, safety and efficiency of health systems in countries. They observed that in UK, Netherlands, Australia, and New Zealand generally used EHRs among general practitioners (each country>90%); Germany was far behind (40–80%); and there was a small minority of doctors in the U.S. and Canada who used EHRs (10–30%). They also explained that it is difficult for hospitals to obtain quality data and that only a small fraction of hospitals (<10%), of the countries analyzed had the key components required by an EHR. As shown in table 1 digital systems have many benefits over paper-based systems.

Despite having many benefits, EHR is not uniformly used for national and international healthcare (Bonomi 2016). Data portability within country and across different states pose a real problem due to different jurisdiction applications on data transfer and ownership. Even though the data belongs to consumers of EHR, its not clear about the use and transfer of such records with or without consumers knowledge. The next section seeks to review the literature and propose a conceptual model for digital health innovation. The next section build on the literature review and the conceptual model.

LITERATURE REVIEW AND CONCEPTUAL MODEL

Research suggests that the use of electronic medical record has the potential to help improve safety, quality, and the cost efficiency of healthcare services (Mohammed & Younus 2017; Agarwal et al 2010). Not only EHR provide better management of consumer health data online, it also provides instant data portability across internet, for providing better access to physician for patient medical treatment. Digital health is about electronically connecting up the points of care so that health information can be shared securely. This is the first step to understanding how digital health can help deliver safer, better quality healthcare (ADHA 2019).

Bonomi (2016) discovered that successful implementation of Digital Health Innovation leads to better access to medical records with detailed past and present clinical information regardless of space or time in order to support more informed decision-making; improvement of safety: digital records reduces the number of possible medical errors and prevents the loss of documents or misreading them of the entered data; improvement of healthcare quality and access to past and present information therefore reference to a larger number of data which facilitates decision-making and promotes the quality of services; improvement of healthcare: it optimizes treatments, consolidates and standardizes information, and links together the various areas of the health system and reduces administrative and management costs (Patrick et al 2016). The information is automatically updated and can be promptly obtained by authorized personnel. At the same time there are various reasons for the obstacles that hinder the implementation due to lack of universal standards or guidelines; Difficulty in economic returns; operational problems (i.e. data input); and reluctance to change.

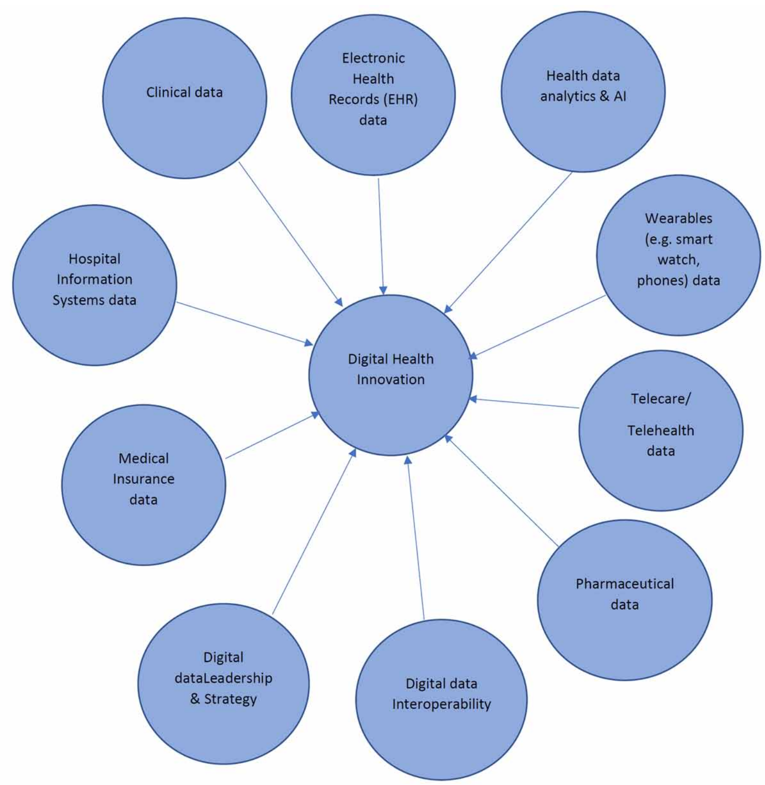
Mohammed & Younus (2017) report that Paper-based records are still by far the most common method of recording patient information for most hospitals and practices in the U.S. most of the doctors still find their ease of data entry and low cost hard to part with. However, as easy as they are for the physicians to record medical data at the point of care, they require large amount of storage space compare to record in electronic form. Data portability from paper records is a slow, time consuming, and a costly process and in circumstances of emergency time can be a critical factor for patients' medical diagnosis and care, compared to digital data that can be made available instantly when needed anywhere and anytime.

Fragidis & Chatzoglou (2018) found that the main reasons which are responsible for adopting a specific Digital Health Innovation implementation approach are usually political. Further, it is revealed that the most significant success factor of a nationwide Digital Health system implementation process is the commitment and involvement of all stakeholders (Yoo et al 2010). On the other hand, the lack of support and the negative reaction to any change from the medical, nursing and administrative community is considered as the most critical failure factor.

An issue that should never be overlooked or underestimated is the alignment between the functionality of the new Digital Health system and users' requirements. Management and maintenance and funding for a national digital health system is also an important area that sometimes hinder the development, due to several issues such as political, cultural, technical, digital data interoperability, sharing analysing data from different systems, and lack of digital leadership expertise as shown in figure 1.

Ginsburg et al (2018) argue that recent developments in data analytics also suggest barriers to change that might be more substantial in the health care field than in other parts of the economy. The authors further emphasise that compared to other industries, the slow pace of innovation reflects challenges that are unique to health care in implementing and applying "big data" tools (Krumholz 2014). These barriers include the nature of health care decisions, problematic data conventions, institutionalized practices in

Figure 1. Digital Systems Innovation for Health Data Analytics



care delivery, and the misaligned incentives of various actors in the industry. To address these barriers, federal policy should emphasize interoperability of health data and prioritize payment reforms that will encourage providers to develop data analytics capabilities.

Ginsburg et al (2018) study shed deeper insight and found that despite the immense promise of health analytics, the industry lags behind other major sectors in taking advantage of cutting-edge tools. Most health care organizations, for example, have yet to devise a clear approach for integrating data analytics into their regular operations. One study even showed that 56 percent of hospitals have no strategies for data governance or analytics.

Summarising key points for Digital Health Innovation as shown in figure 1 below, requires consolidation of several important concepts that will lead to development of Digital Health Innovation and its Acceptance by the consumers.

Cripps and Standing (2012) reported that while much of the recent attention on EHRs has been on the establishment and integration of computer systems, little attention has been paid to privacy and security in the health context. From a technical standpoint, consumers have voiced their concerns about their medical records being stored and used in electronic form citing issues including loss, theft, and misuse of what they consider private and personal information. It has been suggested that the emphasis on privacy and security in digital health information as a requirement for building consumer trust in these systems. Some digital health information systems lack bullet proof security that leads to online

Figure 2. Key statistics about digital connectivity in Australia

information being vulnerable for unauthorised access and use. Figure 2 shows high digital connectivity among Australians and that 84% went online for searching health information.

Prior studies have examined the application of Technology Acceptance Model (Davis 1989) and this research adopts TAM variables usefulness and ease of use and user acceptance. Other research framework from Electronic Servives Acceptance Model, E-SAM, (Sandhu & Corbitt 2008) have been adapted. This research is important because it seeks to adopt TAM to understand the process for Digital Innovation for Health Data Analytics.

This research seeks to investigate the drivers for Digital Innovation for Health Data Analytics by studying a set of following hypotheses. This study proposes the assumption that consumer experience (H1) affects digital health information ease of use. Such a concept is based on consumer having (positive/negative) experience will impact on the ease of use of digital health information. The second assumption proposed is that consumer motivation (H2) affects digital health usefulness, such a concept is based on consumer motivation will impact on the digital health information usefulness.

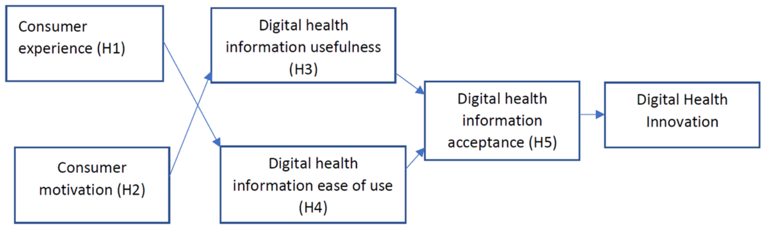
The third assumption proposed is that digital health usefulness (H3) affects digital health information acceptance, such a concept is based on digital health usefulness will impact on the digital health information acceptance. The fourth assumption proposed is that digital health information ease of use (H4) affects digital health information acceptance, such a concept is based on digital health ease of use will impact on the digital health information acceptance. And finally, the fifth assumption is that digital health information acceptance (H5) affects digital health innovation, such a concept is based on digital health information acceptance will impact on the digital health innovation.

The proposed conceptual model for Digital Health Innovation Model is shown in figure 3.

RESEARCH METHODOLOGY

The main purpose of this research is to examine the variables that influence consumer acceptance of digital health information that leads to innovation for digital health. The participants in this study having access & knowledge about digital health and are users of technology and have access to digital data, on their smart phones, tablets, and laptop. Mixed methodology using combination of qualitative research (e.g. interviews, focus group data for case studies, institutional data records) and empirical analysis (e.g. survey data for statistical analysis & PLS modelling, institutional data records) are adopted in this

Figure 3. Digital Health Innovation Model (Digital HIM)



research. Adopting the two different methods provides deeper insights into the research for Digital Innovation for Health Data Analytics.

A set of key interview questionnaires (open and exploratory) in Digital Innovation for Health Data Analytics will be asked and recorded from the eighteen respondents. The interviews will be transcribed, and data analyzed for important findings and for further development of the survey's instruments. A number of following multiple Case Analysis were conducted to examine and improve on the survey instruments that would then lead to identifying important variables in this study.

A set of survey questionnaire will examine thirty-five respondents' attitude towards acceptance of digital health information and innovation. The questionnaire will be set on a Likert scale for responses to be measured on a scale from low (1) to high (5). The survey data will be analyzed using SPSS software to make meaningful sense of the data using descriptive statistics and confirmatory factor analysis. Partial Least Square modelling (Chin 2010) will be adopted for examining and testing the conceptual model for hypotheses path testing and validation and for measuring the variables developed in this study. The next section is into the three Case Analysis.

CASE ANALYSIS

Case Study 1: Empowering Customers with Digital Health Information

Customers interact with vast amounts of information online, whether it is visiting websites, social media, travel arrangements, online learning, emails, and the activities are endless. Customer's interaction with digital health information has been slow. Digital health information access has been restricted due to number of reasons, such as people's health privacy, non-availability or limited and restricted access to one's health data from health organisations perspectives such as hospitals and government institutions, and as well as bureaucracy towards data access within health institutions.

Over the year's government and health institutions maintained digital health data records for people, but in the last few years' technology such as World Wide Web has made it easy for consumers to get access to digital data online. Health institutions and governments have been least prepared towards knowing how to make the health data available to consumers. Some organisations are struggling to meet the demands of the consumers, whereas other have not yet started planning or implementing strategies for the delivering digital health data to their customers. Customers should have access to their digital health data.

Case Study 2: Digital Health Transformation

Health institutions such as hospitals, have for a long-time maintained records (paper and digital) of customers, with very limited or restricted access to customers. Though paper records demonstrate what information the customers "need to know", such as medical history, medications, doctors & hospital visits, and financial transaction, whereas access to other information which the intuition considers "sensitive" are not available to customers. Hospitals and institutions policies differ on information access to customers, which in today's time does not take into account the technology adoption by customers for digital information availability online.

Hospital institutions are also faced with legislations that they have to follow, and which have not been updated for recent times. Hospital and government institutions have been slow adopters of digital health technologies. Many institutions in regional areas lack technological capabilities and infrastructure due to lack of funding, and availability of skilled personnel that can steer the digital health innovation project. And hence reliance on the old paper-based record system as the only option for driving and maintaining a paper-based health record system.

Case Study 3: Digital Health Innovation

Innovation has been studied in different disciplines, but its understanding in digital health has been limited. For an idea or a concept to lead to innovation must meet the following requirements: (1) provide newer ways for a method, idea, or a product, to be usefully adopted; (2) needs to be cost effective; (3) can be applied widely; (4) have technological element; and (5) outcomes can be measured. To bind Digital Health Innovation together, means linking Digital Technology, Health, and Innovation, as one. Research has shown that Digital Technology has a track record of widescale penetration and adoption across several industries such as social media, shared economy, travel, tourism, online learning, and many more.

Digital Technology has shown to have the potential to transform Health by injecting the element of Innovation, as customers are the biggest driver of technologies. Digital Health Innovation can not only provide newer ways for customers to interact with digital health information, it can also transform health organisations business models for doing business. Customers are not only information users, they are also content creators as seen on social media, which is user driven, which is unique and distinctive, which have learning lessons for health institutions to develop digital systems that can cater to customers creating content in digital health and engaging with that content. For a long time, "health" has had an "image" of being serious, sad, when people are sick.

This "image" is quickly changing around the world, when people engage with digital health information online, such as wearing smart watches, smart phones, and monitoring health devices, that tracks their steps, calories, heart beats, blood pressure, and gym workouts, which also is linked to studies about better health and image for individuals to stay fit and active and taking control of their health. With the availability and engaging with newer data to customers digital health innovation can slow down several diseases such as obesity, diabetes, heart attacks, by people taking control of their health, which also means low medical insurance bills for the government, and the savings can be invested into other innovations that can further drive digital health innovations like a ripple effect. The next section is about conclusions, limitations, and future research directions.

SUMMARY OF THE RESULTS FROM STATISTICAL ANALYSIS

The statistical evidence revealed that consumer experience and empowerment were the key drivers for the adoption of digital health and need for information was considered significant to make a decision to use or not to use digital healthcare. Consumer motivation enhanced the use of digital healthcare, but it was not known the level of impact it had on their attitude towards newer technologies implementing digital healthcare (e.g. smartphones, smartwatches, etc.). Digital health information usefulness was highly valued as a core driver, further it also had emphasis and differentiates on different ways the usefulness could be spread across different areas of digital healthcare transformation, as consumer expected usefulness to be multifaceted that can be made available on a wide variety of digital platforms to boost healthcare.

The data disclosed that Digital health ease of use though was a primary driver, nevertheless the use of technology being simplified in terms of ease, had an important interplay with other distinct features by easily interfacing with digital healthcare. Consumers reported that it was easier to transform their healthcare records and that Digital health information acceptance lead to making important decisions and participation in their healthcare management, which also demonstrates a level of autonomy consumers enjoyed in managing their healthcare digitally. The evidence revealed that Digital health innovation was highly dependent on modern technology for transformation, which meant as newer technologies were integrated into healthcare, more pronounced versions of digital health innovation were discovered, similarly lower integration of technology also had an impact, which lead to fewer innovations being discovered. Statistical data shows that there is a strong bond between modern IT and Healthcare that leads to amalgamation of these two important elements to transform digital healthcare innovation.

CONCLUSION, LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

This research in progress (from a bigger study being conducted in Global Digital Health in 12 countries) attempts to understand the key factors for Digital Innovation for Health Data Analytics. Literature review shows that Digital Health Innovation provides many opportunities to manage digital data for consumers, but it also at the same time faces obstacles such as: consumer's resistance, technical problems, political, digital leadership, data portability, data sharing and use, data security and access, data transfer and ownership, and data authorization. Some of these issues are technically related with digital health systems development whereas other issues relate to trust and consumer confidence, and significance of consumer culture, in data management by health service providers.

From a technical perspective each of the issues that are studied here have an important role to play in digital health innovation to be successful. The limitation of this study is based on the data being investigated from respondents at universities, and findings of this study needs to be amplified and used with caution, and the conceptual constructs, variables, research instrument scales and validation, hypotheses and the model, further tested on larger population of respondents. This study will focus on the discovery of key factors and provide a deeper insight into successful functioning of Digital Health Innovation.

REFERENCES

ADHA. (2019). What is digital health? *Australian Digital Health Agency*. Retrieved from https://www.digitalhealth.gov.au/get-started-with-digital-health/what-is-digital-health

Agarwal, R., Gao, G., Des Roches, C., & Jha, A. K. (2010). Research commentary—The digital transformation of healthcare: Current status and the road ahead. *Information Systems Research*, *21*(4), 796–809. doi:10.1287/isre.1100.0327

Australia's National Digital Health Strategy. (2019). Retrieved from https://conversation.digitalhealth.gov.au/sites/default/files/adha-strategy-doc-2ndaug_0_1.pdf

Bonomi, S. (2016). *The Electronic Health Record: A Comparison of Some European Countries*. Available from: https://www.researchgate.net/publication/303364932_The_Electronic_Health_Record_A_Comparison_of_Some_European_Countries

Chin, W. W. (2010). How to Write Up and Report PLS Analyses. In V. E. Vinzi, W. W. Chin, J. Henseler, & H. Wang (Eds.), *Handbook of Partial Least Squares Concepts, Methods and Applications* (pp. 650–690). Berlin: Springer-Verlag. doi:10.1007/978-3-540-32827-8_29

Cripps, H., & Standing, C. (2012). Building patient trust in electronic health records. In *Australian eHealth Informatics and Security Conference*. Edith Cowan University Research Online. Retrieved from https://ro.ecu.edu.au/cgi/viewcontent.cgi?referer=https://www.google.com.au/&httpsredir=1&article=1002&context=aeis

Dameri, R. P. (2012). Defining an evaluation framework for digital cities implementation. In *Information Society (i-Society), 2012 International Conference on* (pp. 466-470). IEEE.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319-340. Retrieved from http://www.jstor.org/stable/249008

Fragidis, L., & Chatzoglou, P. (2018). Implementation of a Nationwide Electronic Health Record (EHR): The International Experience in 13 Countries. *International Journal of Health Care Quality Assurance*, *31*(2), 116–13. doi:10.1108/IJHCQA-09-2016-0136 PMID:29504871

Ginsburg, P., Loera-Brust, A., Brandt, C., & Durak, A. (2018). *The opportunities and challenges of data analytics in health care*. Report Produced by Artificial Intelligence and Emerging Technologies Initiative The Brookings Initiative on artificial intelligence and emerging technologies seeks to establish a proper societal framework for the impending "digitalization of everything." Retrieved from https://www.brookings.edu/research/the-opportunities-and-challenges-of-data-analytics-in-health-care/

Hambleton, S., & Aloizos, J. (2019). Australia's digital health journey. *The Medical Journal of Australia*, *210*(6), S5–S6. doi:10.5694/mja2.50039 PMID:30927473

Jha, A. K., Doolan, D., Grandt, D., Scott, T., & Bates, D. W. (2008). The use of health information technology in seven nations. *International Journal of Medical Informatics*, *77*(12), 848–854. doi:10.1016/j.ijmedinf.2008.06.007 PMID:18657471

Krumholz, H. M. (2014). Big data and new knowledge in medicine: The thinking, training, and tools needed for a learning health system. *Health Affairs*, *33*(7), 1163–1170. doi:10.1377/hlthaff.2014.0053 PMID:25006142

Mohammed, A., & Yunus, A. (2017). Technology Acceptance in Healthcare Service: A Case of Electronic Medical Records (ERM). *International Journal of Academic Research in Business and Social Sciences, 7*(11).

Patrick, K., Hekler, E.B., Estrin, D., Mohr, D.C., Riper, H., Crane, D., Godino, J., & Riley, W.T. (2016). *The pace of technologic change: implications for digital health behavior intervention research*. Academic Press.

Sandhu, K., & Corbitt, B. (2008). A framework for electronic services system. *International Journal of Electronic Customer Relationship Management, 2*(1). Retrieved from https://www.inderscienceonline.com/doi/abs/10.1504/IJECRM.2008.019568

World Health Organisation. (2019). Retrieved from https://www.who.int/behealthy/digital-health

World Health Organisation. (2019). Retrieved from https://www.who.int/behealthy/digital-health

Yoo, Y., Henfridsson, O., & Lyytinen, K. (2010). Research commentary—the new organizing logic of digital innovation: An agenda for information systems research. *Information Systems Research*, *21*(4), 724–735. doi:10.1287/isre.1100.0322

Chapter 20
Predictive Analytics to Support Clinical Decision Making:
Opportunities and Directions

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ABSTRACT

A key activity in healthcare is clinical decision making. This decision making typically has to be made rapidly and often without complete information. Moreover, the consequences of these decisions could be far reaching including the difference between life or death. Today analytics can assist in clinical decision making as the following chapter highlights. However, to gain the most from any type of analytics, it is first necessary to fully understand the dynamics around the clinical decision making process.

CRITICAL ATTRIBUTES OF CLINICAL DECISION-MAKING PROCESS

Clinical Decision Making (CDM) is a central aspect of healthcare in the present day (Stinson, 2017). While making patient care decisions has always been connected to clinical staff, it is gradually becoming a major facet in the role of radical caregivers; now present in the healthcare sector (Smith et al., 2008). The general aim of clinical decision making is to offer better-quality patient care (ibid). Further, it plays a significant role in value-based care that physicians can offer to patients (ibid). While its impacts the overall spectrum of the care team, it is typically encountered with primary medical choices on a daily basis (ibid). According to Stinson (2017), pitiable decision making can result in detrimental happenings and lead to adverse costs for individuals (ibid). In fact, it is projected that about sixty-five percent of the detrimental happenings may possibly have been mitigated had caregivers made improved choices (Smith et al, 2008). Therefore, being aware of the aspects that impact decision-making practice intensifies the probability of offering improved and relaxing patient care (ibid). Clinicians are responsible for their

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patients, their occupation, and the institution for which they work (ibid). For that reason, it is beneficial that critical tools are involved in clinical decision making (ibid). Given that the decisions that the care team make have such greater consequences; it is prudent to understand critical aspects of clinical decision making as the following sets out to do.

CDM PROCESS

According to Hardy & Smith (2008), many psychologists have come up with numerous interpretations to define clinical decision making. However, Gillepse (2010) defines CDM as the reasoning practice of selecting another course of action in offering patient care concerning both clinical judgment and reasoning. This comprises of managing a range of data from diverse sources to come up with critical judgment. In CDM, physicians most precisely evaluate and realize deviancies from a standard medical depiction of healthiness or disease and make a choice in accordance with the information accessible (ibid).

With changes in the delivery of care-services, augmented patient insight, and improved responsibility in physicians' choices, it is crucial to comprehend in what ways caregivers come up with medical choices and the key aspects that impact them (Hardy and Smith, 2008). Individuals within acute care settings have worse conditions that require more experienced clinical experts who will offer the utmost degrees of value-based care (ibid). This is predominantly accurate in acute precaution (ibid). In this environmental setting, choices are made with urgency and more frequently (Smith et al, 2008). An interruption in the decision making practice with such a setting can be a problem of survival or death (ibid). According to Stinson (2017), there are several key aspects of clinical decision making which influence the entire decision-making process. These include the experience, environment, education, and intuitions (ibid). Moreover, the experience aspect is vital when considering a CDM practice (ibid). It continues to be a critical provider even when determining medical choices (ibid).

Clinical decision making is an intricate practice that obliges nurses to be experienced and to have access to suitable data sources and work in a supportive environmental setting (ibid). As the health practitioner's occupational role expands, they turn out to be accountable for a wider array of medical decisions (Kozlowski et al, 2017). Clinical decisions necessitate that physicians ought to be experienced and well informed in pertinent facets of nursing (ibid). Consequently, clinical decision making becomes less complicated and more manageable (ibid). Physicians have to decide what the issue is, what data to collect, how to handle the concern, if the therapeutic is efficient or whether the patient requires to have a clinical review for further examination and cure (Stinson, 2017).

INTERNAL ASPECTS

Several decision making studies in the healthcare sector have recognized that aspects of patients impact CDM, with specific reference to decision making biases (ibid). Aspects of the practitioners (decision makers) such as their degree of expertise and experiences, intuition capabilities, and confidence also impact their decision making (ibid). Most of the clinicians have a number of personal qualities as well as abilities in CDM that enhances them to make efficient decisions in association with the task, and also putting into account the framework of the practice (ibid). When physicians poses a higher self-efficacy, they experience a greater willingness and confidence in making the right decisions (ibid).

Experience is one of the core internal aspects that determine the physicians' capability to undertake decisions (Gillespie, 2010). Clinical experiences have been found to positively enhance practitioners care as well as influencing the level of clinical knowledge which ultimately determines the accuracy of medical decisions. Knowledge is the basis of the CDM and it offers physicians the capability to realize data cues involving the choice concern (Gillespie, 2010). If a physician's know-how is limited, little choices will be centered on incomplete data resulting in lesser judgments (ibid). Medical experience, therefore, improves the real-world and efficient familiarity that practitioners want to make intricate choices (ibid). Through experience, the healthcare practitioners become more informed of their role in CDM process (Smith et al., 2008). Stinson (2017) indicated that, through experience, practitioners turn out to be more relaxed as well as confident in their medical practice and their capabilities to offer safe medical care. Additionally, they are more poised and at ease with their performance and acts in a focused and therapeutic manner (ibid). Experience is also thought to offer physicians power and reliability and is regarded as the core backup for the intuitive actions which the practitioners participate in (Smith et al, 2008). Experienced doctors make medical decisions in accordance with the cues that they realize during the situation at hand (ibid). These clues are learnt from earlier experience as well as explicit knowledge (ibid). On the other hand, such experience is believed to be obtained from identifying patients' healthiness conditions and then coming up with action approaches to manage these illnesses (Gillespie, 2010).

Experienced practitioners adopt CDM that is more explicit, creative, and advanced towards the patient needs (ibid). They use more interpretations, and critiques in the decision-making process, being more confident and self-dependent (ibid). Further, they handle uncertainty in CDM more efficiently by embracing a concrete certainty, being capable of participating in prudent risk-taking and acquiring a better knowledge base that minimizes the relative uncertainty of the CDM (Gillespie, 2010). The practitioners' knowledge base is usually adapted, multidimensional, and often includes better knowhow of the limits of their familiarity in regards to what could be known (ibid). More experienced practitioners also have more improved cognitive abilities for CDM, being more adaptive, flexible, and having greater extents of emotional abilities, being at a position to separate emotions from the actual tasks, understanding the patients' disease experiences, and being knowledgeable on how to use their personal traits and its impacts in their CDM (Stinson, 2017). Therefore, experienced practitioners critically apply norms as well as a strategy for decision making, where they understand the origins of the regulations and hence implement them more prudently (ibid).

Intuition is another internal aspect impacting the CDM process (ibid). Clinical decisions undertaken by physicians are intuitive in nature rather than being logic (ibid). Intuition is the instant apprehension of knowhow devoid of sensible thought. Stinson (2017), claims that intuition in medical care is a process in which physicians identify something about the individual that is actually hard to verbalize. It is characterized by factual understanding, which is independent of the linear rationale process (ibid). As soon as intuition is used, the decision maker filters data initially spurred by the imagination, resulting in the incorporation of all awareness and data to problem solve (ibid). Physicians use their relations with the individuals and intuition, drawing on inferred knowledge, to apply the right knowledge to come up with correct decisions to solve patients' needs Hardy & Smith, 2008).

Intuition is a manner through which expert practitioners depend on their intuitive judgment that has been established over time (ibid). It is an informal, amorphous, non-analytically based, and measured calculation that enhances the solving of clinical problems, a process of reaching salient conclusions according to comparatively small data and knowledge (ibid). Professional clinicians can have a rapid understanding of a condition by using intuition to realize patterns and commonalities and attain a rational comprehension (Gillespie, 2010). Intuitive acknowledgment of commonalities, as well as resemblances between situations, is often the first diagnostic cues or rather early cautions that must then and there be followed-up with an acute assessment of evidence among the competing situations (ibid). This condition, therefore, calls for intuitive clinical judgment that shows decisions made by expert physicians (ibid).

According to Kozlowski et al (2017), acute care team usually comes up with decisions basing on their experience in similar conditions and in line with cues they recognize in the medical conditions that they meet. Similar to the Hardy and Smith, (2008) argument, intuitive decision making capability emanates from years of experience and know-how accumulated from analogous circumstances or pattern cases (ibid). Nonetheless, it does not mean that the physicians are undertaking the first chance to resort back to normal procedure, instead, the experienced caregiver can adjust to increasingly changing patient condition and undertaking the correct action at the given time to attain the desired patient outcome (ibid).

EXTERNAL ASPECTS

The broader framework of CDM can be viewed to comprise of varying attributes that become significant to certain decisions such as social, environmental, and organizational extents. In a number of studies, several examples have been used to demonstrate how decisions are impacted by these contextual attributes (Gillespie, 2010). The social factor, for instance, has been presented to have a large impact on CDM (ibid). Studies have revealed that physicians talk about attributes of their decision making to others in the framework, specifically when a decision is challenging to make, use chatting with other practitioners to check their CDM (ibid). Additionally, they use their views to come up with new perspectives and often anchor their decision making to the choices others have made in the past (ibid). However, Wu et al (2016) assert that the influence of the social aspect can either be positive or negative.

In addition to social factors, it is evident that the most dynamic aspect of CDM is the environment which illustrates the intricacy of the decision task (ibid). According to Williams & Brown (2014), intricacy can involve several influences that proliferate the cognitive burden on the decision makers. Empirically, the quality of decision making is shown to be affected when the obscurity is increased (ibid). Time pressure is another strong aspect that impairs the clinical decision-making process (ibid). Wu et al (2016) assert that physicians come up with choices about involvements either in certainly no time restraint or in no time pressure. Health practitioners with added capability often make improved choices as soon as they are self-driven (ibid). However, presenting time pressure disregard this gain and all physicians performs below par. In the health process, time pressure is established in numerous types. For instance, learners' practitioners feel pressured to accomplish their role and to prepare a well-organized sheet after their shift for the practitioners coming in the next shift (ibid). This shows a self-imposed burden in time which may affect the practitioners' CDM (ibid).

Disruptions within the environmental aspects influence the CDM process (Wu et al., 2016). When interruptions occur it places an added reasoning pressure on the decision maker by imposing the physicians to process data that is often inept to the present role (ibid). The contending data put out of place memory subjects, some of which is crucial to and significant to the medical decision (Wu et al, 2016). Nevertheless, this interruption does not result in worse choices as such. Simply when rational strains exceed the physician's reasoning capability it will affect the decision precision. Thus, this aspect relates to task intricacy (ibid).

ROLE OF KNOWLEDGE MANAGEMENT IN CDM

Shahmoradi et al (2017) indicate that the healthcare industry depends heavily on knowledge in its everyday activities, and mostly, the delivery of care relies on the cooperation of several partners that ought to share knowledge to offer quality care for individuals. For this reason, clinical knowledge ought to be made accessible and freely available to all in need of it. Thus, knowledge management is significant for cooperation and sharing of know-how so that utmost results of the care services is attained (ibid). Generally, there are a number of benefits of implementing knowledge management in the healthcare sector (ibid).

As noted by Shahmoradi et al (2017), knowledge management (KM) has significant consequences on medical decision making in the healthcare industry. Effective KM ought to support the practice of CDM and strategic planning (ibid). For instance, KM plays a core role in the planning stage of healthcare projects to ensure that patients receive quality and timely care services (ibid). Based on the current data, clinical analysts guide medical decision makers in making intricate decisions in the healthcare sector, which is characterized by augmented risks as well as uncertainties (ibid). The overall decision-making effort is thus made in accordance with the outcome of the clinical analysis, a knowledge rigorous task (Simon, 2016). KM is therefore essential in tactical Clinical Decision Making (ibid).

The purpose of KM in CDM to advance the value of care delivery is concerned with adopting the right approach of handling knowledge for prudent decision making (ibid). Though the use of the knowledge management techniques to support CDM, chances become open to advance individual care and minimize expenses that result to a constructive social transformation in reducing the inequality in the medical care delivery structure (ibid). Furthermore, KM helps clinicians to monitor the situations within their environmental settings (Simon, 2016). They are thus able to collect data which enables them to track the existing conditions and become aware of new warnings as well as emerging conditions (ibid). In addition, clinical decision makers are able to do evaluations (ibid). This evaluation assists them to learn from their previous experiences (Shahmoradi et al, 2017). Therefore, it is evident that KM offers an immense contribution at varying stages of the CDM (ibid).

Better-quality decision making is a crucial element of the good clinical process (Simons, 2016). If the physicians are to apprehend, evaluate, and advance CDM, it is vital that the physicians should apprehend the aspects that are considered during decision making (ibid). When working towards improving the clinical decisions, a wide-ranging perspective ought to be adopted that considers elements such as the practitioner's decision-making attributes (including, experience, and intuition) as well as the impact of external aspects on decision making (ibid). The evidence-based process is constantly viewed as a means for advancing the quality of clinical processes (ibid). A broader context of aspects impacting clinical decision making shows how evidence-based process needs to be incorporated with several other facets of medical practice (ibid). For healthcare sector to promote efficient CDM, they need to comprehend how best they can teach clinical decision making that takes into account and manage the complexity of aspects that impact it, instead of paying attention only to the instant CDM tasks of illness identification and interventions (ibid).

PREDICTIVE ANALYTICS TO SUPPORT CLINICAL DECISION MAKING

The rapid growth in the healthcare sector is producing a massive amount of important facts on patient's insurance covers, therapeutic plans, populations, and payments thus becoming an issue of interest to technologists and physicians (Shahmoradi et al., 2017). With the growth in the healthcare sector, some challenges have started to emerge such as the escalating expenses, pitiable quality, increased inefficiencies, and intricacy (ibid). For instance, in America, the expenditure rates between 2010 and 2015 had increased by about 123% (ibid). Some of these outlays are connected to poor quality care (ibid). Statistically, so many patients in America die each year because of therapeutic errors (ibid). However, with the available information, clinicians are able to have a better decision making which helps to mitigate these problems and promotes the transition of the healthcare from a non-value to a value-based healthcare sector (ibid). This transition needs clinicians to overwork to be more effective and productive (ibid). Currently, hospitals are adopting information technology in their management process (ibid). Big data is collected through these technological systems on a consistent basis with an aim of predicting and mitigating poor medical outcomes (ibid). Therefore, analytics offers technologies and methods to gather data from this intricate and capacious information (ibid). Moreover, analytics also offers approaches to translate the big data into information to aid in policymaking in healthcare (ibid). Once the analytic tools are applied correctly, medical practitioners attain a high level of effectiveness and accuracy of the workflow is achieved (ibid).

PREDICTIVE ANALYTICS

Predictive analytics has been defined in various ways by different authors. Alharthi (2018) has defined predictive analytics as the use of data and algorithms, as well as machine learning methods to detect the probability of upcoming outcomes according to the historical data. Normally, historical facts are used to form a mathematical model that captures significant trends in the healthcare industry (ibid). The predictive model is used on the current statistics to identify the future happenings and suggests actions that the care team ought to take for optimal results (ibid). The aim of this technological advancement is to go beyond gaining insights on what has happened to offer the best evaluation of what will take place in the future (ibid). Its implementation in the healthcare sector can determine individuals who are at a higher risk of developing particular conditions including asthma, heart conditions, diabetes, and other chronic diseases (Wessler et al, 2015). The clinical decision systems integrate predictive analysis to enhance clinical decisions at the care level (ibid).

Healthcare prediction focuses on minimizing future expenditures. According to Janke et al (2016), the retrieving and reviewing of the past details of a patient, data, and diagnosis from the records enhances the predictive approaches to take place by forecasting, minimizing on expenditures and time. Some hospitals in the US have launched a predictive structure which scans all the individuals' data and details to detect potential threats and outcomes (ibid). Thus, the health centers have saved more million dollars, and especially in some illnesses such as heart failure. Similarly, the hospitals have been able to predict diseases in regards to the performance of patients' monitoring and mitigating future complications (ibid).

ROLE OF PREDICTIVE ANALYTICS

The healthcare sector is being faced with numerous challenges that result in poor quality and pricey care services (Alharthi, 2008). As a result, the improvement of the healthcare industry in regards to quality and cost as well as the lessening of waste is a worldwide imperative (ibid). It is estimated that about 21% to 47% of what may be used on health services in America is for non-value interventions (Wessler et al, 2015). Various inept activities such as readmissions, fraud, and the wrong consumption of antibiotics comprises of a greater percentage of these massive expenses (ibid). Though the percentages may vary across nations, it is evident that the challenges are a global concern (ibid). However, with predictive analytics, these challenges can be addressed (ibid). This enhances the healthcare facilities to identify patients who require alternate therapeutic accounts for some of the poor clinical as well as economic outcomes in the present day healthcare model (ibid). With prediction analysis, care teams are able to learn adequately about a patient, and significant healthcare data, to aid in making choices that are most probable to benefit the patient (ibid). For instance, if hospitals can identify which diabetic, cancer and heart conditions individuals need a changed treatment plan, then they may advance outcomes and save a lot of finances by not employing an inefficient or possibly risky treatment (Wessler et al, 2015). With predictive analytics tools, evidence-supported decisions are enhanced. Evidence-based decisions in healthcare are a stride in the right direction and offer more support than simple guesses for doctors (ibid). Prediction analysis can thus help physicians to decide the precise treatments for those patients (Alharthi, 2018). The healthcare sector will only be transformed if the administrators will be able to use all the data available to them to make improved decisions (ibid).

Predictive analytics helps the healthcare industry to attain a high level of efficient overall care as well as preventive care (Wessler et al., 2015). As the prediction outcomes enhance appropriate therapeutic actions to be undertaken when all the threats are identified in early stages, this help to reduce expenses. Moreover, Amarasingham et al (2014) assert that the technology era has increased considerable value to the clinical decision-making system. These systems can be enhanced by paying attention to patients' diagnoses, and prevention so as to attain a high level of therapeutic care and advance healthcare economies (ibid).

APPLICATION OF PREDICTIVE ANALYTICS TO CLINICAL DECISION MAKING

According to Parikh et al (2016), doubt over a medical decision often leads doctors to over-treat or under-treat patients. However, clinical decision support tools have increasingly become renowned among healthcare sectors to blend the massive data and make certain that the major information does not escape doctors' attention (ibid). The rise in the adoption of predictive analytics has therefore generated delight over the potential for caregivers to transform diagnostics, such as in the areas of radiology, imaging as well as pathology (ibid). Predictive analytics can enable doctors to direct high expense interventions to those high-risk patients who truly need them (ibid). These tools will revolutionize the expertise levels of human physicians, medical goals and priorities, reliance and consistency of the underlying data, diagnostic decision making, integration of clinical decision systems into the EHR, and medicament support (ibid). According to Amarasingham et al (2014), nearly 86% of health centers that have adopted the new prediction system have confirmed that this tools are highly scalable, which allows health centers facilities to determine if the already existing data are adequate to support novel algorithms created to spur actionable insights from operational, patient-driven sources, and financial clinical sources (ibid).

Parikh et al (2016) claim that, as the healthcare industry moves into the next level of clinical decision systems, it is time to incorporate content. In the days to come, healthcare systems need to consolidate clinical decision systems to support all members of the care providers' team. The care teams are currently moving beyond alerts to offer all-inclusive content in the healthcare workflow to motivate each intended medical action (ibid). This would help to cover post-acute care, more home care, inpatient, as well as ambulatory care, and would ultimately result in an improved decision making and a decline in the unpremeditated variability of care (ibid).

Currently, healthcare systems are finding the need to harmonize data (Parikh et al., 2016). They are thus thinking about patients and are working towards delivering directly to patients the same information it offers to providers but in a patient-centered manner (ibid). Parikh et al (2016) assert that by aligning the decision support system of the care team with that of the patients, the healthcare system will be able to deliver patient participation with their care in a manner that aligns to the general plan of treatment. In numerous cases, feedback gathered from a patient, such as the measurements of the blood sugar levels by a diabetic individual, would spur not only the patient's direction but also the provider direction (ibid). Having a look at the clinical decision support systems in the long term, hospitals must start to take the data collected by caregivers, learn from the information, and then use it in a simulated feedback circle to enhance informed direction content (Twa, 2018). In addition, healthcare systems are creating a cycle where they offer decision support, come-up with evidence, apprehend what do and don't work for the caregivers and patients, and responds in a constant and iterative drive to improved care delivery (ibid).

The prediction data analytics are not only used to analyze the past data but they also assist in maximizing the decision value in the healthcare industry (ibid). The utmost fundamental use of the search analytics comprises of gathering and scrutinizing data about the healthcare performance and maximizes on the decision making procedure without necessarily depending on others (ibid). With numerous different tools, most health facilities waste a large amount of time as well as finances whereby using the predictive analytics initiative every person can be able to attain huge benefits and make the most of the decision making procedure (Kankanhalli et al, 2016).

Therefore, healthcare data when mined for predictions, they offer major awareness for decision makers in regards to diseases patterns and trends or predicting certain demands for certain healthcare services (ibid). Getting an apprehension of these trends assists the healthcare administrators to redesign their operations and placement of health services to the individuals who are at a greater risk of illness prevalence leading to improved healthcare delivery (ibid). Parikh et al (2016) state that prediction of demand for particular services helps in improved planning ahead of major trends identified in the medical sector. Analysis of the massive data coming from health centers offers indicators of care delivery failures thereby bettering the service care delivery as well as avoiding wastage of resources (ibid). It is therefore evident that predictive analytics helps the healthcare sectors to leverage their past data to learn what is likely to occur in the upcoming days or years, realize actionable understandings, and intervene to minimize on costs (ibid). In most cases, these analyses often offer a direct improvement in patient care and operational effectiveness. It also shows factual promises in demographic health management (ibid). Actually, there are almost incessant potential applications of prediction analysis (Parikh et al, 2016).

According to Wang et al (2018), a number of visionary organizations have developed real-time decision-making abilities using the predicted information. The use of predictive analytics, allows healthcare administrators to have a real-time decision-making capacity that cannot be compared to the traditional models (ibid). The tools offer real-time information for both the patient and the care team on their devices such as smartphones or tablets (ibid). They receive a constant stream of great capacity healthcare demand data and availability of care services in varying geographic regions (ibid). The administrators in the hospital, therefore, come up with demand management methods building on the real-time demand data (Janke et al, 2016). The real-time reflectiveness is very crucial to make improved decisions faster and finding the weaknesses in healthcare service delivery (ibid). When the data is accessed instantly from all locations without wastage of time, the care team is able to make better-informed decisions (ibid). Additionally, the caregivers are also able to make more precise and faster decisions by attaining deeper understandings as well as greater visibility towards the healthcare sector (Kankanhalli et al, 2016). Prediction analytics instrument panel helps to organize and to convey information for the administrative decision-making method in such a manner that improves overall effectiveness and performance (ibid). Healthcare facilities, therefore, end up making the best decisions according to the right information due to the increased understandings of the analyzed data (ibid).

APPROACHES

Predictive analytics are comprised of three characteristics: timely, actionable, and role-specific features which make the technology successful in the healthcare sector (Kankanhalli et al, 2016). They promote clinical decision making and also informs organizational priorities as well as actions (ibid). According to Parikh (2016), risk stratification approach plays a major role in prioritizing the clinical workflow, minimizing system waste, and creates financially effective demographic management initiatives. Established risk scoring can play a core role in a number of healthcare scenarios (ibid). For instance, a calculated risk score can aid in reducing system waste by establishing workflow priorities for follow-ups of patients' populations suffering from heart failure (ibid). Based on this predictive risk stratification approach, caregivers are prompted to pay attention to those patients at higher threats and preventively get involved with prescription reconciliation, home care as well as follow-up appointments (ibid).

Budgaga et al (2016) assert that the simulation approach in predictive analytics deals with what if cases, which are valuable when doctors want to ask simple questions such as what if the question about a particular clinical area or administrative role. This helps to reduce variation in a particular medical care process (ibid). Predictive analytics used in this simulation approach offers physicians and administrators a prevue into what if cases and the possible outcomes of a certain combination of occurrences (ibid). On the other hand, the mapping approach in predictive analytics is routinely used to envisage weather and capitalize supply chains (Bedeley et al, 2018). The approach aims at leveraging GIS mapping of healthcare centers, responsible care populaces, and patient illness burden (ibid). Mapping is an effective visual method to analytics as well as decision making (ibid).

In light of the above discussion, it is evident that the healthcare industry has come a long way since the technological revolution has transformed the way health sector works (ibid). Big data is assisting the health care facilities to deliver better-quality care services using the analytic approach (ibid). From the discussion presented, it is clear that the predictive analytics methods assists the healthcare sector to gain better understanding, patterns, connections, and relationships which could not be apprehended through traditional analytics (ibid). The prediction analysis helps to support decision making procedure for healthcare executives with the aid of massive data, cost and time reduction plans (ibid). Many hospitals thus use predictive analytics in almost all elements of care delivery services to reap the benefits of the analyses grounded decision making (ibid). With prediction analysis, health facilities can identify and optimize patterns contained within the data to realize risks as well as opportunities (ibid). Predictive analytics model designed to identify the connection between different behavioral elements enables the evaluation of anticipated risks and chances presented by a certain set of health conditions (ibid). This guides health administrators into making informed decisions across the various aspects of healthcare (ibid). As the healthcare sector creates shares, examines, and depends on more and more massive data for service delivery and medical intelligence, caregivers are likely to witness continued developments in the decision support systems (ibid). The decision support will, in turn, enable the hospitals to maintain their upward trail in the quality of their patients' care (ibid). All the predictive whistles across the healthcare facilities globally will improve care service delivery through thoughtful and significant interventions (ibid). Medical leaders who are willing to improve their service delivery ought to base their interventions on proven predictive information (ibid).

DISCUSSION AND CONCLUSION

Rapid decision making is key in quality healthcare delivery. Technology and more especially analytics can assist to enable clinicians to make better decisions. It is necessary though that clinical decision making processes in various contexts are fully understood before analytics is applied to ensure appropriate and quality results ensue.

REFERENCES

Alharthi, H. (2018). Healthcare predictive analytics: An overview with a focus on Saudi Arabia. *Journal of Infection and Public Health*, *11*(6), 749–756. doi:10.1016/j.jiph.2018.02.005 PMID:29526444

Amarasingham, R., Patzer, R. E., Huesch, M., Nguyen, N. Q., & Xie, B. (2014). Implementing electronic health care predictive analytics: Considerations and challenges. *Health Affairs*, *33*(7), 1148–1154. doi:10.1377/hlthaff.2014.0352 PMID:25006140

Bedeley, R. T., Ghoshal, T., Iyer, L. S., & Bhadury, J. (2018). Business analytics and organizational value chains: A relational mapping. *Journal of Computer Information Systems*, *58*(2), 151–161. doi:10.1080/08874417.2016.1220238

Budgaga, W., Malensek, M., Pallickara, S., Harvey, N., Breidt, F. J., & Pallickara, S. (2016). Predictive analytics using statistical, learning, and ensemble methods to support real-time exploration of discrete event simulations. *Future Generation Computer Systems*, *56*, 360–374. doi:10.1016/j.future.2015.06.013

Gillespie, M. (2010). Using the Situated Clinical Decision-Making framework to guide analysis of nurses' clinical decision-making. *Nurse Education in Practice*, *10*(6), 333–340. doi:10.1016/j.nepr.2010.02.003 PMID:20356794

Hardy, D., & Smith, B. (2008). Decision making in clinical practice. *British Journal of Anaesthetic & Recovery Nursing*, *9*(1), 19–21. doi:10.1017/S1742645608000028

Janke, A. T., Overbeek, D. L., Kocher, K. E., & Levy, P. D. (2016). Exploring the potential of predictive analytics and big data in emergency care. *Annals of Emergency Medicine*, *67*(2), 227–236. doi:10.1016/j.annemergmed.2015.06.024 PMID:26215667

Kankanhalli, A., Hahn, J., Tan, S., & Gao, G. (2016). Big data and analytics in healthcare: An introduction to the special section. *Information Systems Frontiers*, *18*(2), 233–235. doi:10.100710796-016-9641-2

Kozlowski, D., Hutchinson, M., Hurley, J., Rowley, J., & Sutherland, J. (2017). The role of emotion in clinical decision making: An integrative literature review. *BMC Medical Education*, *17*(1), 255. doi:10.118612909-017-1089-7 PMID:29246213

Parikh, R. B., Kakad, M., & Bates, D. W. (2016). Integrating predictive analytics into high-value care: The dawn of precision delivery. *Journal of the American Medical Association*, *315*(7), 651–652. doi:10.1001/jama.2015.19417 PMID:26881365

Shahmoradi, L., Safadari, R., & Jimma, W. (2017). Knowledge management implementation and the tools utilized in healthcare for evidence-based decision making: A systematic review. *Ethiopian Journal of Health Sciences*, *27*(5), 541–558. doi:10.4314/ejhs.v27i5.13 PMID:29217960

Simon, L. (2016). *The relationship between knowledge management tools and interprofessional healthcare team decision making*. Academic Press.

Smith, M., Higgs, J., & Ellis, E. (2008). Factors influencing clinical decision making. *Clinical Reasoning in the Health Professions, 3*, 89-100.

Stinson, K. J. (2017). Benner's framework and clinical decision-making in the critical care environment. *Nursing Science Quarterly*, *30*(1), 52–57. doi:10.1177/0894318416680536 PMID:28899295

Twa, M. D. (2018). Deep Learning and Clinical Decision Support. *Optometry and Vision Science*, *95*(4), 275–276. doi:10.1097/OPX.0000000000001210 PMID:29608543

Wang, Y., Kung, L., & Byrd, T. A. (2018). Big data analytics: Understanding its capabilities and potential benefits for healthcare organizations. *Technological Forecasting and Social Change*, *126*, 3–13. doi:10.1016/j.techfore.2015.12.019

Wessler, B. S., Lai, Y. H. L., Kramer, W., Cangelosi, M., Raman, G., Lutz, J. S., & Kent, D. M. (2015). Clinical prediction models for cardiovascular disease: Tufts predictive analytics and comparative effectiveness clinical prediction model database. *Circulation: Cardiovascular Quality and Outcomes*, *8*(4), 368–375. doi:10.1161/CIRCOUTCOMES.115.001693 PMID:26152680

Williams, I., & Brown, H. (2014). Factors influencing decisions of value in health care: a review of the literature. Health Service Management Center: University of Birmingham.

Wu, M., Yang, J., Liu, L., & Ye, B. (2016). An Investigation of Factors Influencing Nurses' Clinical Decision-Making Skills. *Western Journal of Nursing Research*, *38*(8), 974–991. doi:10.1177/0193945916633458 PMID:26906246

Chapter 21
A Theoretical Framework for Research on Readmission Risk Prediction

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ABSTRACT

On the one hand, predictive analytics is an important field of research in information systems; however, research on predictive analytics in healthcare is still scarce in IS literature. One area where predictive analytics can be of great benefit is with regard to unplanned readmissions. While a number of studies on readmission prediction already exists in related research areas, there are few guidelines to date on how to conduct such analytics projects. To address this gap the chapter presents the general process to develop empirical models by Shmueli and Koppius and extends this to the specific requirements of readmission risk prediction. Based on a systematic literature review, the resulting process defines important aspects of readmission prediction. It also structures relevant questions and tasks that need to be taken care of in this context. This extension of the guidelines by Shmueli and Koppius provides a best practice as well as a template that can be used in future studies on readmission risk prediction, thus allowing for more comparable results across various research fields.

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INTRODUCTION

Hospital readmissions, especially unplanned readmissions are an important quality measure in healthcare, as they can indicate issues around treatments, rehabilitation and/or discharge management. Moreover, readmissions are often associated with increased costs resulting from penalties and regulations enforced by policy makers and insurers. At the same time, the increasing availability of healthcare data leads to an uptake in predictive analytics research conducted in the healthcare sector. The identification of patients at high risk of readmission is a significant issue in this context. The main motivation behind this research area is to identify patterns that can help to unravel high-risk patients to allow for timely interventions. The starting point of these interventions lies in the screening of individuals at high risk of discharge failure (Scott, 2010). By identifying high-risk patients, hospital resources can be allocated accordingly and interventions and discharge planning can be adapted. Multiple factors associated with a higher risk of readmission have been identified in research, including health factors (e.g., co-morbidities (Kumar et al., 2017; van Walraven, Bennett, Jennings, Austin, & Forster, 2011), social factors (e.g., marital status (Hasan et al., 2010)), clinical factors (e.g., hospital utilization (Shadmi et al., 2015)), length of stay (Heggestad, 2002)) or effective discharge management (Ohta, Mola, Rosenfeld, & Ford, 2016).

Determining the risk of readmission is an imperative and highly complicated task, relying on different risk factors for various health conditions. While some studies propose general risk scores (Donzé, Aujesky, Williams, & Schnipper, 2013; van Walraven et al., 2010) applicable for all kinds of diseases, research shows significant variation in risk factors for different health conditions. Thus, to be able to accurately predict patients at high risk of readmission, individual prediction models for different health conditions should be preferred. Even though there are a number of studies dealing with this phenomenon, currently no theoretical framework exists to guide these kinds of research projects. This leads to the issue that studies on readmission risk prediction often disregard key characteristics for this prediction task. Also, results from different studies are often difficult to compare and thus unsuitable to generalize best practices. This study proposes a theoretical framework to guide studies on readmission risk prediction by providing a structured overview of relevant definitions, tasks and questions that need to be taken care of in this context. To identify these steps previous studies are analysed to identify project characteristics specifically for hospital readmission prediction.

Background

Hospital Readmissions

While there is no standard definition for readmissions available, they can be broadly described as "a second admission to a hospital within a specified period after a primary or index admission" (Kristensen, Bech, & Quentin, 2015, p. 265). For each healthcare system, criteria concerning the index admission and the second admission to account as a readmission as well as the considered time frame, have to be defined. These criteria can include clinical characteristics (e.g., diagnosis), demographics (e.g., patient age), type of the admission (e.g., elective or emergency) or the treatment facility (Kristensen et al., 2015). To determine the applicable time frame, readmission days are counted from the discharge date of the index admission until the admission date of the second admission. Consequently, a readmission is defined by the relation between two admissions and the time frame in between. There is no international consensus

Figure 1. Process to build an empirical model (Shmueli & Koppius, 2011)

considering the specified period between admissions. The time frame varies among studies from 14-day to 4-year with the most common being 30-day readmissions (Kansagara et al., 2011).

Predictive analytics methods are used in a variety of application fields to extract patterns from historical data to create empirical predictions as well as methods for assessing the quality of those predictions in practice (Shmueli & Koppius, 2011). Predictive analytics are part of data mining, which aims at deriving models that can e.g., use patient-specific information to predict a specific outcome. As opposed to descriptive models that aim to identify human-interpretable patterns and associations in existing data based on pre-defined attributes, predictive analytics tries to foresee outcomes or classifications for new input data using a special response variable, thus the classification (Bellazzi & Zupan, 2008).

Shmueli and Koppius (2011) present a general approach for conducting predictive analyses. They postulate that in general, predictive analyses consist of two components: First, the empirical predictive model, such as statistical methods or data mining algorithms and second, methods that evaluate the predictive power of a model. The latter refers to the ability of a predictive model to accurately represent new observations. The explanatory power, in turn, is related to the strength of the association induced by the statistical model (Shmueli & Koppius, 2011). Figure 1 illustrates the general process steps, which are carried out for the creation of all empirical models. The individual tasks in this process, however, differ extensively when developing an explanatory or predictive model. For example, while explanatory models investigate the explanatory power of their identified relationships (e.g., theoretical coherence, strength-of-fit, statistical significance), predictive models assess the predictive accuracy of a model, e.g., using cross-validation or split-validation measures. The individual modelling steps as proposed by Shmueli and Koppius (2011) guide the development of the readmission prediction framework presented in this paper.

Imbalanced Data

A major concern in predicting readmissions is the occurrence of imbalanced data. Imbalanced data, also known as skewed data, has a strong unequal distribution of the minority and majority classes (Sun, Wong, & Kamel, 2009). In the case of hospital readmissions, this is especially true for unplanned readmissions, as rates usually vary between 1.1 to 6.7% (Kreuninger et al., 2018). The main issue with handling imbalanced data is that traditional classifiers tend to perform best with an equal class distribution while the relevant information from the minority class might be overlooked with regards to the majority class (Sun et al., 2009, 2009). There are a number of different approaches to handle imbalanced data (Nitesh Chawla, 2005; Galar, Fernandez, Barrenechea, Bustince, & Herrera, 2012; He & Garcia, 2009; Kotsiantis, Kanellopoulos, & Pintelas, 2006; Longadge & Dongre, 2013; Sun et al., 2009), the most popular being sampling or ensemble techniques (Haixiang et al., 2017).

Sampling

Two main sampling approaches can be differentiated, namely oversampling and undersampling. Undersampling reduces the entities from the majority class, while oversampling creates additional entities of the minority class (Galar et al., 2012; Kotsiantis et al., 2006). A variety of sampling approaches are available to reach this goal, the most prominent being random over- and undersampling, informed undersampling, synthetic minority oversampling (SMOTE), adaptive synthetic sampling, sampling with data cleaning, and cluster-based sampling methods (He & Garcia, 2009). From the variety of over- and undersampling methods presented in literature (Galar et al., 2012; Haixiang et al., 2017), random undersampling (RUS) is still one of the most commonly applied undersampling techniques (Haixiang et al., 2017). In RUS, entities of the majority class are randomly removed to reduce the data imbalance (Galar et al., 2012). The most commonly used oversampling technique is SMOTE and its derivations (Haixiang et al., 2017). The SMOTE process is introduced by Chawla et al. (2011; 2003). For each entity of the minority class, the k-nearest neighbours are identified; after this, a distance vector from the minority entity to its neighbours is calculated. By randomly multiplying the vector with a number between 0 and 1, SMOTE creates a new data entity, which is added to the training data.

Ensemble Learning

Hybrid methods of predicting imbalanced data include cost-sensitive learning and ensemble learning. Cost-sensitive learning follows the approach of manipulating the algorithm to weight the minority class higher and improve classifier performance. Cost-sensitive approaches have the downside that the actual costs of misclassification must be known (Sun et al., 2009). Another issue in readmission prediction as pointed out by Kansagara et al. (2011) is the poor performance of individual classifiers. Ensemble methods counter this issue by combining multiple classifiers into one classification system to produce a higher accuracy than achieved by its individual components (Galar et al., 2012). Ensemble learning can either be performed by combining different classifiers or by applying variations of the same classifier (Haixiang et al., 2017). Two main approaches that can be differentiated are bagging and boosting. Bagging, which is short for bootstrapped aggregating, is introduced by Breiman (1996) and combines several base classifiers into one classifier. In the first step, data subsets are sampled from the training data. The bagging approach bootstraps the data to create several different bags. Bootstrapping means that random samples are added to the subset until the subsets have the same number of entities as the training data. This leads to intended duplicates in the subsets. Next, for each of the bags, the base classifier is trained and applied to the application set. Subsequently, the differently trained classifiers vote as to which class a new entity belongs, and a majority vote of the classifiers determines in which class the observation fits best. A prominent bagging method are RandomForests, which combine individual decision trees into a single classifier. In boosting, the training set is again split into k subsets. The model building, however, is done sequentially as opposed to the independent training for bagging models. Here, a weight is set for each data element, where misclassified examples increase their weight for the subsequent training round. In addition, a weight is set for each classifier dependent on its individual error rate. Thus, a weighted vote from all classifiers is used for the prediction of a new example (Quinlan, 1996). The most prominent boosting method, AdaBoost (adaptive boosting) (Freund & Schapire, 1997) is based on the principle of boosting introduced by Schapire (1990) and uses the base principle of improving the algorithm in every iteration to achieve a higher performance. Here, the base classifier is applied to the entire training data set. Next, AdaBoost calculates the error rate for each individual sample and adds it to the data. In the next iteration, the algorithm selects the training data by considering the assigned weight to give misclassified samples higher attention. After each iteration, AdaBoost weights the models according to accuracy.

FRAMEWORK DEVELOPMENT

Goal Definition and Study Design

As a first step in any prediction project, the analysis goal has to be defined. While the main objective is to predict patients at risk of readmission to the hospital, the specific terms and criteria to successfully reach this goal need to be defined, namely the *type of prediction*, the interpretation of a *high-risk patient* as well as the parameters for an episode to count as a *readmission*.

Prediction: In supervised learning, two types of prediction tasks can be differentiated, namely classification and regression. Classification aims at predicting discrete values, i.e. predefined categories or classes, whereas regression provides continuous values. In the task of readmission prediction, a categorical value, hence a classification approach, is required. At the highest level, a dichotomous differentiation between readmitted and non-readmitted patients is chosen. If necessary, the classes can be extended to further distinguish the time of readmission (e.g., early versus late readmissions) in a specified time frame, they can be separated by the reason for readmission (e.g., complications or corrections) or the level of risk (e.g., low risk, medium risk, high risk). The main issue for each of these cases is the prior classification of examples in the historical dataset that has to be aligned with the goal of the analysis task. In the case at hand, the main goal is to find out, whether a patient will be readmitted or not. Thus, a binary variable reflecting either 1 (readmission) or 0 (no readmission) is chosen as the classification target.

High-risk: The binary distinction can further be extended by considering the probability of class memberships. This way, prediction models cannot only specify, whether a patient belongs to the predicted readmission group or not, but also the probability of belonging to a group can be determined. The lower the threshold for a required class membership is set, the more risk patients can be identified. On the other hand, this also increases the likelihood of false positives. If the costs for a false positive prediction or a false negative prediction are known, weights can be specified accordingly. The concrete value of wrong predictions, however, is difficult to determine and poses a major challenge in readmission prediction. Costs for a prolonged length of stay or intervention programs can be used as approximations (Jamei, Nisnevich, Wetchler, Sudat, & Liu, 2017).

Readmission: Another issue in readmission prediction lies in the basic definition of the readmission episode itself. Readmissions are commonly differentiated between planned or unplanned readmissions and related or unrelated to the index admission (AHA, 2011). While the identification and prediction of readmissions should primarily focus on unplanned, related readmissions, it is often difficult to assess the relationship between admissions. Also, planned readmissions are often not documented within hospitals and therefore exacerbate the distinction of unplanned readmissions. Besides the admission intent, some studies also differentiate between avoidable and unavoidable readmissions (van Walraven et al., 2011; van Walraven, Wong, & Forster, 2012). The proportion of avoidable readmissions in that context and the underlying criteria to determine whether they are indeed avoidable varies strongly between studies. For example, van Walraven et al. (2011) suggest a median proportion of around 27% of readmissions to be avoidable, or similarly van Galen et al. (2017) propose 27-28% be at least predictable.

Figure 2. Data preparation steps

To specify which episodes qualify for this definition, a variety of factors, including the timespan between admissions and the reasons for readmission have to be clarified. The timeframe can be selected based on regulations at a country or hospital-level or adhere to protocols by insurers. The reasons for readmission to be related to the index admission are highly dependent on the episodes under study. If certain diagnoses or procedures are investigated, the most common diagnoses for readmissions can be identified apriori and categorised into the presented scheme for readmissions (AHA, 2011). This task requires sufficient domain knowledge to undertake the classification for a specific procedure or diagnosis group. Alternatively, existing guidelines or regulations by insurers or governments can also be used.

Data Preparation

The data preparation process covers various steps of cleaning, visualising and reducing the available dataset in order to be suitable for the subsequent analysis. This includes dealing with missing and inconsistent data as well as creating and selecting appropriate features. To get a better understanding of the underlying data and identify noise, exploratory analysis and simple visualizations of the dataset are conducted. Figure 2 gives an overview of the individual steps that are taken to develop the appropriate feature sets in the following sections.

DATA SELECTION

As a first step, data is filtered to only include relevant admissions for the prediction task. It is imperative that the prediction model is trained on the data of the admission episodes that might have led to a readmission, not on the readmission episodes. The following criteria are important for each episode to remove irrelevant data points accordingly:

- The patient is admitted to acute care.
- The patient did not die during or after the hospital stay.
- The patient did not leave the hospital at his/her own risk.

FEATURE CREATION

To complement the data set with further relevant attributes, the availability of the identified risk factors from previous studies is assessed for each procedure group. Based on the insights from systematic reviews by Kansagara et al. (2011) and Zhou et al. (2016) relevant attributes for readmission risk prediction from previous studies can be analysed and, if applicable, integrated into the dataset. Furthermore, if no studies on predictive models are available for the diagnosis or procedure under study, explanatory models can also provide an indication of relevant risk factors.

DATA CLEANING

The term data cleaning describes the process of detecting and removing data errors and inconsistencies. Unclean data can either occur on attribute, record, record type, or source level. According to Rahm (2000) errors can appear on a schematic or at an instance level.

Schematic errors can consist of the following:

- illegal values in attributes (e.g., a BMI of 0),
- inconsistencies on record level (e.g., between age and date of birth),
- record type errors, such as uniqueness violations (e.g., multiple uses of patient or episode IDs), or
- referential integrity violations (e.g., missing descriptions of diagnosis codes).

On an instance level,

- missing values,
- misspellings,
- abbreviations or non-defined codes,
- embedded values (i.e., multiple attributes in one column), or
- misfielded values (e.g., age in the date of birth column) can occur.

Duplicate records or varying value representations (e.g., data types) also affect the integrity of the data set (Rahm & Do, 2000). According to Chen et al. (2014), completeness, accuracy, and timeliness of data are the major factors for data quality specifically in health information systems. To identify errors, data profiling can be performed, which provides metadata to discover errors in the data.

Missing values can be handled in different ways, where entities can either be deleted, missing values can be imputed or the missing values can present knowledge themselves (Grzyb et al., 2017). If missing values don't indicate additional insights, attributes with too many missing values are not taken into further consideration. Also, attributes contributing low or now information are identified by calculating the variance of each variable. Attributes with a variance lower than a predefined threshold can be excluded from the dataset.

EXPLORATORY DATA ANALYSIS

The goal of the exploratory data analysis (EDA) is to analyse the dataset visually and numerically to ensure that the data is suitable for the prediction model. In addition, dimensions are systematically reduced in this step as too many predictors can introduce noise and thus decrease the performance of a prediction model. Depending on the type of the attribute under study, different graphical representations can be used to gain insights into the analysed records. For univariate and bivariate data (e.g., gender), simple plots, such as histograms or scatterplots can be used. The numerical distribution gives an insight into how the two cohorts differ.

CHOICE OF VARIABLES

After reducing dimensions, the next step is to select which variables to use for the prediction models. To this end, the variables must have a measurement quality, which means variables that do not assist in predicting unplanned readmissions are not relevant for the model. A feature is seen as beneficial if it is correlated with the prediction flag but is not redundant to any other relevant feature (Yu & Liu, 2003). This means that the variables must have the ability to predict readmissions while not being highly correlated with each other. Since variables with correlations above 0.70 are seen as highly correlated (Asuero, Sayago, & González, 2007), features with a correlation above 0.70 can be removed.

An additional aspect that distinguishes prediction models from explanatory models is the time of data availability. While explanatory models can utilize all data that is available to identify relationships a posteriori, prediction models need to be based on data that is available at the time of prediction (Shmueli & Koppius, 2011). As the prediction models are usually utilized before patient discharge, only attributes that are available before a patient leaves the hospital can be considered.

Model Development

According to a systematic review by Artetxe et al. (2018) on predictive models for hospital readmission risk, machine learning methods can improve the prediction ability over traditional statistical approaches. Such contributions to this academic field are aimed at first aligning complex and sensitive information across multiple sources, using, among others, administrative, insurance, clinical, and government registry data. This information is thereafter used to identify patients in need of additional healthcare resources by means of various intervention methods (Billings, Georghiou, Blunt, & Bardsley, 2013). The model development is split into several steps (cf. Figure 3) and is tightly connected to the internal evaluation and optimization of a prediction model.

SPLIT THE DATASET

As a first step, the prepared dataset is split into a training and a validation set. The training set is further used to train, test and optimize the models, while the validation set is used in the very last step to evaluate and compare the predictive performance of the final models. The data is split in a stratified fashion, thus the distribution of readmitted and non-readmitted patients is equal in both datasets.

A major issue in predictive analytics is overfitting, which refers to a model that fits the training data perfectly, but fails to generalize in order to correctly predict new examples. Different strategies can be applied during model training to avoid and test if a model overfits, namely hold-out validation and cross-validation. To perform these validations, the data is split into three subsets, a training set and a validation set for cross-validation or hold-out validation and a test set for final evaluation. Depending on the evaluation strategy, these sets are created and used in different manners.

Figure 3. Model development process

Process step	Input	Output
Split dataset	Dataset	*Training set* *Validation set*
Sampling	Training set	*Sampled training set*
Feature selection	Sampled training set	*Sampled training set with relevant attributes*
Hyperparameter tuning	Sampled training set with relevant attributes	*Optimal hyperparameters*
Model building	Sampled training set with relevant attributes + Optimal hyperparameters	*Prediction model*

Training set: This subset is used to fit the model, i.e., derive the relationship between the input variables and the target class.

Validation set: Next, the developed model is tested on unseen data, where the predicted values are compared with the real class membership to determine the error rate of the predictions.

Test set: The test set is used in the last step to evaluate the final model that is built on the full dataset (training + validation) given the optimal hyperparameters previously determined by the training and validation data.

For both approaches, a test set is omitted for final testing of the developed model. The training and validation of the model, however, differs. In hold-out validation, for each parameter setting, the model is only trained once on the training set and then applied to the validation set. When the best parameter setting is found through this approach, the final model is again trained on the entire dataset (training + validation data) and then evaluated using the test set. In cross-validation, on the other hand, the data is split into k subsets, where k equals a positive integer. Next, the model is trained on k-1 subsets and validated on the remaining subset. This is repeated until every subset has been used as a training and validation set (cf. Figure 4). A special form of cross-validation, termed leave-one-out cross-validation (LOOCV), splits the data into k subset, where k equals the number of examples in the dataset. Thus, each data point is used on its own to evaluate the model that is built on the remaining dataset. This approach, however, gets extremely cost-intensive with regards to computing time the bigger the data set. While hold-out validation requires less computing time as the model only has to be trained once, sampling of the training and test set can lead to an unwanted bias. In cross-validation, on the other hand, each data point is used both as a training and a validation example, eliminating the sampling bias. Since computing time

Figure 4. Hold-out validation versus cross-validation

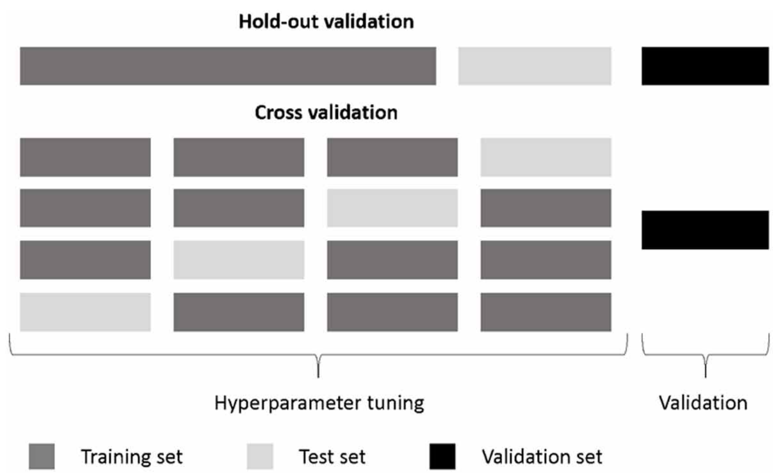
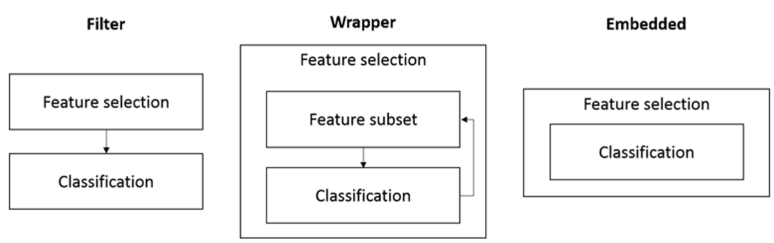


Figure 5. Feature selection approaches (cf. Suppers, van Gool, & Wessels, 2018, p. 7)



is not an imitating factor in this analysis and the size of the data sets is appropriate for cross-validation, this technique is used for evaluating the prediction models in the following sections.

SAMPLING

If the utilized algorithm doesn't support class weights, sampling can be performed on the training data set to handle an imbalanced class distribution. There is no clear suggestion, whether over- or undersampling performs better in a given prediction task, thus both approaches should be tested. In order to avoid shrinking the data set in the sampling process too extensively, the desired ratio between the minority and majority class can be specified.

FEATURE SELECTION

Next, different feature selection approaches are performed for each classifier. In general, filter, wrapper and embedded methods can be distinguished (Guyon & Elisseeff, 2003). The main difference between these approaches lies in the point in time of feature selection with regards to the model development and evaluation (cf. Figure 5).

Filter methods clearly separate the feature selection and model building process. As a first step, attributes are chosen based on model-independent factors, such as variance or correlation thresholds. Wrapper methods, on the other hand, iteratively build and evaluate a model and adapt the feature set based on the results of the model evaluation until a certain threshold is reached. This adaption can be done by increasing or decreasing the number of features. In forwards selection, the initial feature set consists of one attribute that is consistently extended. The main issue with forwards selection is that features whose usefulness is dependent on other features ("feature synergy") might be lost (Kohavi & John, 1997). To overcome this issue, backwards elimination initially uses the entire feature set to build the classification model and attributes are iteratively removed. Recursive feature elimination (RFE) is a type of backwards selection, where the model is first trained on all features, which are then ranked based on their contribution to the prediction task. The lowest-ranking features are removed until the prediction accuracy of the model decreases. Lastly, embedded methods perform the feature selection task during model building. Decision trees are a prominent example of an embedded feature selection model, as the information gain of each attribute is used to choose the features for model building. Since KNN and NB can't consider varying importance of different features, the models are fitted on all attributes. L1 regularization (also termed "least absolute shrinkage and selection operator (LASSO)") also presents an embedded method for a linear regression that adds a penalty for overly complex models, i.e., the number of input factors. Since DT have an embedded method of feature selection based on the information value of attributes, RFE is performed with cross-validation (RFECV) for all other methods. In RFE, attributes are continuously excluded from the data set based on their contribution to the prediction task.

HYPERPARAMETER TUNING

As a next step, hyperparameter tuning is performed where the classifier is fitted to the sampled training set with the remaining relevant attributes. Each model can be trained using a set of hyperparameters relevant for each algorithm. The hyperparameters determine various criteria on how a model is trained, the learning speed and the structure of the model. To identify the best combination of hyperparameters, different search strategies can be applied. With sufficient computing power, formerly popular manual "trial-and-error" settings can be neglected. Instead, parameter combinations can be tested within a given scope using search algorithms, such as random search or grid search. In random search, each parameter setting is sampled from a distribution over possible parameter values. On the other hand, grid search offers an exhaustive search in a specified scope parameter value. Research has shown that random search provides a more efficient way of identifying the optimal parameter setting with at least equally satisfying results (Bergstra & Bengio, 2012).

Table 1. Evaluation metrics

Evaluation metric	Formula*
Accuracy	$\frac{TP+TN}{N}$
Sensitivity (Recall pos. class)	$\frac{TP}{TP+FN}$
Specificity (Recall neg. class)	$\frac{TN}{TN+FP}$
Precision	$\frac{TP}{TP+FP}$
F-Score	$(1+\beta^2) *$ þ $\frac{precision \ *recall}{\left(\beta^2 \ *precision\right)+recall}$

* TP = True Positives, TN = True Negatives, N = All examples, FN = False Negatives, FP = False Positives

MODEL BUILDING

In the last step, the prediction model is built by training the classifier on the entire training and test data set using the identified hyperparameter combination. The resulting model can then be used for the final validation. Depending on the classifier, sample weights or embedded feature selection can be employed during model building. Otherwise, the over- or undersampled data is used to build the prediction model based on the previously identified relevant features.

Evaluation, Validation, and Model Selection

In the last step, the prediction model is applied to the final test set. Thus, the model is tested on previously unseen data that hasn't been involved in the development process. A major issue in predictive analytics is overfitting, which refers to a model that fits the training data perfectly, but fails to generalize in order to correctly predict new examples. A popular strategy to test if a model overfits is to perform cross-validation. For this purpose, the data is split into three subsets, a training set, test set and validation set. For the training and testing data sets, the data is split into k subsets, where k equals a positive integer. Next, the model is trained on k-1 subsets and tested on the remaining subset. This is repeated until every subset has been used as a training and testing set. While cross validation already aims to avoid overfitting of the model during training, it is argued that a final test on an unseen validation set should be performed in addition using data not present in the cross-validation (Ripley, 2009).

For evaluation, different metrics to investigate model performance are available. Since projects on readmission prediction usually concentrate on identifying as many risk patients as possible, the positive class should be focused on in the model evaluation. For this purpose, either the sensitivity or the F-2

Table 2.

Process Step	Main questions	Example
Goal definition	**Prediction:** What is the main purpose of the prediction?	*Define time of prediction, e.g., identify patients at risk for readmissions at admission, before or after discharge*
	High-risk: At what level should the readmission be predicted?	***Discrete:*** *Binary prediction (readmission / no readmission) or Multinominal prediction (e.g., high risk, medium risk, low risk)* ***Continous:*** *Risk probability (0 - 100%)*
	Readmission: How is a readmission defined?	*Reason for readmission (procedure-specific or general)* *Timeframe of readmission (28-day, 30-day, 6 months, etc.)*
Data collection and study design	**Study design:** When is the data collected?	*Retrospective study versus real-time*
	Data collection: Which episodes should be excluded from the dataset?	*Patient is admitted to acute care* *Patient died before or after discharge* *Patient left the hospital against medical advice*
Data preparation	**Selection**: Which data points (episodes) are relevant for the context at hand?	*Focus on specific procedures, diagnoses, patient groups*
	Feature creation: Which additional attributes are potentially interesting?	*Create additional attributes from collected data that are not directly reported (e.g., from previous studies on predictive or explanatory models)*
	Cleaning: Which data points are usable for the prediction task?	*Missing values* *Outliers* *Low variance* *High correlation* *High cardinality*
	Exploratory data analysis: What does the population under study look like?	*E.g., use histograms or scatterplots to compare the distribution between two cohorts (readmission, no readmission)*
	Choice of variables: What data is available at the time of prediction?	*Depends on the prediction goal (at admission, before or after discharge)*
Model development	**Split dataset:** How does the data need to be split for evaluation?	*Training + test dataset (e.g., 80%)* *(Final) validation dataset (e.g., 20%)* *Cross-validation (during model training) versus holdout-validation*
	Sampling: Which sampling method should be applied to reduce the issue of imbalanced data?	*Methods that support class weights (e.g., SVM)* *Undersampling (e.g., Random Undersampling)* *Oversampling (e.g., SMOTE)* *Hybrid Sampling*
	Feature selection: Which attributes contribute to the predictive performance of a model?	*Filter methods (subsequent approach, e.g., variance threshold)* *Wrapper methods (iterative approach, e.g., backwards elimination)* *Embedded methods (integrated approach, e.g., decision trees)*
	Hyperparameter tuning: Which hyperparameter combination leads to the best predictive performance?	*Random search (specify the number of parameter combinations in a given range)* *Exhaustive search (test all parameter combinations in a given range, e.g., grid search)*
	Model building	*Build the model on the entire training + test dataset using the identified optimal hyperparameters* *Use sample weights and embedded feature selection (if applicable)*
Evaluation, validation, and model selection	**Evaluation:** Which evaluation measure should be chosen?	*Focus on readmission cohort: F2-score, Precision-recall curve, AUC*
	Validation: How well does the model perform on unseen data?	*Apply the model on the validation set*
	Interpretation: How can the final model be interpreted?	*Logistic regression: Odds ratio for each attribute* *Decision tree: Deduct rules from tree*
	Selection: What model should be selected for the final prediction task?	*Predictive performance, computing time, interpretability*

score should be chosen as they put more emphasis on the positive class (cf. Table 1). Besides the resulting predictive performance stated by the evaluation metrics, model interpretability and computing time should also be considered for the final model selection.

Table 2 summarizes the results of this study by defining five main process steps that are further subcategorized in relevant tasks and questions that need to be answered in any readmission prediction project.

DISCUSSION AND CONCLUSION

This study set out to identify and unpack key issues around applying predictive analytics to healthcare especially in the area of hospital readmissions. In doing so the study has several contributions for theory and practice as follows: The proposed framework can be used to perform future studies on readmission risk prediction in a more systematic and guided way. Common mistakes in these kinds of projects can therefore be avoided and results are better comparable. Furthermore, this work extends the theoretical knowledge on predictive analytics based on Shmueli and Koppius (2011). In a next step, the proposed framework will be further tested and adapted by means of a systematic literature review on readmission risk prediction. Furthermore, an exemplary prediction project is conducted based on the presented guidelines to test its applicability in practice. For this purpose, episode data from an Australian hospital group is used to predict unplanned readmissions.

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REFERENCES

AHA. (2011). *Examining the Drivers of Readmissions and Reducing Unnecessary Readmissions for Better Patient Care.* Retrieved from https://www.aha.org/guidesreports/2018-02-09-examining-drivers-readmissions-and-reducing-unnecessary-readmissions

Artetxe, A., Beristain, A., & Graña, M. (2018). Predictive models for hospital readmission risk: A systematic review of methods. *Computer Methods and Programs in Biomedicine*, *164*, 49–64. doi:10.1016/j.cmpb.2018.06.006 PMID:30195431

Asuero, A. G., Sayago, A., & González, A. G. (2007). The Correlation Coefficient: An Overview. *Critical Reviews in Analytical Chemistry*, *36*(1), 41–59. doi:10.1080/10408340500526766

Bellazzi, R., & Zupan, B. (2008). Predictive data mining in clinical medicine: Current issues and guidelines. *International Journal of Medical Informatics*, *77*(2), 81–97. doi:10.1016/j.ijmedinf.2006.11.006 PMID:17188928

Bergstra, J., & Bengio, Y. (2012). Random Search for Hyper-Parameter Optimization. *Journal of Machine Learning Research*, *13*(Feb), 281–305. Retrieved from http://www.jmlr.org/papers/volume13/bergstra12a/bergstra12a.pdf

Billings, J., Georghiou, T., Blunt, I., & Bardsley, M. (2013). Choosing a model to predict hospital admission: An observational study of new variants of predictive models for case finding. *BMJ Open*, *3*(8), e003352. doi:10.1136/bmjopen-2013-003352 PMID:23980068

Breiman, L. (1996). Bagging Predictors. *Machine Learning*, *24*(2), 123–140. doi:10.1007/BF00058655

Chawla, N. (2005). Data Mining for Imbalanced Datasets: An Overview. In O. Z. Maimon & L. Rokach (Eds.), *Data mining and knowledge discovery handbook* (pp. 853–867). New York, NY: Springer. doi:10.1007/0-387-25465-X_40

Chawla, N., Bowyer, K., Hall, L., & Kegelmeyer, W. P. (2011). SMOTE: Synthetic Minority Over-sampling Technique. *Journal of Artificial Intelligence Research*; Advance online publication. doi:10.1613/jair.953

Chen, H., Hailey, D., Wang, N., & Yu, P. (2014). A Review of Data Quality Assessment Methods for Public Health Information Systems. *International Journal of Environmental Research and Public Health*, *11*(5), 5170–5207. doi:10.3390/ijerph110505170 PMID:24830450

Donzé, J., Aujesky, D., Williams, D., & Schnipper, J. L. (2013). Potentially avoidable 30-day hospital readmissions in medical patients: Derivation and validation of a prediction model. *JAMA Internal Medicine*, *173*(8), 632–638. doi:10.1001/jamainternmed.2013.3023 PMID:23529115

Freund, Y., & Schapire, R. E. (1997). A Decision-Theoretic Generalization of On-Line Learning and an Application to Boosting. *Journal of Computer and System Sciences*, *55*(1), 119–139. doi:10.1006/jcss.1997.1504

Galar, M., Fernandez, A., Barrenechea, E., Bustince, H., & Herrera, F. (2012). A Review on Ensembles for the Class Imbalance Problem: Bagging-, Boosting-, and Hybrid-Based Approaches. *IEEE Transactions on Systems, Man and Cybernetics. Part C, Applications and Reviews*, *42*(4), 463–484. doi:10.1109/TSMCC.2011.2161285

Grzyb, M., Zhang, A., Good, C., Khalil, K., Guo, B., Tian, L., ... Gu, Q. (2017). Multi-task cox proportional hazard model for predicting risk of unplanned hospital readmission. In *2017 Systems and Information Engineering Design Symposium (SIEDS)* (pp. 265–270). IEEE. 10.1109/SIEDS.2017.7937729

Guyon, I., & Elisseeff, A. (2003). An introduction to variable and feature selection. *Journal of Machine Learning Research*, *3*, 1157–1182. Retrieved from http://dl.acm.org/ft_gateway.cfm?id=944968&type=pdf

Haixiang, G., Yijing, L., Shang, J., Mingyun, G., Yuanyue, H., & Bing, G. (2017). Learning from class-imbalanced data: Review of methods and applications. *Expert Systems with Applications*, *73*, 220–239. doi:10.1016/j.eswa.2016.12.035

Hasan, O., Meltzer, D. O., Shaykevich, S. A., Bell, C. M., Kaboli, P. J., Auerbach, A. D., ... Schnipper, J. L. (2010). Hospital readmission in general medicine patients: A prediction model. *Journal of General Internal Medicine*, *25*(3), 211–219. doi:10.100711606-009-1196-1 PMID:20013068

He, H., & Garcia, E. A. (2009). Learning from Imbalanced Data. *IEEE Transactions on Knowledge and Data Engineering*, *21*(9), 1263–1284. doi:10.1109/TKDE.2008.239

Heggestad, T. (2002). Do Hospital Length of Stay and Staffing Ratio Affect Elderly Patients' Risk of Readmission? A Nation-wide Study of Norwegian Hospitals. *Health Services Research*, *37*(3), 647–665. doi:10.1111/1475-6773.00042 PMID:12132599

Jamei, M., Nisnevich, A., Wetchler, E., Sudat, S., & Liu, E. (2017). Predicting all-cause risk of 30-day hospital readmission using artificial neural networks. *PLoS One*, *12*(7), e0181173. doi:10.1371/journal.pone.0181173 PMID:28708848

Kansagara, D., Englander, H., Salanitro, A., Kagen, D., Theobald, C., Freeman, M., & Kripalani, S. (2011). Risk prediction models for hospital readmission: A systematic review. *Journal of the American Medical Association*, *306*(15), 1688–1698. doi:10.1001/jama.2011.1515 PMID:22009101

Kohavi, R., & John, G. H. (1997). Wrappers for feature subset selection. *Artificial Intelligence*, *97*(1-2), 273–324. doi:10.1016/S0004-3702(97)00043-X

Kotsiantis, S. B., Kanellopoulos, D., & Pintelas, P. E. (2006). *Handling imbalanced datasets: A review.* Retrieved from https://pdfs.semanticscholar.org/95df/dc02010b9c390878729f459893c2a5c0898f.pdf

Kreuninger, J. A., Cohen, S. L., Meurs, E. A. I. M., Cox, M., Vitonis, A., Jansen, F. W., & Einarsson, J. I. (2018). Trends in readmission rate by route of hysterectomy - a single-center experience. *Acta Obstetricia et Gynecologica Scandinavica*, *97*(3), 285–293. doi:10.1111/aogs.13270 PMID:29192965

Kristensen, S. R., Bech, M., & Quentin, W. (2015). A roadmap for comparing readmission policies with application to Denmark, England, Germany and the United States. *Health Policy (Amsterdam, Netherlands)*, *119*(3), 264–273. doi:10.1016/j.healthpol.2014.12.009 PMID:25547401

Kumar, A., Karmarkar, A. M., Graham, J. E., Resnik, L., Tan, A., Deutsch, A., & Ottenbacher, K. J. (2017). Comorbidity Indices Versus Function as Potential Predictors of 30-Day Readmission in Older Patients Following Postacute Rehabilitation. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, *72*(2), 223–228. doi:10.1093/gerona/glw148 PMID:27492451

Lavrač, N., Gamberger, D., Todorovski, L., & Blockeel, H. (Eds.). Chawla, Nitesh, Lazarevic, A., Hall, Lawrence, & Bowyer, Kevin. (2003). Smoteboost: Improving Prediction of the Minority Class in Boosting. In N. Lavrač, D. Gamberger, L. Todorovski, & H. Blockeel (Eds.), Lecture Notes in Computer Science: Vol. 2838. Knowledge Discovery in Databases: PKDD 2003: 7th European Conference on Principles and Practice of Knowledge Discovery in Databases, Cavtat-Dubrovnik, Croatia, September 22-26, 2003. Proceedings (Vol. 2838, pp. 107–119). Berlin: Springer. 10.1007/978-3-540-39804-2_12

Longadge, R., & Dongre, S. (2013). *Class Imbalance Problem in Data Mining Review*. Retrieved from http://arxiv.org/pdf/1305.1707

Ohta, B., Mola, A., Rosenfeld, P., & Ford, S. (2016). Early Discharge Planning and Improved Care Transitions: Pre-Admission Assessment for Readmission Risk in an Elective Orthopedic and Cardiovascular Surgical Population. *International Journal of Integrated Care*, *16*(2), 10. doi:10.5334/ijic.2260 PMID:27616965

Quinlan, J. R. (1996). *Bagging, boosting, and C4.S*. AAAI Press.

Rahm, E., & Do, H. H. (2000). Data Cleaning: Problems and Current Approaches. In Zinc Industry. Woodhead Pub. doi:10.1016/B978-1-85573-345-9.50005-4

Ripley, B. D. (2009). *Pattern recognition and neural networks*. Cambridge, UK: Cambridge University Press.

Schapire, R. E. (1990). The strength of weak learnability. *Machine Learning*, *5*(2), 197–227. doi:10.1007/BF00116037

Scott, I. A. (2010). Preventing the rebound: Improving care transition in hospital discharge processes. *Australian Health Review: a Publication of the Australian Hospital Association*, *34*(4), 445–451. doi:10.1071/AH09777 PMID:21108906

Shadmi, E., Flaks-Manov, N., Hoshen, M., Goldman, O., Bitterman, H., & Balicer, R. D. (2015). Predicting 30-day readmissions with preadmission electronic health record data. *Medical Care*, *53*(3), 283–289. doi:10.1097/MLR.0000000000000315 PMID:25634089

Shmueli, G., & Koppius, O. (2011). Predictive Analytics in Information Systems Research. *Management Information Systems Quarterly*, *35*(3), 553–572. doi:10.2307/23042796

Sun, Y., Wong, A., & Kamel, M. (2009). Classification of imbalanced data: A review. *International Journal of Pattern Recognition and Artificial Intelligence*, *23*(04), 687–719. doi:10.1142/S0218001409007326

Van Galen, L. S., Brabrand, M., Cooksley, T., van de Ven, P. M., Merten, H., So, R. K., ... Nanayakkara, P. W. (2017). Patients' and providers' perceptions of the preventability of hospital readmission: A prospective, observational study in four European countries. *BMJ Quality & Safety*, *26*(12), 958–969; Advance online publication. doi:10.1136/bmjqs-2017-006645 PMID:28642333

Van Walraven, C., Bennett, C., Jennings, A., Austin, P. C., & Forster, A. J. (2011). Proportion of hospital readmissions deemed avoidable: a systematic review. CMAJ: Canadian Medical Association Journal = Journal De L'Association Medicale Canadienne, 183(7), E391-402. doi:10.1503/cmaj.101860

Van Walraven, C., Dhalla, I. A., Bell, C., Etchells, E., Stiell, I. G., Zarnke, K., . . . Forster, A. J. (2010). Derivation and validation of an index to predict early death or unplanned readmission after discharge from hospital to the community. CMAJ: Canadian Medical Association Journal = Journal De L'Association Medicale Canadienne, 182(6), 551–557. doi:10.1503/cmaj.091117

Van Walraven, C., Wong, J., & Forster, A. J. (2012). Derivation and validation of a diagnostic score based on case-mix groups to predict 30-day death or urgent readmission. *Open Medicine: a Peer-Reviewed, Independent, Open-Access Journal*, *6*(3), e90–e100. PMID:23687525

Yu, L., & Liu, H. (2003). Feature Selection for High-Dimensional Data: A Fast Correlation-Based Filter Solution. Academic Press.

Zhou, H., Della, P. R., Roberts, P., Goh, L., & Dhaliwal, S. S. (2016). Utility of models to predict 28-day or 30-day unplanned hospital readmissions: An updated systematic review. *BMJ Open*, *6*(6), e011060. doi:10.1136/bmjopen-2016-011060 PMID:27354072

Chapter 22
Trying to Predict in Real Time the Risk of Unplanned Hospital Readmissions

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ABSTRACT

This study aims to identify predictors for patients likely to be readmitted to a hospital within 28 days of discharge and to develop and validate a prediction model for identifying patients at a high risk of readmission. Numerous attempts have been made to build similar predictive models. However, the majority of existing models suffer from at least one of the following shortcomings: the model is not based on Australian Health Data; the model uses insurance claim data, which would not be available in a real-time clinical setting; the model does not consider socio-demographic determinants of health, which have been demonstrated to be predictive of readmission risk; or the model is limited to a particular medical condition and is thus limited in scope.

INTRODUCTION

Like all OECD countries, Australia is also facing cost pressure regarding delivering high quality care. In the private healthcare sector in Australia unplanned readmissions are 3.1 typically requires the joint analysis of multiple sources of data (Sherman, 1984). However, this can be challenging as data is often incomplete, fragmented and/or consists of misaligned information (Buhl, Röglinger, Moser, & Heidemann, 2013). This limitation in data quality in turn has hindered epidemiologists to extrapolate demographic information to within plausible limits (Murray, Lopez, & Organization, 1996). Additionally, fragmented data spread across multiple sources makes it difficult for policymakers to compare the relative cost-effectiveness of different interventions (Chechulin, Nazerian, Rais, & Malikov, 2014). Thus, measuring, gauging and creating benchmarks for unplanned readmission is difficult and yet trying to solve this problem, as is the goal of this research, will have many far reaching consequences.

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LITERATURE REVIEW AND BACKGROUND

Recent developments in the fields of data warehousing and data science have enabled researchers to contribute to a growing body of knowledge in predictive analytics (Buhl et al., 2013). In particular, the building, training and application of predictive models to stratify patients into various risk groups based on information from administrative, insurance, clinical, and government registry sources is becoming a key focus (Chechulin et al., 2014). Such studies are aimed at first aligning complex and sensitive information across multiple sources (Blumenthal, Chernof, Fulmer, Lumpkin, & Selberg, 2016). This information is then used to identify patients in need of additional healthcare resources by means of various intervention methods (Blumenthal et al., 2016).

The preponderance of research on predicting unplanned readmissions applies logistic regression models using dichotomous dependent variables (Blumenthal et al., 2016; Chechulin et al., 2014; Cunningham, 2017; Fleishman & Cohen, 2010; Hartmann, Jacobs, Eberhard, von Lengerke, & Amelung, 2016; Leininger, Saloner, & Wherry, 2015; Li, Cairns, Fotheringham, Ravanan, & Group, 2016; Rodriguez, Munevar, Delaney, Yang, & Tumlinson, 2014) and occasionally linear regressions (Fleishman & Cohen, 2010; Rodriguez et al., 2014). Although the variable to be explained is dichotomous, logistic regression can additionally determine the probability of belonging to a certain group, for example, whether a patient is cost intensive (i.e. a likely unplanned readmission or high risk patient) or not (a relatively healthy patient unlikely to have complications) (Snider et al., 2014). Compared to logistic regression, the scale level of the dependent variable in linear regression is metric (Snider et al., 2014). On the one hand, the use a dichotomous dependent variable with a well-defined threshold allows for a better comparability. However, the dichotomous dependent variable has the disadvantage that potential cost savings can not directly be assigned (Cunningham, 2017). In addition to regression models, classification models such as Support Vector Machine (SVM) and Decision Tree (DT) methods can be applied (Behnke, 2014; Bertakis & Azari, 2010; Koukouvinos, 2016). Classification is the assignment of data objects to a suitable class, whereby, for example, the minimization of the classification error or the maximization of the degree of affiliation are used as performance evaluation criteria (Moturu, Johnson, & Liu, 2007). In SVMs, data objects are represented as vectors in a d-dimensional data space. An SVM looks for a boundary where the objects with different class affiliation are separated as distinctively as possible. This limit is represented by so-called support vectors. In case of more than two attributes, the separating boundary corresponds to a hyperplane (Moturu et al., 2007). Drosou and Koukouvinos (Bertakis & Azari, 2010) use SVM to find an optimal hyperplane that separates cost-intensive from "regular" patients. However, comparing different classification and predictive models, Moturu, Johnson, and Liu (Behnke, 2014) show that SVM have the lowest performance. In their study, Bertsimas et al. (Bertsimas et al., 2008) utilize DT to classify high-cost patients. The advantage of decision trees lies in the ability to be easily interpreted, where the importance of an attribute is reflected by its proximity to the root node. However, especially for data sets with many attributes, the danger of overfitting occurs (Moturu et al., 2007). In this case, very large decision trees are created. Although a large decision tree leads to a high classification accuracy on the training data, it does not necessarily lead to a high classification accuracy on the test data (Moturu et al., 2007). Since the mentioned classification models have not shown a sufficient performance in literature and logistic regression has the advantage of generating probabilities as well, this method is chosen for the predictive analysis. In order to evaluate whether overfitting occurs when learning a classifier, cross-validation of the models is applied.

There are a variety of different influencing factors in literature that increase the likelihood of becoming a cost-intensive patient. Especially demographic variables are often used as the first factor in predictive analysis, where aspects such as age and gender are known to be reliable predictors (Behnke, 2014; Buhl et al., 2013). Bertakis and Azari (Bertakis & Azari, 2010) intensively examine the influence of gender in their study and confirm that women are associated with higher costs. Chechulin et al. (Chechulin et al., 2014) further verify that good estimates of future costs can be made based on a person's age. Although pure predictive demographic models perform worse in terms of prognosis quality compared to models with clinical variables, they provide meaningful predictions for the small amount of information available. This allows for categorization at a time when no other information is given (Behnke, 2014). Other important indicators are clinical variables based on the ICD9 and ICD-10 diagnostic codes (Buhl et al., 2013). Cucciare and O'Donohue (Cucciare & O'Donohue, 2006) further suggest that predictions that include diagnoses show very accurate results. Here, certain chronic diseases, such as diabetes, chronic heart failure (CHF) and chronic obstructive pulmonary disease (COPD), should be studied separately, as these have a major impact on the resulting costs (Buhl et al., 2013). Hartmann et al. (Cunningham, 2017) identify accordingly that the metabolic system, especially diabetes, is a trigger for a high number of other diseases and may have long-term effects. Snider et al. (Li et al., 2016) support this finding by identifying obesity as an important indicator in their study. This is also related to the body mass index (BMI), sociodemographic variables and other comorbidities. Additionally, people who suffer from a CHF tend to become cost-intensive because they tend to use more healthcare resources of all kinds (Lenz, 2013). Li et al. (Li et al., 2016), define different levels of care, showing that patients with regular care needs are characterized, among other things, by COPD and asthma. In general, diseases can also be summarized in co-morbidity indices and incorporated into the modeling as a predictor (Rose, 2017). An example is the Charlson Comorbidity Index, which includes diagnoses based on ICD-10 codes (Leininger et al., 2015; Quan et al., 2005). Other relevant predictors include the self-assessment of one's own health status (Leininger et al., 2015; Quan et al., 2005), previous healthcare costs (Amin, Rahim, Ali, Khan, & Anwar, 2015; Hofmann & Klinkenberg, 2013), resource demands such as number of hospitalizations and number of visits (Buhl et al., 2013; Quan et al., 2005), and medication (Crawford Albert, Fuhr Joseph, & Hubbs Brandon, 2005; Rose, 2017). In the current study we built several models to predict all-cause 28-day readmission risk and included Socio-economic Indexes for Areas (SEIFA) data as proxies for socio-demographic determinants of health. Additionally, instead of using insurance claims data, which could require several weeks to process, we focussed on building our own models using data that is readily available during the inpatient stay or at the time of discharge, as the following presents.

METHODOLOGY

To address shortcomings in previous studies, several models were built to predict all-cause 28-day readmission risk and included Socio-economic Indexes for Areas (SEIFA) data as proxies for socio-demographic determinants of health. Additionally, instead of using insurance claims data, which could require several weeks to process, the presented models use data that is readily available during the inpatient stay or at the time of discharge.

One of the primary objectives of this study is to accurately predict, (ultimately) in real time, the risk of hospital readmission within 28 days of discharge. The following sections describe the underlying data constructions and assumptions that were built into our models.

Data Preparation

Before developing prediction models, the data set has to be cleaned and prepared. First, variables that have more than 90% missing values or have a constant value over all cases are excluded. Due to input errors in the data set, cases showing inconsistencies across multiple attributes are removed.

Dataset

The developed models of readmission risk utilised hospital activity, patient characteristics and clinical data, which were derived from six years of admitted patient episode care data, from fiscal year 2012-2013 through fiscal year 2017-2018. These datasets contained episode level information regarding hospital activity, patient characteristics, procedures performed and diagnoses. A separate dataset containing information regarding the specialist, including specialist identification, name and age, was also utilised to develop the model. Eight different SEIFA 2016 scores at a postal code level were incorporated as proxies for socio-demographic determinants of health. This initial dataset contained 202 variables across 926,778 episodes.

OUTCOME VARIABLE

A not for profit tertiary healthcare organisation counts readmissions at the episode level. For the purposes of this study, readmissions were considered for any patient that was readmitted under the following conditions:

- Readmission occurred within 1 to 28 whole days following discharge; and
- readmission occurred for a unique episode; and
- The readmission sequence was discarded.

Episodes were excluded from the outcome variable for the following reasons:

- Patients were readmitted at a rehabilitation facility; or
- Patients were readmitted at cancelled or hold wards; or
- Patients were readmitted with dialysis or oncology codes; or
- Patients were readmitted with same day mental health treatment; or
- Patients were readmitted with electroconvulsive therapy (ECT) treatment.

Of the 926,778 episodes in the initial dataset, 102,282 are identified as readmissions, which represents a readmission rate of 11.24%.

It is important to note that the readmission rate is not included in our model as the dependent (outcome) variable, as a readmission is the final consequence. Because our goal is to predict the risk of readmissions prior to the discharge on the first instance, we instead used the readmission index. The readmission index considers the admission immediately preceding the readmission episode, as quantifying the risks of readmissions prior to discharge from the initial episode can allow clinicians to identify patients who might benefit from more intensive pre-discharge care.

The readmission variable was calculated according to the formula described in the next section IV.1.2. Then the index readmission was derived and validated to predict the risk of readmissions within 28 days after discharge from this not for profit tertiary healthcare organisation.

Data Cleaning

To further refine the variables used in the model, we excluded or transformed factors based on the following reasons:

Unrelated Variables

An extensive consultation process was undertaken with the Clinical Outcomes and Analytics team, the Chair of Health Information Management for a not for profit tertiary healthcare organisation, and external consultants to determine the potential risk factors for readmissions. Empirical evidence suggested that the following variables do not have significant impacts on the risk that a particular patient will be readmitted to the hospital within 28 days of discharge: the division type, the care type, the number of noncertified days of stay, the number of private bed days, the conversion from outpatient to inpatient stays, the conversion from inpatient stays to outpatient stays, the rehabilitation episode type, death after discharge, fund diagnosis related group (DRG) version, hospital DRG version, principal Commonwealth Medicare Benefits Schedule (CMBS) date and principal CMBS banding.

Missing Feature Values

An important number of variables did not include complete records. Careful consideration of methods for dealing with missing data was performed, as failure to appropriately consider missing data can lead to biased results. Variables were generally treated with one of the following methods:

Elimination

When the missing data represented more than 10% of the total records, the variable was excluded from the modelling dataset. Eliminated variables included the following: unplanned admissions to the ICU, referred by doctor, referred by specialty doctor, referred by doctor at a clinical institute, referred to doctor, referred to specialty doctor, principal shared care doctor clinical institute, miscellaneous code 1, miscellaneous code 2, miscellaneous code 3, miscellaneous code 4, miscellaneous code 5, miscellaneous code 6, miscellaneous code 7, miscellaneous code 8, miscellaneous code 9, miscellaneous code 10, the Australian national subacute and non-acute patient (An-Snap) classification, Snap version, assessment only indicator, date of discharge plan, usual accommodation prior to admission, living arrangement prior to admission, employment status, existing comorbidity, emergency department treating doc 2, emergency department treating doc 3, emergency department treating doc 4, emergency department waiting, emergency department time, triage category, emergency department provisional dx code, emergency department provisional dx, discharge to usual accommodation, policy type and admission patient classification.

Mean Substitution

For continuous variables that contained a low percentage of missing variables, such as the age of the practitioner, the mean value was computed from available cases and was used to replace the missing data values for the remaining cases.

Method of treating missing feature values as special values

For categorical variables that contained a low percentage of missing variables, such as the insurer group model and SEIFA 2016 factors, the missing variables were treated as new values.

Inaccuracies

After careful quality inspection of the data, we eliminated the values of discharge age, readmission within 28 days, readmission days, readmission option, height and weight, as these variables were identified as having formulation problems, making their calculations inaccurate.

Descriptive data

While descriptive data is important for the team to understand the data, these variables were not important for modelling purposes and were therefore excluded: fund DRG description, CMBS description 1, CMBS description 2, CMBS description 3, CMBS description 4, CMBS description 5, CMBS description 6, CMBS description 7, CMBS description 8, CMBS description 9, CMBS description 10, principal diagnosis description, principal coding onset code description, diagnosis coding onset code description 2, diagnosis coding onset code description 3, diagnosis coding onset code description 4, diagnosis coding onset code description 5, diagnosis coding onset code description 6, diagnosis coding onset code description 7, diagnosis coding onset code description 8, diagnosis coding onset code description 9, diagnosis coding onset code description 10, and principal procedure description.

Insurance claim data

Our primary objective is to develop a model that can be employed in hospital settings to support data-driven discharge interventions to mitigate the risks of hospital readmissions. Thus, we excluded insurance claims data, which could take several weeks to process, as our models requires data that is available during the inpatient stay or at the time of discharge. The variables that fall into this category are the following: fund DRG code, principal diagnosis code, diagnosis code 2, diagnosis code 3, diagnosis code 4, diagnosis code 5, diagnosis code 6, diagnosis code 7, diagnosis code 8, diagnosis code 9, diagnosis code 10, principal procedure code, procedure code 2, procedure code 3, procedure code 4, procedure code 5, procedure code 6, procedure code 7, procedure code 8, procedure code 9, and procedure code 10.

Redundant data

The following variables overlap with other relevant factors and were therefore excluded: discharge destination, Local Government Areas (LGA) code, discharge patient classification, ICU hours, discharge doctor clinical institute, reference to doctor clinical institute, principal procedural doctor clinical institute, CMBS code 2, CMBS code 3, CMBS code 4, CMBS code 5, CMBS code 6, CMBS code 7, CMBS code 8, CMBS code 9, and CMBS code 10.

Feature construction/Transformation

Based on our previous experience, the discovery of meaningful features contributes to a better understanding of the underlying causes of readmissions. Thus, after another extensive consultation process with the Clinical Outcomes and Analytics team, the Chair of Health Information Management for a not for profit tertiary healthcare organisation and external consultants, the following features were derived and/or transformed: admission patient, insurer identifier grouping, marital status, language, age of admitting doctor, age of discharge doctor, age of procedural doctor, age of anaesthetic doctor, indicator of emergency admission, number of emergency procedures, number of procedure codes used, admission month, admission year, discharge year, discharge month, patient age at discharge, number of previous admissions, and number of previous readmissions within 180 days.

Normalization

As part of our normalization process, we performed discretization on some continuous variables, such as previous readmissions within 180 days. We also attempted to normalize the remaining continuous variables; however, this approach did not improve modelling performance. Therefore, we did not normalize continuous variables in the final dataset.

De-Identification

A crypto-graphical hash function was applied to the following sensitive variables: patient identification, episode identification, insurer group, doctor identification, and patient date of birth. The variables were internally serialized, and we implemented a cyclic redundancy check (CRC) hash function algorithm to compute a compact digest of the serialized object.

PATIENTS

To develop a robust risk prediction model, a number of records were removed based on characteristics related to the episode of care. These records were removed to ensure that their inclusion in the modelling dataset did not reduce the robustness of the risk prediction model. These trimmed records generally fell into one of three categories.

The first category included episodes that were considered to be outliers, as their inclusion would disproportionately skew the risk prediction model. These episodes included the following:

- The number of wards for patients that had visited more than four wards;
- The number of anaesthetic doctors for patients with more than three anaesthetic doctors;
- Patients with negative lengths of stay or lengths of stay greater than 41 days for a single episode;
- Patients that spent more than 300 minutes in the operating theatre;
- Patients that visited more than 7 operating theatres for a single episode;
- Patients over 100 years old; and
- Patients that have visited A not for profit tertiary healthcare organisation more than 95 times.

The total number of episodes considered to be outliers represented 5% of the dataset.

The second category included episodes that were removed on the advice of the Clinical Outcomes and Analytics team, as having admission characteristics could not lead to readmission or being generally unrepresentative for the purposes of determining the probability of readmission. This category included the following:

- Episodes related to rehabilitation health admissions in Brighton, Richmond and the Transitional Living Centre.

The final category was related to decisions regarding which episodes were considered out-of-scope or not representative of the patient population. These episodes were trimmed if they included the following characteristics:

- Duplicate episodes; and
- Intersex or indeterminate patients (2 patients in the whole dataset).

MODELLING

Feature Selection

Feature subset selection is the process of identifying and removing variables that do not have significant impacts on the risk of a particular patient being readmitted to the hospital within 28 days of discharge. We conducted a univariate logistic regression to identify relevant variables.

Univariate Variable Selection

This step identified the top-ranked attributes. For categorical variables, the significance of the correlation between each variable and the index readmission was determined using the likelihood ratio test (LRT), using the p values of the fitted logistic regression. In addition, the prevalence, the chi-squared test and the odds ratio were also considered. For continuous variables, the significants of the correlation between each variable and the readmission outcome index was determined using the LRT, using the p values of the fitted logistic regression. In addition, the odds ratio was considered. For all variables, the response factor was the index readmission, and the explanatory factor was the tested variable. Attributes with significance levels of p<0.01 in the univariate analyses were retained for further analyses. In addition, all factors and conditions with prevalence values of less than 1% within the population of patients were excluded from further analyses. The following features were excluded at this stage: ICU days, language v1, language v2, discharge method, admission shift, urgency of admission, discharge month, admission month, discharge day, unplanned theatre visit during episode, admission day, robot use and same-day or overnight stay indicator.

At this stage, the socioeconomic attribute (Decile Index of Relative Socio-economic Advantage and Disadvantage (IRSAD) that most correlated with the index readmission outcome was selected among the following eight variables: Rank IRSAD, Rank Index of Education and Occupation (IEO), Rank Index of Relative Socio-economic Disadvantage (IRSD), Rank Index of Economic Resources (IER), Decile IRSAD, Decile IEO, Decile IRSD and Decile IER, based on the lowest univariate AIC value.

In addition, the Clinical Outcomes and Analytics team confirmed that some values related to the insurer group could be further grouped together.

Correlated Variables

Correlation coefficients were obtained among all of the continuous variables A consultation process with the Clinical Outcomes and Analytics team was undertaken to select the most representative variables among heavily correlated variables (<0.30).

- The total number of beds and the total number of wards exhibited a correlation of 0.83. The total number of wards was selected.
- The total number of anaesthetic doctors and the total number of procedure doctors exhibited a correlation of 0.38. The total number of anaesthetic doctors was selected.
- The length of stay and the total number of procedure doctors exhibited a correlation of 0.31. The length of stay was selected.
- The total number of procedures codes and the total number of procedure doctors exhibited a correlation of 0.78. The total number of procedures codes was selected.
- The length of stay and the total number of beds exhibit a correlation of 0.30. The length of stay was selected.
- The admitting doctor age and the discharge doctor age exhibit a correlation of 0.99. The discharge doctor age was selected.

Variables related to the admitting doctor and the discharge doctor were heavily correlated; thus, it was decided that variables related to the discharge doctor should be retained for further analyses.

Training, Testing and Validation Datasets

A training dataset composed of 80% of the total sample was used to train the models. A validation dataset composed of 20% of the total sample data was used for the unbiased evaluation of suitable models. A testing dataset composed of 10% of the total sample data was used to provide an unbiased evaluation of a final model fit to ensure that the model did not overfit the data.

We ensured that the three datasets followed the same probability distributions among key variables, such as the index readmission.

Unbalance Dataset

For machine learning problems, differences in prior class probabilities and class imbalances have been reported to hinder the performance of classification algorithms. To account for these potential issues, we tested several re-sampling techniques, such as under-sampling the majority (normal) class, over-sampling the minority (abnormal) class, random over-sampling examples (ROSE), and synthetic minority oversampling (SMOTE), which have previously been proposed to address class imbalance problems, and compared their effectiveness. The performance of these techniques was measure by the receiver operating characteristic curve (ROC) method. In previous studies, the results obtained by using similar methods on artificial domains have been linked to the results obtained in real-world domains.

Classification Algorithms

Initially, we experimented with several classic and modern classifiers, including logistic regression, elastic net and random forests. In each case, a 5-fold cross validation was performed.

DISCUSSION AND CONCLUSION

This exploratory study served to identify key steps when analysing large healthcare data sets including: defining the index, managing imbalanced data using various techniques and yet achieving a reasonable ROC and assessing various classification algorithms. Crucial insights include the need to focus on index so as to assess ahead of time likelihood of readmission, gender did not play a key role but being alone at home did appear to have an impact. There were also aspects that might be addressed due to more focussed patient education in some procedures so that bleeding/pain does not automatically mean the need to return to hospital or the emergency department.

While it is exploratory in nature, this study has several contributions to both theory and practice. As noted above we have been able to provide insights into strategies to adopt in order to develop reasonably reliable predictive models using unbalanced data as well as assess the merits of different classification algorithms in the context of data analytics in healthcare. From the perspective of practice, given that today private healthcare organisations in Australia are facing increasing pressures around reducing unplanned readmissions, a necessary first step is to be able to develop robust strategies to best predict likely readmissions at the time of the initial admission and then implement appropriate risk mitigation strategies to avoid the likely unplanned readmissions. Our results have enabled us to progress with this approach for the specific healthcare organisations data and patient population; however, we believe are findings have wider implications and benefits given the move to value-based care in many healthcare systems globally and thereby the need to manage problematic unplanned readmissions in a systematic and critical fashion. To date, while the need for data analysis, machine learning and deep leaning in the context of healthcare is recognised as important, key findings, algorithms, models and solutions are still not well developed. This study has served to try to assist in this regard. The developed models will now be tested in a large not for profit tertiary healthcare organisation to assess their predictive powers.

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REFERENCES

Amin, A., Rahim, F., Ali, I., Khan, C., & Anwar, S. (2015). *A comparison of two oversampling techniques (smote vs mtdf) for handling class imbalance problem: A case study of customer churn prediction. In New Contributions in Information Systems and Technologies* (pp. 215–225). Springer.

Behnke, J. (2014). *Logistische Regressionsanalyse: Eine Einführung*. Springer-Verlag.

Bertakis, K. D., & Azari, R. (2010). Patient gender differences in the prediction of medical expenditures. *Journal of Women's Health*, *19*(10), 1925–1932. doi:10.1089/jwh.2009.1448 PMID:20831429

Bertsimas, D., Bjarnadóttir, M. V., Kane, M. A., Kryder, J. C., Pandey, R., Vempala, S., & Wang, G. (2008). Algorithmic prediction of health-care costs. *Operations Research*, *56*(6), 1382–1392. doi:10.1287/opre.1080.0619

Blumenthal, D., Chernof, B., Fulmer, T., Lumpkin, J., & Selberg, J. (2016). Caring for high-need, high-cost patients—An urgent priority. *The New England Journal of Medicine*, *375*(10), 909–911. doi:10.1056/NEJMp1608511 PMID:27602661

Buhl, H. U., Röglinger, M., Moser, F., & Heidemann, J. (2013). *Big data*. Springer.

Chechulin, Y., Nazerian, A., Rais, S., & Malikov, K. (2014). Predicting patients with high risk of becoming high-cost healthcare users in Ontario (Canada). *Healthcare Policy*, *9*(3), 68. PMID:24726075

Crawford Albert, G., Fuhr Joseph, P., & Hubbs Brandon, O. (2005). *Comparative Effectiveness of Total Population versus Disease-Specific Neural Network Models in Predicting Medical Costs*. Department of Health Policy of Jefferson Medical College.

Cucciare, M. A., & O'Donohue, W. (2006). Predicting future healthcare costs: How well does risk-adjustment work? *Journal of Health Organization and Management*, *20*(2), 150–162. doi:10.1108/14777260610661547 PMID:16869351

Cunningham, P. J. (2017). Predicting high-cost privately insured patients based on self-reported health and utilization data. *The American Journal of Managed Care*, *23*(7), e215–e222. PMID:28850789

Fleishman, J. A., & Cohen, J. W. (2010). Using information on clinical conditions to predict high-cost patients. *Health Services Research*, *45*(2), 532–552. doi:10.1111/j.1475-6773.2009.01080.x PMID:20132341

Hartmann, J., Jacobs, S., Eberhard, S., von Lengerke, T., & Amelung, V. (2016). Analysing predictors for future high-cost patients using German SHI data to identify starting points for prevention. *European Journal of Public Health*, *26*(4), 549–555. doi:10.1093/eurpub/ckv248 PMID:26850904

Hofmann, M., & Klinkenberg, R. (2013). *RapidMiner: Data mining use cases and business analytics applications*. CRC Press.

Kleinwechter, H., Schäfer-Graf, U., Bührer, C., Hoesli, I., Kainer, F., & Kautzky-Willer, A. (2011). *Gestationsdiabetes mellitus (GDM). Evidenzbasierte Leitlinie zu Diagnostik, Therapie u. Nachsorge der Deutschen Diabetes-Gesellschaft (DDG) und der Deutschen Gesellschaft für Gynäkologie und Geburtshilfe (DGGG).* Retrieved from www. deutsche-diabetes-gesellschaft. de

Koukouvinos, K. D. C. (2016). Proximal support vector machine techniques on medical prediction outcome. *Journal of Applied Statistics*, *44*(3), 533–553.

Leininger, L. J., Saloner, B., & Wherry, L. R. (2015). Predicting high-cost pediatric patients: Derivation and validation of a population-based model. *Medical Care*, *53*(8), 729–735. doi:10.1097/MLR.0000000000000391 PMID:26172939

Lenz, R. M. M. a. H.-J. (2013). *Business Intelligence*. Berlin: eXamen Press, Springer Vieweg.

Li, B., Cairns, J., Fotheringham, J., Ravanan, R., & Group, A. S. (2016). Predicting hospital costs for patients receiving renal replacement therapy to inform an economic evaluation. *The European Journal of Health Economics*, *17*(6), 659–668. doi:10.100710198-015-0705-x PMID:26153418

Moturu, S. T., Johnson, W. G., & Liu, H. (2007). *Predicting future high-cost patients: A real-world risk modeling application.* Paper presented at the 2007 IEEE International Conference on Bioinformatics and Biomedicine (BIBM 2007). 10.1109/BIBM.2007.54

Murray, C. J., Lopez, A. D., & Organization, W. H. (1996). *The global burden of disease: a comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020: summary*. Academic Press.

Quan, H., Sundararajan, V., Halfon, P., Fong, A., Burnand, B., Luthi, J.-C., ... Ghali, W. A. (2005). Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. *Medical Care*, *43*(11), 1130–1139. doi:10.1097/01.mlr.0000182534.19832.83 PMID:16224307

Rodriguez, S., Munevar, D., Delaney, C., Yang, L., & Tumlinson, A. (2014). *Effective management of high-risk medicare populations*. Washington, DC: Avalere Health LLC.

Rose, A. J. (2017). Targeted approaches to improve outcomes for highest-cost patients. *Israel Journal of Health Policy Research*, *6*(1), 25. doi:10.118613584-017-0151-6 PMID:28593037

Sherman, H. D. (1984). Hospital efficiency measurement and evaluation: Empirical test of a new technique. *Medical Care*, *22*(10), 922–938. doi:10.1097/00005650-198410000-00005 PMID:6436590

Snider, J. T., Bognar, K., Globe, D., Ng-Mak, D., Sullivan, J., Summers, N., & Goldman, D. (2014). Identifying patients at risk for high medical costs and good candidates for obesity intervention. *American Journal of Health Promotion*, *28*(4), 218–227. doi:10.4278/ajhp.121116-QUAN-561 PMID:24359175

Chapter 23
Using Intelligent Tools to Support Clinical Decision Making:
The Case of Hip and Knee Arthroplasty

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ABSTRACT

Intelligent tools and collaborative systems can be used in healthcare contexts to support clinical decision making. Such an approach is concerned with identifying the way in which information is gathered and decisions are made along specific care pathways. This study develops a real-time collaborative system using an intelligent risk detection model (IRD) to improve decision efficiency in the clinical case of patients undergoing hip or knee arthroplasty. The benefits of adopting this improved clinical decision-making solution include increasing awareness, supporting communication, improving the decision making process for patients and caregivers while also improving information sharing between surgeons as key collaborative parties in the research case. This in turn leads to higher levels of patient and clinical satisfaction and better clinical outcomes.

INTRODUCTION

Leading healthcare organizations are recognizing the need to incorporate the power of a decision efficiency approach, driven by intelligent solutions (N 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 increas-

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Table 1. The Key Objectives

Objective	Description
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. Ideally this includes risk identification preop, periop and postop.
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. In addition patient reported outcomes will be considered.
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.

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

This paper directly examines the benefits of an Intelligent Risk Detection (IRD) Model (F. Moghimi, Wickramasinghe, & Zadeh, 2011; H. 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?

Table 1 below lists the key objectives of this study.

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.

Hip and Knee Arthroplasty

By 2030, the number of total hip arthroplasty (THA) and total knee arthroplasty (TKA) performed annually in the United States is projected to exceed 500,000 (Kurtz, Ong, Lau, Mowat, & Halpern, 2007). Most patients undergoing TKA are older; the mean age at surgery was reported to be 70 years (Smith, Blake, & Hing, 2011) while in terms of THA, 40% increased risk for complications after the surgery is noted for every decade above the age of 65 years (Keener et al., 2003).

Numerous studies state that detecting pre and post operation risk factors (Wetters et al., 2013), estimating the quality of life (Arenaza, 2009; Bruyère et al., 2012) and planning relevant wellness services (Stevens, Reininga, Bulstra, Wagenmakers, & van den Akker-Scheek, 2012; Wagenmakers et al., 2011), may impact morbidity rates after THA and TKA.

Post-surgical indications for THA and TKA are guided by pain, functional impairment, physical examination, and radiographic imaging (Philippon, Briggs, Yen, & Kuppersmith, 2009). However, an initial course of conservative therapy should always be monitored and attempted with analgesia, activity modification, ambulatory aids, and weight loss (Hunter & Lo, 2008). Also, regular post-operative assessment of patient and implant outcomes is necessary to monitor long-term patient satisfaction, results of surgical techniques and also patient perceptions (Carr et al., 2012; Dorr et al., 2010; Westby & Backman, 2010).

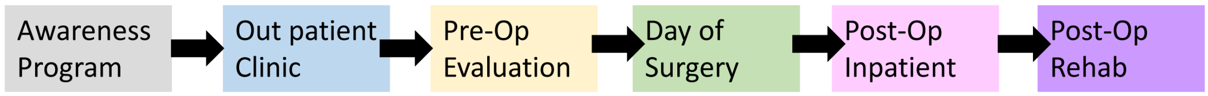
The other important risk factor that should be detected after the surgery is infection. Most infections related to the surgery occur within two years of the initial surgery (Urquhart et al., 2010) and are related to the implanted prosthesis (Jämsen et al., 2010; Senneville et al., 2011). Patient risk factors for deep post-operative infection include previous surgery of the joint, rheumatoid and inflammatory arthritis, corticosteroid therapy, poorly controlled diabetes mellitus, poor nutritional state, obesity and advanced age (Lau, Bozic, Berry, & Parvizi, 2010; Senneville et al., 2011; Wright, 2013).

In general, total hip and total knee arthroplasty surgeries are successful and are performed frequently, especially for people experiencing pain associated with degenerative joints (Katz et al., 2004). However, there are different types of partial hip and knee arthroplasties that are more complex and involve additional operative risk factors such as early revision. Since, these risk factors can contribute to a decrease in the patient's quality of life (Dijkman, Kooistra, Ferguson, & Bhandari, 2008), regular assessment and risk detection processes are of significant importance for post hip and knee arthroplasty. Additionally, hip and knee implants and operative procedures are undergoing a relatively rapid rate of innovation and improved technology with unknown outcomes that should be monitored effectively (Nilmini Wickramasinghe, Bali, Choi, & Schaffer, 2009).

Benefits of Using IRD as a Collaborative Solution for Hip and Knee Arthroplasty

Decision-making regarding the treatment and surgery for patients undergoing hip and knee arthroplasty can be especially multi-faceted and complex, including for example the clinical condition of the patients, their age and body mass index (Karlson et al., 2003). The decision to embark upon orthopaedic treatments with either drugs, or surgery, or a combination of both depends on a large number of factors (Roy & Brunton, 2008). Hence, applying the IRD Model to detect surgical risk factors prior to the surgery and better predict the surgery outcomes based on these risk factors is postulated to be an effective and efficient to improve surgery outcomes.

Figure 1. Orthopaedic Continuum of Care Process. Adapted from (Bali, Wickramasinghe, & Lehaney, 2009



The decision making process in the context of THA and TKA can be divided into six broad phases (figure 1). Phase 1 and phase 2, awareness programs and outpatient orthopaedic clinical environment are varied in different hospitals. In the third phase, or pre-operation optimization and evaluation phase, the surgeon, having received much information about the patient and their associated medical conditions, needs to make a decision relating to whether surgery is in fact the best treatment option. Once patients and surgeons have agreed to proceed with surgery, in phase four, ad-hoc decisions pertaining to the unique situations that may arise during the surgery must be addressed. In the post operative phase, or phase five, decision making is primarily done at two levels;

1. Assessing relevant clinical factors to ensure a sustained successful result for the patient during aftercare and beyond,
2. Developing and modifying an initial plan for post-operative treatment through rehab programs.

The IRD Framework can be applied in each of these six phases. The benefits of using the IRD Framework by surgeons, as a real-time collaborative tool, are summarized as follows:

- ***Increasing awareness:*** by early assessment that can help inform patients and lead to detection of operative and post-operative risk factors
- ***Improving decision making process:*** by building a common understanding of operative risks and possible outcomes between caregivers and patients.
- ***Reducing costs:*** by optimizing costs and the time towards collaborative decision making while avoiding untoward events and additional operative procedures
- ***Improving information sharing:*** by providing a large set of information as inputs
- ***Supporting communication:*** by enabling communication between caregivers and with patients regarding logistics and the care process; all of which can help avoid complications. Moreover, having the data organized and classified can assist the systematic assessment of clinical processes and outcomes especially when evaluating permutations to protocols.

Conceptual Framework

In order to develop the IRD Model, it is necessary to present the supporting conceptual framework of the decision making stages and risk assessment (figure 2). The left-most block in figure 2 depicts the first stage of risk assessment. The output of the risk assessment process will help in determining important surgery risk factors and will also assist in predicting outcomes (in risk detection block) based on the specific risk factors. The predicted results enable the surgeons to then make better informed decisions regarding whether (or not) to proceed with the surgery in the first phase, to be followed by a second and third surgical phase.

Figure 2 Conceptual Framework

If the decision is indeed to proceed with the surgery, all relevant information then needs to be passed on to the patients/parents, in pre-operative phase, in order to allow them to make their final decision regarding the surgery. Depending on their decision there will be a move to a second phase of surgery, or the process will be concluded. Any such conflicts become feedback into the system for future risk assessments for the same or other similar patient conditions.

Methodology and Research Design

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 a 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 research 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 2 maps the application of DSRM to the proposed decision-support solution.

Problem-Centered Approach

The lack of appropriate and clinically developed computerized decision support systems in the context of hip and knee arthroplasty is an obvious void in the current use of information technology for healthcare. With the increasing number of these surgeries, providing decision support to surgeons based on well-organized and categorized risk factors is expected to be highly beneficial, both clinically and financially.

Design Data Collection and Analysis

After identifying the research problem and the objective of the planned artifact, collecting the required data launches the start of Activity 3: Design and Development. To do so, an online survey was designed to target 58 clinically active and busy arthroplasty surgeons at one of the biggest private hospitals in Melbourne with specific questions regarding THA and TKA. 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:

Table 2. Mapping DSRM (Peffers et al., 2007) to IRD proposed system

DSRM Activity	Activity description	Application on this study
Problem identification and motivation	Defining the specific research problem and justifying the value of a solution based on knowledge of the state of the problem.	With the increasing number of TKA and THA surgeries, and diversity of emerging risk factors, the lack of computerised decision support system is vital and key for better outcomes.
Definition of objectives of the solution	The objectives can be qualitative or quantitative i.e. create or improve an artifact respectively based on knowledge of the state of the problem and current solutions, if any, and their efficacy.	The objective is qualitative, as this research aims to CREATE an artifact to reduce the burden of THA and TKA, improve the treatment and management of these surgeries, gain better understanding of the consequences of THA and TKA, and to develop preventative measures to reduce complications or suboptimal results with THA and TKA.
Design and development	Creating the artifact, including the desired functionality and its architecture based on the knowledge of theory that can be used to apply in developing a solution.	The artifact is to be designed to estimate risk factors for each patient according to their individual conditions. Prior to the planned surgery, a surgeon and their medical team would have developed better understanding of the risk factors. To do so, a precise data collection process has taken place to categorise possible risk factor.
Demonstration	Demonstrate the use of the artifact to solve the problem.	The artifact is to be tested and tried, and then in-depth analysis will be performed to measure the level to which the proposed system helps solve the problem.
Evaluation	Iterate back to better design the artifact if needed.	As needed, iteration back will take place, based on in-depth analysis to identify rooms of improvement.
Communication	Publish and let the value of the solution talk about itself.	Conference publications and other presentation activities to develop the project further.

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 and final response rate was 76%. During the intervening period, preparations were made for the second round of data collection by organizing a focus group to gain an in-depth evaluation of the responses. This focus group was held two weeks after closing the online survey and included four senior arthroplasty surgeons who were expected to provide further details on the responses.

For data analysis of the online survey, IBM SPSS Statistics 21 (IBM, New York) and the integrated data analysis tool within SurveyGizmo (SurveyGizmo, Colorado) were used to analyze the online survey. The data coding from the focus group was analyzed using NVivo (QSR International, Melbourne, Australia). These analyses were expected to assist in the design and development of the prototype computerized decision support solution.

Design Results

The results to date can be examined under specific categories as follows:

Table 3. Results on device related risk factors

Risk Factor	Percentage of respondents indicating Yes	Estimate risk level (Out of 5)	
Type of prosthesis	86%	2	44%
Correct sizing of components	72%	2 – 4	29%
THA Femoral head size	66%	3	42%
Cementless fixation	55%	3	50%
Cemented fixation (THA)	55%	1	38%

- **Grouping Risk Factors**

The first action is to categorise the risk factors into broad groupings. Ideally, these groupings are mutually exclusive and collectively exhaustive. The following comprised 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 for THA, experience of surgeon, and volume of cases).
3. Patient factors (demographics, age, mobility, BMI, ASA, educational, socioeconomic factors).
4. Co-morbidities.
5. Process issues (time out, antibiotics, DVT prophylaxis, theatre where operation performed).

The respondents were asked to say if they agreed or disagreed with this grouping. 96.6% of the respondents agreed while 3.3% disagreed. During the focus group, the participants provided further clarification and agreement with the minor modification of changing "process Issues" to "process logistics" to provide a more global connotation.

- **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 3 shows the results:

- **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 come from the online survey administered to all surgeons to complete are in Table 4.

These results initiated extensive discussions between the surgeons during the focus group. In summary, the participants suggested keeping "volume of cases" 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

Table 4. results on surgeon's related risk factors

Risk Factor	Percentage	Estimate risk level (Out of 5)	
Volume of cases	75%	3	52%
Surgeon experience	71%	3	40%
THA Approach	55%	Lateral: 2 Posterior: 2 Anterior: 3	38% 50% 31%

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 and comorbidities were also identified as major risk categories affecting surgical outcomes. The respondents were asked to opine whether or not they agree with the proposed risk factors and to estimate the risk level of each of them. Patient's factors and comorbidities included age, gender and ethnicity as well as obesity, diabetes, cardiac conditions and use of blood thinning anticoagulation medications.

During the focus group, "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 participants agreed that obesity and diabetes represented major risk factors. Psychological health of patients was raised as an issue during the discussions, and the surgeons suggested capturing that by analysing 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 6 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 disposition (whether the patient is going to a ward, home, or rehabilitation, etc.).

Based on the previous results, and aligning with the DSRM model, 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 arthroplasty surgeons will be invited to participate in Activity 4: Demonstration, where this research intends to trial this software and provide decision support. Case study methodology will be used in this stage and sufficient proof will be sought to permit the next step Activity 5: Evaluation.

Table 5. Results on process issues

Risk Factor	Percentage	Estimate risk level (Out of 5)	
Appropriate administration and timing of antibiotics	68%	3	26%
DVT prophylaxis	68%	2 – 3	32%
Theatre where operation performed	64%	2	56%
Time out being documented	64%	1 – 2	31%

DISCUSSION

This study attempts to explore the potential of today's intelligent tools to facilitate better healthcare and better healthcare outcomes. The first phase of the research, presented in this paper, has revealed findings that identify relevant risk groups and risk factors that are significant for patients undergoing hip or knee arthroplasty procedures while also assessing the design and development of a prototype IRD solution.

The major contributions of this study to practice include: 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.

Furthermore, this study has contributed to theory and the body of knowledge by proving the importance of Design Science Research Methodology for a clinical context; i.e., hip and knee arthroplasty. In addition, this study contributes to the importance of knowledge discovery, clinical decision support systems, and risk detection in developing and designing a collaborative decision support solutions for healthcare contexts. Given the current challenges facing healthcare today this is particularly germane.

Of the hospital clinicians who were participants in the study on-line survey and focus group, all indicated an intention to use IRD to detect surgical risk factors and to predict surgical outcomes more accurately. The participants also commented and believed that the IRD model 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 divergent views regarding these items. "Patient's Factors and Co-morbidities" were the issues that provided the most common risk topic for discussion between participants. For example, one of participants raised the issue of patient's mental health as an important risk factor, to be placed in the "Patient's Factors and Co-morbidities" group. In this regards, the other participants opined that capturing psychological issues is not easy; however, it might be possible by reviewing at the patient's medication. There are other instruments that could also be considered. Hence, we inserted the "psychological health", as a risk factor as well. Moreover, "Prior Hip and Knee Surgery" also was proposed as a risk factor within this group.

"Process Issues" also generated significant discussion in the expert focus group. Surgeons proposed the alternative term "Process Logistics" for this risk group and proposed that that discharge status, design of the operating theatre (single bed, double bed) and duration of operation are other important risk factors that should be included under "Process Logistics" and in the prototype.

The findings from this study become more relevant during the transition to a value based healthcare system and a bundled payment model with well-defined care paths that dictate specific care processes

(Porter and Teisberg, 2009). Specifically, a value driven bundled payment system focuses on six key enablers: 1. Organising around an integrated practice unit, 2. Measuring outcomes and costs for every patient, 3. Moving to a bundled payment system for care cycles, 4. Integrating care delivery across separate facilities, 5. Expanding excellent services geographically and 6. Having an enabling IT platform (Kaplan & Porter, 2011; ME. Porter, 2010; M Porter & Teisberg, 2014; M. E. Porter & Lee, 2013). Given that a critical success factor of this approach is the ability to measure risk and outcomes our model could therefore make an invaluable contribution.

CONCLUSION

The management of long term clinical conditions in pre- and post-operative processes normally requires close collaboration between care providers. The IRD solution proposed aims to support 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 specifically for patients undergoing a hip or knee arthroplasty procedure?" The hip and knee arthroplasty clinical experts involved in this study uniformly agreed that this approach could be very useful and beneficial to optimize clinical decisions and patient outcomes.

This study presents initial data from research in progress that seeks to enable better clinical decision making especially around risk detection and mitigation using intelligent tools and collaborative systems. Our initial findings indicate that this is likely to have far reaching implications and benefits especially in a value based care model that uses bundled payments. Next steps for this research include the testing and validation of the proffered IRD solution. There is little doubt that better risk detection and consequent mitigation will lead to better clinical and patient reported outcomes, higher clinician and patient satisfaction and higher value in care delivery.

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REFERENCES

Arenaza, J. C. (2009). Predictors of health-related quality-of-life change after total hip arthroplasty. *Clinical Orthopaedics and Related Research*, *467*(11), 2886–2894. doi:10.100711999-009-0868-9 PMID:19412646

Bali, R. K., Wickramasinghe, N., & Lehaney, B. (2009). *Knowledge management primer*. Routledge. doi:10.4324/9780203894712

Bruyère, O., Ethgen, O., Neuprez, A., Zégels, B., Gillet, P., Huskin, J.-P., & Reginster, J.-Y. (2012). Health-related quality of life after total knee or hip replacement for osteoarthritis: A 7-year prospective study. *Archives of Orthopaedic and Trauma Surgery*, *132*(11), 1583–1587. doi:10.100700402-012-1583-7 PMID:22842917

Carr, A. J., Robertsson, O., Graves, S., Price, A. J., Arden, N. K., Judge, A., & Beard, D. J. (2012). Knee replacement. *Lancet*, *379*(9823), 1331–1340. doi:10.1016/S0140-6736(11)60752-6 PMID:22398175

Dijkman, B., Kooistra, B., Ferguson, T., & Bhandari, M. (2008). Decision making open reduction/internal fixation versus arthroplasty for femoral neck fractures. *Techniques Orthopediques*, *23*(4), 288–295. doi:10.1097/BTO.0b013e318196fb53

Dorr, L. D., Thomas, D. J., Zhu, J., Dastane, M., Chao, L., & Long, W. T. (2010). Outpatient total hip arthroplasty. *The Journal of Arthroplasty*, *25*(4), 501–506. doi:10.1016/j.arth.2009.06.005 PMID:19640672

Gibbons, M. C., Bali, R. K., & Wickramasinghe, N. (2010). *Perspectives of knowledge management in urban health* (Vol. 1). Springer. doi:10.1007/978-1-4419-5644-6

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. *Management Information Systems Quarterly*, *28*(1), 75–105. doi:10.2307/25148625

Hunter, D. J., & Lo, G. H. (2008). The management of osteoarthritis: An overview and call to appropriate conservative treatment. *Rheumatic Diseases Clinics of North America*, *34*(3), 689–712. doi:10.1016/j.rdc.2008.05.008 PMID:18687278

Jämsen, E., Varonen, M., Huhtala, H., Lehto, M. U., Lumio, J., Konttinen, Y. T., & Moilanen, T. (2010). Incidence of prosthetic joint infections after primary knee arthroplasty. *The Journal of Arthroplasty*, *25*(1), 87–92. doi:10.1016/j.arth.2008.10.013 PMID:19056210

Kaplan, R. S., & Porter, M. E. (2011). How to solve the cost crisis in health care. *Harvard Business Review*, *89*(9), 46–52. PMID:21939127

Karlson, E. W., Mandl, L. A., Aweh, G. N., Sangha, O., Liang, M. H., & Grodstein, F. (2003). Total hip replacement due to osteoarthritis: The importance of age, obesity, and other modifiable risk factors. *The American Journal of Medicine*, *114*(2), 93–98. doi:10.1016/S0002-9343(02)01447-X PMID:12586227

Katz, J. N., Barrett, J., Mahomed, N. N., Baron, J. A., Wright, R. J., & Losina, E. (2004). Association Between Hospital and Surgeon Procedure Volume and the Outcomes of Total Knee Replacement. *The Journal of Bone and Joint Surgery (American)*, *86*(9), 1909–1916. doi:10.2106/00004623-200409000-00008 PMID:15342752

Keener, J. D., Callaghan, J. J., Goetz, D. D., Pederson, D. R., Sullivan, P. M., & Johnston, R. C. (2003). Twenty-five-Year Results After Charnley Total Hip Arthroplasty in Patients Less than Fifty Years Old A Concise Follow-up of a Previous Report*. *The Journal of Bone & Joint Surgery*, *85*(6), 1066–1072. doi:10.2106/00004623-200306000-00013 PMID:12784004

Kurtz, S., Ong, K., Lau, E., Mowat, F., & Halpern, M. (2007). Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. *The Journal of Bone & Joint Surgery*, *89*(4), 780–785. PMID:17403800

Lau, E., Bozic, K. J., Berry, D., & Parvizi, J. (2010). Prosthetic joint infection risk after TKA in the Medicare population. *Clinical Orthopaedics and Related Research*, *468*(1), 52–56. doi:10.100711999-009-1013-5 PMID:19669386

Moghimi, F., Wickramasinghe, N., & Zadeh, H. S. (2011). *An Intelligence Risk Detection Framework to Improve Decision Efficiency in Healthcare Contexts: The Example of Pediatric Congenital Heart Disease.* Paper presented at the System Sciences (HICSS), 2011 44th Hawaii International Conference on. 10.1109/HICSS.2011.58

Moghimi, H., Zadeh, H., Schaffer, J., & Wickramasinghe, N. (2012). Incorporating intelligent risk detection to enable superior decision support: The example of orthopaedic surgeries. *Health and Technology*, *2*(1), 33–41. doi:10.100712553-011-0014-z

Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A design science research methodology for information systems research. *Journal of Management Information Systems*, *24*(3), 45–77. doi:10.2753/MIS0742-1222240302

Philippon, M., Briggs, K., Yen, Y.-M., & Kuppersmith, D. (2009). Outcomes following hip arthroscopy for femoroacetabular impingement with associated chondrolabral dysfunction MINIMUM TWO-YEAR FOLLOW-UP. *The Journal of Bone and Joint Surgery. British Volume*, *91*(1), 16–23. doi:10.1302/0301-620X.91B1.21329 PMID:19091999

Porter, M. (2010). What Is Value in Health Care? *The New England Journal of Medicine*, *364*(13). doi:10.1056/NEJMc1101108 PMID:21142528

Porter, M., & Teisberg, E. (2014, June). Redefining Competition in Health Care. *Harvard Business Review*, 64-78.

Porter, M. E., & Lee, T. H. (2013). The strategy that will fix health care. *Harvard Business Review*, *91*(10), 1–19.

Pulakkazhy, S., & Balan, R. (2013). Data Mining in Banking and Its Applications-A Review. *Journal of Computational Science*, *9*(10), 1252–1259. doi:10.3844/jcssp.2013.1252.1259

Roy, C. B., & Brunton, S. (2008). Managing multiple cardiovascular risk factors. *The Journal of Family Practice, 57*(3), 13-20.

Senneville, E., Joulie, D., Legout, L., Valette, M., Dezèque, H., Beltrand, E., ... Caillaux, M. (2011). Outcome and predictors of treatment failure in total hip/knee prosthetic joint infections due to Staphylococcus aureus. *Clinical Infectious Diseases*, *53*(4), 334–340. doi:10.1093/cid/cir402 PMID:21810745

Smith, T. O., Blake, V., & Hing, C. B. (2011). Minimally invasive versus conventional exposure for total hip arthroplasty: A systematic review and meta-analysis of clinical and radiological outcomes. *International Orthopaedics*, *35*(2), 173–184. doi:10.100700264-010-1075-8 PMID:20559827

Stevens, M., Reininga, I. H., Bulstra, S. K., Wagenmakers, R., & van den Akker-Scheek, I. (2012). Physical Activity Participation Among Patients After Total Hip and Knee Arthroplasty. *Clinics in Geriatric Medicine*, *28*(3), 509–520. doi:10.1016/j.cger.2012.05.003 PMID:22840311

Urquhart, D. M., Hanna, F. S., Brennan, S. L., Wluka, A. E., Leder, K., Cameron, P. A., . . . Cicuttini, F. M. (2010). Incidence and risk factors for deep surgical site infection after primary total hip arthroplasty: a systematic review. *The Journal of Arthroplasty, 25*(8), 1216-1222.

Wagenmakers, R., Stevens, M., Groothoff, J. W., Zijlstra, W., Bulstra, S. K., van Beveren, J., ... van den Akker-Scheek, I. (2011). Physical activity behavior of patients 1 year after primary total hip arthroplasty: A prospective multicenter cohort study. *Physical Therapy*, *91*(3), 373–380. doi:10.2522/ptj.20100148 PMID:21233307

Westby, M. D., & Backman, C. L. (2010). Patient and health professional views on rehabilitation practices and outcomes following total hip and knee arthroplasty for osteoarthritis: A focus group study. *BMC Health Services Research*, *10*(1), 119. doi:10.1186/1472-6963-10-119 PMID:20459834

Wetters, N. G., Murray, T. G., Moric, M., Sporer, S. M., Paprosky, W. G., & Della Valle, C. J. (2013). Risk factors for dislocation after revision total hip arthroplasty. *Clinical Orthopaedics and Related Research*, *471*(2), 410–416. doi:10.100711999-012-2561-7 PMID:22956236

Wickramasinghe, N., Bali, R., Gibbons, M., Choi, J., & Schaffer, J. (2008). A systematic approach: Optimization of healthcare operations with knowledge management. *Journal of healthcare information management*. *Journal of Healthcare Information Management*, *23*(3), 44–50. PMID:19663164

Wickramasinghe, N., Bali, R. K., Choi, C. J. H. J., & Schaffer, J. L. (2009). *A Systematic Approach Optimization of Healthcare Operations with Knowledge Management*. Paper presented at the HIMSS.

Wright, W. F. (2013). Prosthetic joint Infections. *Essentials of Clinical Infectious Diseases*, 241.

Chapter 24

Understanding the Influence of Diabetes Management Practices on Co-Morbidity Development

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ABSTRACT

Diabetes type 2 is a chronic condition that currently has no cure. Hence, proper management is key as the best approach to ensure the wellness of sufferers. To establish the attitudes of self-care patients towards the management of this ailment, the authors designed a study that targeted 100 Australian residents in the first phase. These participants provided quantitative and qualitative information about various diabetes type 2 management practices that include exercising and diet management and the co-morbidities they currently suffer.

INTRODUCTION

As the population of people suffering from diabetes type 2 increases in Australia (Shaw and Tanamas 2012) and around the world (WHO 2016) due to factors that could be prevented, the need for proper management of the pandemic cannot be overstated. Effective management is therefore expected to rely heavily on the understanding and motivation of patients (Albright *et al*. 2001) who can better their quality of life through conscious self-management effort. To this end, exercising and diet management plans

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have featured prominently among the self-care options that contribute significantly to wellness (WHO 2016, Brown 1999). Considering the chronic nature of diabetes type 2 and the overall impact on the quality of life, healthcare resources, and the entire economy, researchers have worked hard to promote self-care strategies as possible options for bolstering the wellness of the patients. Hence, continuous education of the patients has been explored as a potential option for encouraging the sufferers to adhere to the best management practices (ADA 1989). This will enable them to know how several factors of self-management such as social context, which can come in the form of supports from family and friends, patient-doctor relationship, psychological stress, *etc.* play into an effective outcome (Albright *et al.* 2001).

It has been shown that the management of diabetes type 2 can be done effectively when patients contribute through exercising and diet management (Horton 1988, Bastiaens *et al.* 2009) following self-motivation inspired by the knowledge of the disease (Gould *et al.* 2019). Norris *et al.* (2001) also affirmed that self-management of diabetes type 2 holds numerous benefits in the short-term but the benefits can be sustained in the long-term if the patients are motivated and resilient and have other support networks (Powers *et al.* 2017). The quality of life outcome of the patients can be further enhanced through early intervention (Nolan *et al.* 2011). Therefore, the education of patients could be vital for the reversal of overnutrition and minimization of the adipose tissue defects when done at the early stages of diabetes type 2 diagnosis. Despite the difficulties associated with this change of lifestyle for the patients, adherence to the self-management strategies have been shown to be one of the most effective ways of managing diabetes type 2 (Nathan 2002).

We aim to explore how different diabetes type 2 management practices influence the development and risk factor of co-morbidities like arthritis, heart problems, vision loss, shaking and dexterity problems, asthma, and neuropathy. Although co-morbidities can be caused by genetic, environmental and ageing factors (Gijsen *et al.* 2001, Tahrani *et al.* 2011, Van Acker *et al.* 2009), the vulnerability of diabetes type 2 patients to certain diseases due to poor management practices and the duration of diagnosis cannot be overlooked. Imperatively, we seek to understand the relationship between these co-morbidities and the management practices using qualitative and quantitative analysis of the responses from interview questions from individuals (adults) diagnosed with diabetes type 2. Our study also explored the core influencers of poor diabetes management practices and the effects of self-management on the development and risk factors of the co-morbidities. We used different hypotheses to determine the influence of the management practices on the comorbidities, duration of diabetes type 2 diagnosis and the gender of the participants.

METHODOLOGY

This study is designed to obtain qualitative and quantitative information from diabetes type 2 patients who are diagnosed with other diseases such as arthritis, heart problems, vision loss, shaking and dexterity problems, asthma, and neuropathy. Australian residents from the age of twenty-one were approached to provide information about different techniques for managing diabetes type 2, the level of their compliance to the management strategy and the other co-morbidities they have been formally diagnosed by a qualified physician. The participants also provided information about the duration of the diabetes type 2 diagnosis, age, and specific information about the management practices that are difficult for them. The participants were specifically asked to identify the management practices from exercise, diet management, understanding of diabetes, overall motivation and appointment scheduling. They were also given

Table 1. Demographic characteristics of respondents

Number of participants	21
Minimum age (years)	41 .00
Maximum age (years)	60 .00
Mean age (years)	50.10
Standard deviation of age (years)	5.83
Median age (years)	48.00

the opportunity to include other management practices, which are not part of the interview questions but have frustrated them. Opportunities were also given to the participants to write the reasons for the frustrations they face with diabetes management practices. A total of twenty-one responses were received from the initial hundred participants surveyed in the first phase of this study.

To establish if there is any statistical significance at 0.05 significant level between the patients' frustration with the diabetes management strategies and their co-morbidities, we used analysis of Variance (ANOVA). This is because it helps to establish the existence of any variability in the means of the co-morbidities due to different diabetes management strategies. We also examined the various co-morbidities individually for the influence of the management strategies to determine if any sort of relationship exists between them. This makes it possible to establish the consistency of the respondents' information vis-à-vis further inferences. We also used Pearson's chi-square test to correlate diabetes management practices with the co-morbidities developed by the participants over the duration of diabetes type 2 diagnosis. This helps to establish the likelihood of acquiring chanced events in the survey information. Hence, the approach of using the goodness-of-fit test to find how independent the distributions of the events are across the studied events. The causes of the frustrations faced by the respondents, which are the core reasons for non-adherence to the diabetes management practices were captured qualitatively.

RESULTS

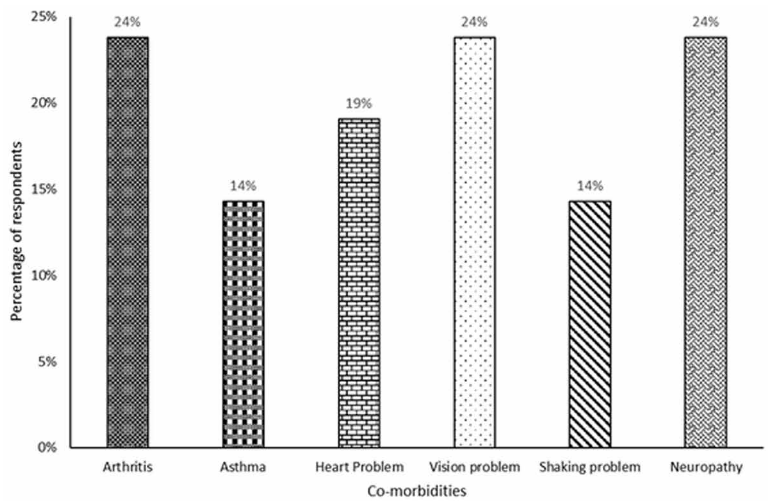
In this section, we show the results of the analysed interview questions with the demographic characteristics of the participants, co-morbidities, duration of diabetes type 2 diagnosis and the management practices. The reasons behind the non-adherence of the participants to the management practices are also shown with the tested hypotheses.

Demographic Characteristics of Participants

A total of twenty-one responses received from one hundred surveyed participants who were diagnosed with other co-morbidities such as arthritis, asthma, heart problems, vision problems, shaking and dexterity and neuropathy are represented in Table 1. Male participants make up 57% of the respondents and have a mean age of 50.83 years whereas 43% are female with a mean age of 51.87 years.

At least 1 in 2 of the participants have one of the studied co-morbidities with 1 in 7 having asthma and shaking and dexterity problems. More people (1 in 4 participants) are exposed to arthritis, heart

Figure 1. Graph showing the percentage of diabetes type2 sufferers with other diagnosed diseases



problems, vision problems, and neuropathy. Figure 1 shows the proportion of respondents that are diagnosed with the studied co-morbidities.

The breakdown of the duration of diagnosis of diabetes type 2 for all the respondents is shown in Table 2. More respondents who suffer diabetes type 2 for 5-10 years were diagnosed with more co-morbidities than the other time spans considered. The respondents with 10-15 years of diabetes type 2 diagnosis are about 26% of those with 5-10 years of diagnosis whereas 63% and 76% of these participants represent those with >15 years and <5 years of diabetes type 2 diagnosis respectively.

Diabetes Management

The study shows that more than 2 in 5 of the participants are having problem with using exercises for managing diabetes type 2 with overall motivation being the next most frustrating practice followed by diet management and understanding of diabetes (Table 3). The main reasons why the participants were finding it difficult to manage their diabetes type 2 properly was also summed up under four main reasons that include – time management, health impairment, motivation/support and addition/poor self-control (Figure 2). These factors are closely related to the factors that have been identified to be responsible for improved self-care for diabetes type 2 patients (Albright et al. 2001, Wang et al. 1996).

A summary of the duration of diabetes type 2 diagnosis and the percentage of respondents that are finding it difficult to effectively manage their condition using exercise, diet management, overall motivation and understanding of the disease is shown in Figure 3. There are only very few participants whose poor understanding of diabetes type 2 is playing a role in the management of the disease. Exercise and diet management are strong factors influencing diabetes type 2 management for those with < 5 years, 5-10 years and > 15 years of diagnosis.

Table 2. Summary of respondents by co-morbidity and duration of diabetes diagnosis

Duration of Diagnosis	<5 years	5-10 years	10-15 years	>15 years
Age (years)				
Mean	48.17	50.25	55	50.2
STD	5.24	6.26	0	5.74
Minimum	41	42	55	45
Maximum	55	60	55	59
Co-morbidity				
% respondent	29%	38%	10%	24%
Arthritis	5%	10%	5%	5%
Asthma	0%	5%	10%	0%
Heart Problem	0%	5%	5%	10%
Vision problem	0%	5%	10%	10%
Shaking problem	0%	5%	5%	5%
Neuropathy	5%	14%	0%	5%

Table 3. Summary of diabetes management strategies and the proportion of frustrated respondents

Diabetes management strategy	Proportion of respondents
Exercise	42.86%
Diet management	23.81%
Overall motivation	28.575
Understanding diabetes	4.76%

Figure 2. Core areas of challenges faced by patients in diabetes management

Figure 3. Classifying the percentage of Respondents frustrated with different diabetes management strategy according to the duration of diabetes

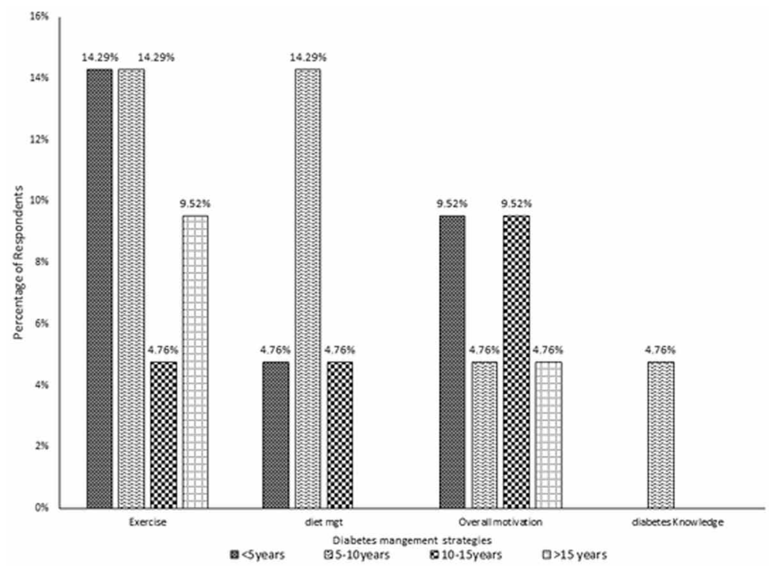
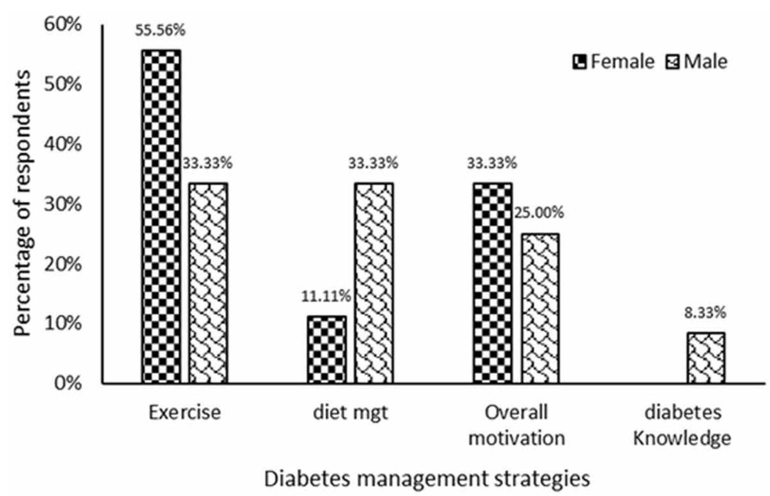


Figure 4. Proportion of male and female respondents frustrated with different diabetes management strategies



When poor diabetes management is considered according to gender and management strategies, more females than males are having problem adhering to their exercising plan whereas more males than females are unable to manage their diets properly (Figure 4). More male participants are generally motivated to manage the ailment properly than female whereas no female is seeing the understanding of the disease as a problem in the management.

Hypotheses Development and Testing

Although the real causes of diabetes type 2 are not known, the interplay of some key variables that include unhealthy living that is characterized by physical inactivity and unhealthy diet are among the factors that increase the risk of infection (WHO 2016). Evidence from the research is pointing the risk to over consumption of sugar and beverages (Imamura et al 2015, Te Morenga et al. 2013) because of their ability to trigger overweight, which is a common risk factor in diabetes type 2 disease. Other experts have attributed poor diet management especially less consumption of fibre (Ley et al. 2014, WHO/FAO 2003) to the disease while poor self-motivation and limited understanding are also pointed (Heisler *et al.* 2005, Shigaki *et al.* 2010).

Correlation of Patients' frustration with diabetes management practices and co-morbidities

There is a very high likelihood that when diabetes type 2 is poorly managed by patients, other health complications can start to surface in the individual. This view is shared by numerous researchers that attributed the disease to other co-morbidities such as retinopathy, heart attack, stroke and neuropathy (Laakso and Kuusisto 2007, Kaiser *et al.* 2018, Selvin *et al.* 2004, Doaousi *et al.* 2004). It is therefore important to know if there is any relationship between the poor management of the disease due to frustration and the development of the co-morbidities. Again, many diabetes type 2 sufferers are diagnosed with several co-morbidities at different stages of suffering the ailment (Sullivan *et al.* 2005). The question now is to know whether these number of co-morbidities have a close association with the diabetes management practices hence, it is hypothesised that –

Hypothesis 1: "Diabetes management practices are associated with the number of co-morbidities suffered by patients".

This imperatively means that the more patients get frustrated with the management practices, they are most likely not able to engage in the activities and that reduces their wellness thereby, giving room for the development or manifestation of the symptoms of other latent co-morbidities. The above hypothesis is tested for the total number of co-morbidities suffered by the patients and for individual co-morbidities. The summary of the hypothesis testing with a one-way Analysis of Variance (ANOVA) is shown in Table 4.

Correlation of Diabetes Management Practices with the Duration of Diabetes Diagnoses and Gender of Patients

The gender of diabetes type 2 patients and the duration of diagnosis have been shown to influence their susceptibility to diseases (Song *et al.* 2010, ACCORD Study Group and ACCORD Eye Study Group 2010). The variation in biological makeup, cultural practices, lifestyle, environment, and socioeconomic status also impact male and female predisposition to diabetes type 2 differently (Kautzky-Willer *et al.* 2016). Furthermore, endocrine imbalances relating to cardiometabolic traits such as excess androgen in women and men with hypogonadism have been associated with increased risk of diabetes type 2 and other associated outcomes such as heart problems. Although increased knowledge of diabetes type 2 is seen as an important factor for the management and wellness of patients (Heisler *et al.* 2005, Gould *et*

Table 4. Summary of one-way ANOVA results for diabetes management practices and co-morbidity

Co-morbidity	H0: null hypothesis	P_{value}	Statistical significance	Remark
All*	Diabetes management practices are associated with the number of co-morbidities suffered by patients	0.5957	There is no significant difference between the number of co-morbidities developed by the patients and various diabetes management practices. ($P_{value} > P_{0.05}$)	There is a similarity in the average number of patients' co-morbidities for various diabetes management practices (H0: accepted)
Arthritis	Diabetes management practices are associated with patients' development of arthritis	0.7088	There is no significant difference between the diabetes management practices and patients' development of the co-morbidities. ($P_{value} > P_{0.05}$)	There is a similarity in the average number of patients' that developed the studied co-morbidities and the various diabetes management practices (H0: accepted)
Asthma	Diabetes management practices are associated with patients' development of asthma	0.5096		
Heart problem	Diabetes management practices are associated with patients' development of heart problems	0.8697		
Vision problem	Diabetes management practices are associated with patients' development of vision problem	0.7088		
Shaking and dexterity problems	Diabetes management practices are associated with patients' development of shaking and dexterity problems	0.5096		
Neuropathy	Diabetes management practices are associated with patients' development of neuropathy	0.8728		

Table 5. Summary of ANOVA results for comparing diabetes management practices with the duration of diagnosis of diabetes type 2 and gender of participants

	H0: null hypothesis	P_{value}	Statistical significance	Remark
Duration of diabetes	The management practices did not improve with the duration of suffering diabetes type 2.	0.2164	There is no significant difference between diabetes type 2 management practices and the length of time the participants have suffered the ailment. ($P_{value} > P_{0.05}$)	There is a similarity in the average number of patients frustrated with the management practices across the various groups of diabetes durations (H0: accepted)
Gender of patients	Gender of respondents did not influence the management practices	0.1083	There is no significant difference between diabetes type 2 management practices and the gender of the respondents. ($P_{value} > P_{0.05}$)	There is a similarity in the average number of patients of both genders that shared the same frustration with the various diabetes management strategies. (H0: accepted)

Table 6. Summary of Pearson's chi-squared test result for comparing poor diabetes management practices with the duration of diabetes diagnosis and the number of developed co-morbidities

H0: Null hypothesis	P_{value}	chi-squared (χ^2)	Statistical significance	Remarks
Poor exercising results in developing more co-morbidities as the duration of diabetes type 2 diagnosis increases.	0.3999	29.25	No statistical difference	H0 is accepted
Poor exercising increases the likelihood of diabetes type 2 patients developing the studied co-morbidities.	0.9888	0.6		
Diabetes type 2 patients develop more co-morbidities with the increase in the duration of their diabetes if proper dieting plan is neglected.	0.3528	6.6667		
Poor diet management increases the chances of diabetes type 2 patients developing co-morbidities.	0.9626	1		
Diabetes type 2 patients are prone to develop more co-morbidities as the duration of diagnosis of the disease increases if they lack overall motivation to manage the ailment.	0.4335	8		
There are increased chances of diabetes type 2 patients developing other co-morbidities if they lack overall motivation for managing the disease.	0.6386	3.4		

al. 2019), some researchers have shown that the knowledge has not been overly helpful in proper self-management (Albright *et al.* 2001). We, therefore, hypothesis as follows:

Hypothesis 2: "Diabetes type 2 management practices did not improve with the duration of diagnosis".

The statistical estimations of the influence of diabetes management practices on the duration of diagnosis and gender of participants are shown in Table 5.

Since the duration of diagnosis of diabetes type 2 can also impact the vulnerability of patients to other ailments (Van Acker *et al.* 2009), it is worthwhile to know the expected influence of diabetes management practices on co-morbidities development. Considering the influences of the disease duration of diagnosis and gender on co-morbidities, we believe it is important to know if proper diabetes management practices will influence the development of the co-morbidities in patients. It is also necessary to know if the patients change their altitude about diabetes management with the increase in the duration of diabetes type 2 diagnosis. This statement can hold because of the good knowledge of the effect of the disease and the consequences of inaction on the quality of life. To ascertain if the management of diabetes type 2 over the duration of diagnosis has any influence on the development of the co-morbidities, we proposed hypotheses 3 below.

Hypothesis 3: "Poor diabetes management practices result in developing more co-morbidities as the duration of diagnosis of diabetes type 2 increases".

Table 6 is a summary of Pearson's chi-square test result for comparing diabetes management practices, number of co-morbidities and the duration of diagnosis of diabetes type 2.

DISCUSSION

Proper management of diabetes type 2 has been linked to wellness of sufferers (Ring *et al.* 2015) but efficient management strategies are needed to ensure that the goal is reached. To achieve this goal will, therefore, be a function of putting up the right attitudes in self-care behaviour (Albright 2001), which will rely on motivation to put the management strategies of exercising and diet management into action. This study has shown that numerous factors that influenced patients' characteristics are similar to what has been previously reported by other researchers (Beardsley and Goldstein 1993, Oster *et al.* 2006). These conditions, which are broadly classified as time management, health impairment, motivation/support, and addiction/poor self-control have contributed to the participants' frustrations in the management of diabetes type 2. Although many of the participants are not interested in exercises and diet management due to the lack of motivation, they will miss out on the benefits of adhering to proper management practices. Imperatively, with the increased frustration of the participants with exercises, they get more exposed to cardiovascular complication due to insufficient stimulation of the vascular functions (Ring et al. 2015). There is also a high tendency that other disease such as stroke, vision loss, neuropathy will follow (Sullivan *et al.* 2005, Kaiser *et al.* 2018, Selvin *et al.* 2004, Doaousi *et al.* 2004) due to the poor diabetes management practices.

The number of co-morbidities suffered by the participants is associated with the management practices due to the link between the overall motivation of the participants and following the exercise regimes and adhering to the diet plans. This association though not favourable to wellness can be traced to lack of companionship from friends and family members (Teli 2019, Wen *et al.* 2004) who always act as a motivating force for effective diabetes management practice (Manson et al. 2002, Mora et al. 2007). The social network of the participants, socio-economic status and their health conditions are also among the crippling factors that are making it difficult for them to effectively adhere to the management practices. These findings are like the conclusions of different authors (Albright et al. 2001, Ring et al. 2015) who have associated poor self-care behaviours of diabetes type 2 patients to poor management of the disease. This sentiment is also shared by numerous researcher that have shown clinically and empirically that diabetes type 2 patients are at heightened risks of developing numerous diseases including the co-morbidities studied in this study due to poor exercises and poor diets (Laakso and Kuusisto 2007, Xie and Cheng 2012, Gerich 2003, Selvin et al. 2004).

Unfortunately, diabetes type 2 management did not improve with the duration of diagnosis of the disease despite the expectation that the increased knowledge of the disease via self-management plan acquired over the duration of the ailment would culminate in sticking to the management practices. On the other hand, research has shown that a 3 years duration of self-management of diabetes type 2 did not result in the quality of life improvement (Khundi et al. 2012) despite the increased risk of cardiovascular diseases and mortality being associated with the increase in the duration of the disease (Spikerman *et al.* 2002).

Gender of the participants did not influence how they managed the disease, but this is contrary to other research that showed that gender impacted on diabetes type 2 management strategies (Williams 1999). Evidence from this study also points to a connection between poor exercising, diet management, and overall motivation with development of the studied co-morbidities. The risk of developing the co-morbidities generally increased with the duration of diagnosis of the disease but poor management practices enhance the risk factor dramatically. When participants have strong motivation, they are generally poised to continue the various diabetes management practices as evidenced by the strong correlation between self-care behaviours and social context, patients' satisfaction and personal stress (Albright *et al.* 2001).

CONCLUSION AND FUTURE WORK

We designed a study to collect information about various diabetes type 2 management strategies from Australian participants to know their adherence to exercising regime and diet management following their understanding of the ailment. The study looked at the influence of understanding diabetes type 2 and the overall motivation of patients on the willingness to follow the self-management plans. The correlation of the management practices, which were broadly classified as exercise, diet management, overall motivation and understanding of diabetes with the development of co-morbidities was also highlighted.

After using a one-way ANOVA and Person's chi-square test to analyse the gathered information from participants that were aged between 41 and 60 years, the following conclusions were reached:

- The frustration of participants with the various diabetes management practices increased their likelihood of not following the self-management information to better their health conditions.
- The participants were having problem with the management practices because of time management, health impairment, social support gaps and addictions
- The increased understanding of diabetes type 2 with increased time of diagnosis did not culminate in enhanced management practices.
- Poor management practices and increased duration of diagnosis played significant roles in the development of co-morbidities like arthritis, asthma, vision loss, shaking and dexterity, heart problems, and neuropathy.

To make the acquisition of self-management technique easy and long-lasting, education and support of the patients are expected to be ongoing for the benefits of diabetes management practices to be obtained.

We will continue this study to understand the effect of increased food choices and active peer support groups on diabetes type 2 management practices and wellness of the patients. The influence of diabetes type 2 management on other diseases such as stroke and hypertension may be studied closely to know their association for different age groups.

REFERENCES

ACCORD Study Group and ACCORD Eye Study Group. (2010). Effects of medical therapies on retinopathy progression in type 2 diabetes. *The New England Journal of Medicine*, *363*(3), 233–244. doi:10.1056/NEJMoa1001288 PMID:20587587

Albright, T. L., Parchman, M., & Burge, S. K. (2001). Predictors of self-care behavior in adults with type 2 diabetes: An RRNeST study. *Family Medicine-Kansas City*, *33*(5), 354–360. PMID:11355645

American Diabetes Association (ADA). (1989). Standards of medical care for patients with diabetes mellitus. *Diabetes Care*, *12*(5), 365–368. doi:10.2337/diacare.12.5.365 PMID:2721345

Beardsley, G., & Goldstein, M. G. (1993). Psychological factors affecting physical condition: Endocrine disease literature review. *Psychosomatics*, *34*(1), 12–19. doi:10.1016/S0033-3182(93)71923-4 PMID:8426887

Brown, S.A. (1999). Interventions to promote diabetes self-management: state of the science. *The Diabetes Educator, 25*(6_suppl), 52-61.

Daousi, C., MacFarlane, I. A., Woodward, A., Nurmikko, T. J., Bundred, P. E., & Benbow, S. J. (2004). Chronic painful peripheral neuropathy in an urban community: A controlled comparison of people with and without diabetes. *Diabetic Medicine*, *21*(9), 976–982. doi:10.1111/j.1464-5491.2004.01271.x PMID:15317601

Gerich, J. E. (2003, April). Contributions of insulin-resistance and insulin-secretory defects to the pathogenesis of type 2 diabetes mellitus. *Mayo Clinic Proceedings*, *78*(4), 447–456. doi:10.4065/78.4.447 PMID:12683697

Gijsen, R., Hoeymans, N., Schellevis, F. G., Ruwaard, D., Satariano, W. A., & van den Bos, G. A. (2001). Causes and consequences of comorbidity: A review. *Journal of Clinical Epidemiology*, *54*(7), 661–674. doi:10.1016/S0895-4356(00)00363-2 PMID:11438406

Gould, J. S., Tong, C., Ly, J., Vazirian, S., Windt, A., & Khan, K. (2019). Process evaluation of team-based care in people aged> 65 years with type 2 diabetes mellitus. *BMJ Open*, *9*(8), e029965. doi:10.1136/bmjopen-2019-029965 PMID:31377711

Heisler, M., Piette, J. D., Spencer, M., Kieffer, E., & Vijan, S. (2005). The relationship between knowledge of recent HbA1c values and diabetes care understanding and self-management. *Diabetes Care*, *28*(4), 816–822. doi:10.2337/diacare.28.4.816 PMID:15793179

Horton, E. S. (1988). Role and management of exercise in diabetes mellitus. *Diabetes Care*, *11*(2), 201–211. doi:10.2337/diacare.11.2.201 PMID:3289869

Imamura, F., O'Connor, L., Ye, Z., Mursu, J., Hayashino, Y., Bhupathiraju, S. N., & Forouhi, N. G. (2015). Consumption of sugar sweetened beverages, artificially sweetened beverages, and fruit juice and incidence of type 2 diabetes: Systematic review, meta-analysis, and estimation of population attributable fraction. *BMJ (Clinical Research Ed.)*, *351*, h3576. doi:10.1136/bmj.h3576 PMID:26199070

Kautzky-Willer, A., Harreiter, J., & Pacini, G. (2016). Sex and gender differences in risk, pathophysiology and complications of type 2 diabetes mellitus. *Endocrine Reviews*, *37*(3), 278–316. doi:10.1210/er.2015-1137 PMID:27159875

Khunti, K., Gray, L. J., Skinner, T., Carey, M. E., Realf, K., Dallosso, H., ... Davies, M. J. (2012). Effectiveness of a diabetes education and self management programme (DESMOND) for people with newly diagnosed type 2 diabetes mellitus: Three year follow-up of a cluster randomised controlled trial in primary care. *BMJ (Clinical Research Ed.)*, *344*(apr26 2), e2333. doi:10.1136/bmj.e2333 PMID:22539172

Laakso, M., & Kuusisto, J. (2007, August). Cerebrovascular disease in type 2 diabetes. In *International Congress Series* (Vol. 1303, pp. 65–69). Elsevier.

Ley, S. H., Hamdy, O., Mohan, V., & Hu, F. B. (2014). Prevention and management of type 2 diabetes: Dietary components and nutritional strategies. *Lancet*, *383*(9933), 1999–2007. doi:10.1016/S0140-6736(14)60613-9 PMID:24910231

Manson, J. E., Greenland, P., LaCroix, A. Z., Stefanick, M. L., Mouton, C. P., Oberman, A., ... Siscovick, D. S. (2002). Walking compared with vigorous exercise for the prevention of cardiovascular events in women. *The New England Journal of Medicine*, *347*(10), 716–725. doi:10.1056/NEJMoa021067 PMID:12213942

Mora, S., Cook, N., Buring, J. E., Ridker, P. M., & Lee, I. M. (2007). Physical activity and reduced risk of cardiovascular events: Potential mediating mechanisms. *Circulation*, *116*(19), 2110–2118. doi:10.1161/CIRCULATIONAHA.107.729939 PMID:17967770

Nathan, D. M. (2002). Initial management of glycemia in type 2 diabetes mellitus. *The New England Journal of Medicine*, *347*(17), 1342–1349. doi:10.1056/NEJMcp021106 PMID:12397193

Nolan, C. J., Damm, P., & Prentki, M. (2011). Type 2 diabetes across generations: From pathophysiology to prevention and management. *Lancet*, *378*(9786), 169–181. doi:10.1016/S0140-6736(11)60614-4 PMID:21705072

Norris, S. L., Engelgau, M. M., & Narayan, K. V. (2001). Effectiveness of self-management training in type 2 diabetes: A systematic review of randomized controlled trials. *Diabetes Care*, *24*(3), 561–587. doi:10.2337/diacare.24.3.561 PMID:11289485

Oster, N. V., Welch, V., Schild, L., Gazmararian, J. A., Rask, K., & Spettell, C. (2006). Differences in self-management behaviors and use of preventive services among diabetes management enrollees by race and ethnicity. *Disease Management*, *9*(3), 167–175. doi:10.1089/dis.2006.9.167 PMID:16764534

Powers, M. A., Bardsley, J., Cypress, M., Duker, P., Funnell, M. M., Fischl, A. H., ... Vivian, E. (2017). Diabetes self-management education and support in type 2 diabetes: A joint position statement of the American Diabetes Association, the American Association of Diabetes Educators, and the Academy of Nutrition and Dietetics. *The Diabetes Educator*, *43*(1), 40–53. doi:10.1177/0145721716689694 PMID:28118121

Ring, M., Eriksson, M. J., Fritz, T., Nyberg, G., Östenson, C. G., Krook, A., ... Caidahl, K. (2015). Influence of physical activity and gender on arterial function in type 2 diabetes, normal and impaired glucose tolerance. *Diabetes & Vascular Disease Research; Official Journal of the International Society of Diabetes and Vascular Disease*, *12*(5), 315–324. doi:10.1177/1479164115588548 PMID:26092821

Selvin, E., Marinopoulos, S., Berkenblit, G., Rami, T., Brancati, F. L., Powe, N. R., & Golden, S. H. (2004). Meta-analysis: Glycosylated hemoglobin and cardiovascular disease in diabetes mellitus. *Annals of Internal Medicine*, *141*(6), 421–431. doi:10.7326/0003-4819-141-6-200409210-00007 PMID:15381515

Shaw, J., & Tanamas, S. (2012). *Diabetes: the silent pandemic and its impact on Australia.* Melbourne: Baker IDI Heart and Diabetes Institute. Available from https://static.diabetesaustralia.com.au/s/fileassets/diabetes-australia/e7282521-472b-4313-b18e-be84c3d5d907.pdf

Shigaki, C., Kruse, R. L., Mehr, D., Sheldon, K. M., Ge, B., Moore, C., & Lemaster, J. (2010). Motivation and diabetes self-management. *Chronic Illness*, *6*(3), 202–214. doi:10.1177/1742395310375630 PMID:20675362

Song, Y., Klevak, A., Manson, J. E., Buring, J. E., & Liu, S. (2010). Asthma, chronic obstructive pulmonary disease, and type 2 diabetes in the Women's Health Study. *Diabetes Research and Clinical Practice*, *90*(3), 365–371. doi:10.1016/j.diabres.2010.09.010 PMID:20926152

Spijkerman, A. M. W., Dekker, J. M., Nijpels, G., Jager, A., Kostense, P. J., Van Hinsbergh, V. W. M., ... Stehouwer, C. D. A. (2002). Impact of diabetes duration and cardiovascular risk factors on mortality in type 2 diabetes: The Hoorn Study. *European Journal of Clinical Investigation*, *32*(12), 924–930. doi:10.1046/j.1365-2362.2002.01090.x PMID:12534452

Sullivan, P. W., Morrato, E. H., Ghushchyan, V., Wyatt, H. R., & Hill, J. O. (2005). Obesity, inactivity, and the prevalence of diabetes and diabetes-related cardiovascular comorbidities in the US, 2000–2002. *Diabetes Care*, *28*(7), 1599–1603. doi:10.2337/diacare.28.7.1599 PMID:15983307

Tahrani, A. A., Bailey, C. J., Del Prato, S., & Barnett, A. H. (2011). Management of type 2 diabetes: New and future developments in treatment. *Lancet*, *378*(9786), 182–197. doi:10.1016/S0140-6736(11)60207-9 PMID:21705062

Te Morenga, L., Mallard, S., & Mann, J. (2013). Dietary sugars and body weight: Systematic review and meta-analyses of randomised controlled trials and cohort studies. *BMJ (Clinical Research Ed.)*, *346*(jan15 3), e7492. doi:10.1136/bmj.e7492 PMID:23321486

Teli, M. (2019). Family Empowerment Model for Type 2 DM Management: Integration of Self care Model by Orem and Family Centered Nursing by Friedman in Sikumana Health Center-Kupang. *Jurnal Info Kesehatan*, *17*(1), 75–87. doi:10.31965/infokes.Vol17.Iss1.261

Van Acker, K., Bouhassira, D., De Bacquer, D., Weiss, S., Matthys, K., Raemen, H., ... Colin, I. M. (2009). Prevalence and impact on quality of life of peripheral neuropathy with or without neuropathic pain in type 1 and type 2 diabetic patients attending hospital outpatients clinics. *Diabetes & Metabolism*, *35*(3), 206–213. doi:10.1016/j.diabet.2008.11.004 PMID:19297223

Wang, C. Y., & Fenske, M. M. (1996). Self-care of adults with non-insulin-dependent diabetes mellitus: Influence of family and friends. *The Diabetes Educator*, *22*(5), 465–470. doi:10.1177/014572179602200506 PMID:8936125

WHO/FAO Expert Consultation, WHO Technical Report Series 916 Diet, Nutrition, and the Prevention of Chronic Diseases. (2003). Geneva: WHO. Available from http://health.euroafrica.org/books/dietnutritionwho.pdf

Williams, C. (1999). Gender, adolescence and the management of diabetes. *Journal of Advanced Nursing*, *30*(5), 1160–1166. doi:10.1046/j.1365-2648.1999.01168.x PMID:10564415

World Health Organization (WHO). (2016). *Global report on diabetes: executive summary* (No. WHO/NMH/NVI/16.3). World Health Organization. Available from https://apps.who.int/iris/bitstream/handle/10665/204871/9789241565257_eng.pdf?sequence=1

Xie, L. J., & Cheng, M. H. (2012). Body adipose distribution among patients with type 2 diabetes mellitus. *Obesity Research & Clinical Practice*, *6*(4), e270–e279. doi:10.1016/j.orcp.2012.09.003 PMID:24331587

Chapter 25
Mobile Health:
Precision Post-Operative Wellness Monitoring Solutions

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ABSTRACT

Today most people have at least one smart phone irrespective of socio-economic standing. Such a penetration of mobile phones has enabled mobile health to rapidly develop over the last 5 years. There are many benefits to patients and clinicians afforded by mobile health including the convenience of any time anywhere access to data and information and the possibility to monitor so that critical issues can be caught early. One key area is in the post discharge phase as patients return home to ensure they are making good progress. This chapter discusses developments of mobile health solutions and precision post-operative wellness monitoring solutions.

INTRODUCTION

Mobile Health

With the current globalization, smartphones have become an integral part of people's lives with their use being applied in many industries. The healthcare system is certainly not left behind in adopting mobile technology in their treatment approaches (Stephanie et al., 2017). Mobile health is enough proof of mobile technology's importance in the healthcare system (Robbins et al., 2017) MHealth applications have dominated the health care landscape due to their capability to simplify access to care and deliver greater care experience from both the health professionals' and the patient's perspectives (ibid). The mobile health applications have not only developed into a vibrant ecosystem or a market that is not only dynamic but also provides massive potential (ibid). With the adoption of smartphones in the medical care sector proliferating, the business opportunity for MHealth is great (ibid).

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The fast-growing digital sector, as well as the slow, paced healthcare sector continues to collide thus bringing disruptive alterations to the market (ibid). However, the MHealth applications market has been increasing steadily over the last few years with the emergence of the novel technologies, novel business models as well as novel workflows that are revolutionizing the healthcare industry (Stephanie et al, 2017). Shareholders within the healthcare sector are giving life to these revolutionary MHealth solutions. The innovation of the mobile technologies is accelerating fast and maintains a great promise with evidence of these tools playing a positive role in costs of care as well as patient outcomes (ibid).

Statistics on Mobile Health

The number of mobile health applications in the present market has proliferated substantially. There are now more than 318,000 health applications available on the top app stores across the globe, approximately double the number of apps which were available in 2015 with more than 200 apps being added in every single day (Källander et al, 2013). The worldwide MHealth apps market is estimated to be valued at 28.320 billion dollars as of 2018 and is postulated to reach 102.35 billion dollars by 2023 (Källander et al, 2013). The core driving aspects motivating the growth of the MHealth market is the up surged adoption of mobile phones and the continued heavy investments into the digital medical market (ibid). Källander et al (2013) assert that healthcare consumers continue to show a robust use of digital technology, with numbers increasing annually. Actually, nearly 75% of users surveyed stated that technology is essential to managing their health (ibid). This study also recorded increases across the board in the use of smartphones, social media, online communities, electronic health records, and wearable devices (ibid). Particularly, approximately half of the healthy population (48%) is consuming MHealth apps compared to 16% consumption in 2014 (Källander et al, 2013).

Healthcare users are taking advantage of the fact that they can use their smartphones anytime and anywhere to access care (Robbins et al., 2017). In actual fact, nearly 79% of respondents are more likely to identify a caregiver who enhances them to conduct healthcare interactions whether online or on smartphones (ibid). Moreover, 50% of consumers are promising to leave their current providers for one that undertakes better technology (Robbins et al, 2017). With this constant and widespread adoption of mobile technologies, mobile technology has evolved as a novel subfield of health (ibid). As the eHealth is widely focused on information and communication technologies, mHealth looks forward to discovering more into mobile devices as well as wireless communication (ibid). Up to this time, no standardized definitions for MHealth have been recognized (ibid). However, WHO defines MHealth as the use of smartphones, personal digital assistants, other wireless communications, and monitoring devices to aid health and public health practice (ibid). It was postulated that 50% of persons in remote areas across the world would own mobile phones by 2012 while 500 million individuals would have access to these mobile phones MHealth applications by the year 2015 (Carroll et al, 2017). Accordingly, MHealth is likely to carry all the promises of Electronic Health (ibid).

From 2015, approximately 64%, which amounts to about two-thirds of the United States citizens owned smartphones (Carroll et al., 2017). This is a proliferation from a 35% recorded in 2011 and it is estimated that 90% of the global population will own a smartphone by 2020 (Carroll et al, 2017). According to the current UK data, it is revealed that smartphone usage is up-surging as 66% of the adult population had possession of a mobile phone in the year 2015 (ibid). This is an upsurge from 61% in the year 2014 (ibid). Smartphone possession is higher among younger individuals with about 77% possession for those within the 16-24 age brackets (Carroll et al, 2017). Although smartphones possession is particularly higher among young people and those with higher educational achievement and income, those that have a lower income, as well as educational success, is presently probable to be smartphones dependent (ibid). This is to mean that they fail to have broadband access at home and have few other options for web-based access other than through smartphones (ibid).

Notably, the upsurge of smartphone ownership has led to an increase in the percent of mobile phone apps in the marketplace (ibid). Most of these applications are designed to promote health with more than 100,000 health applications available in the Google store as well as iTunes (Carroll et al, 2017). This massive number speaks to both the vast market as well as the ongoing demand for novel tools to assist the public to manage their limitations of the current medical care system to offer such resources (ibid). It also helps the public to manage weight-related aims, diet, and fitness. According to a recent study by Carroll et al (2017), about 53% of mobile phones owners possess a smartphone which translates to nearly 45% of all US adults and half of this population has used their phones for looking up on their medical information. While America leads the market in the MHelth growth, other markets are illustrating growth too (ibid). For instance, the Asian-Pacific is estimated to develop at a higher rate of more than 35% thus making it the fastest growing MHealth market (ibid). According to Carroll et al (2017) research, it is estimated that the United Kingdom, Germany as well as France accounts for 45% share in the Europe mobile health device market as of the year 2014. Thus, it is reasonable to conclude that MHealth technologies are increasing in popularity worldwide and as a result revolutionizing the face of healthcare (ibid). Additionally, there is proliferating usage of health apps among caregivers, patients, as well as the general public. It is good to note that, these apps can only play a role in creating awareness, remote monitoring of individuals, illness self-management, and collection of dietary information (Carroll et al, 2017).

Approximately two-thirds of all adults in America own smartphones or powerful personal computers and tablets that are portable and always connected to the internet (Robbins et al., 2017). These devices have the capacity to run sophisticated mobile applications which can help the health professionals and caregivers to understand where the patients are and what they are doing in regards to maintaining their health through following keenly on the prescribed activities (ibid). Notably, these applications are powerful as they are connected to an extensive array of other devices from wearable sensors to other health systems (ibid). The growth of smartphones has wide-ranging implications for the entire healthcare system (ibid). In simpler terms, smartphones, as well as other mobile technologies, seem to be the single most promising avenue health professionals have to assist individuals to manage their health and to do so at a certain measure (ibid). From encouraging patients to do physical activity to aiding cancer patients with the management of chemotherapy side effects, MHealth is progressively becoming a core platform for delivering medical interventions (ibid).

Using technologies such as the text messaging and personal digital assistants as well as smartphones apps, mobile health has a boundless perspective to reduce health problems and advance healthcare delivery, especially in the low and middle-income communities (ibid). Abaza & Marschollek (2017) contends that the texting programs have been carried out to create awareness to patients and educate patients, promoting reporting and communication, aiding in data collection of health records, and offering adherence and appointment reminders (ibid). Moreover, SMS has also helped to advance maternal as well as children medical health by taking women through the various levels of pregnancy (ibid). In addition, personal digital assistants have been used to offer home-based counseling and gathering important medical data that is necessary for identifying some illnesses such as HIV and TB (Abaza & Marschollek, 2017).

Recent applications in the healthcare industry offer consumers with several functions similar to those offered by computers applications. Anshari & Almunawar (2016), claims that most of the healthcare-related apps are available and are easily downloadable from some of the well-known download sites. These apps in the healthcare system can be designed to aid healthcare providers to better their services and work products such as offering online access to health data, health imaging as well as laboratory outcomes (ibid). There are several mobile applications that will allow patients to use their mobile phones to track their medical states such as monitoring their heart rate, emergency unit control, and their heart rate (ibid).

Health and fitness mobile applications usage has grown by more than 330% in recent years (Robbins et al., 2017). Advances in artificial intelligence presently enhance apps to comprehend patient cases and respond to questions from consumers with appropriate follow-up inquiries (ibid). Fitness, as well as nutrition apps, follow caloric consumption (ibid). Integration with some sensors such as the wearable devices expands their capacities dramatically (ibid). In fact, health and fitness applications illustrate very high retention rates (ibid). As stated in a study by Flurry Analytics, more than 75% of active consumers access their fitness apps at least twice per week and more than 25% of consumers access their health apps over ten times weekly (Anshari & Almunawar, 2016). The great rate of recurrence of usage pushes up involvement, which for app developers offers an attractive chance to upsurge monetization (ibid).

Focus Areas

Clearly, the recent explosion in the mobile health invention has come from both the development of research in health sciences, human-computer interactions, and growth in the commercial industry. Commercial fitness mobile technologies such as Nike Fuelband and Fitbit have brought the mobile health into the conventional path, while the health research is making efforts towards developing novel ways to aid patient's efforts to manage their health and to test the effectiveness of the resulting interventions (Klasnja & Pratt, 2014).

A key focus of mobile health research and development in the recent past has been on assisting patients to adopt and maintain healthy lifestyles (ibid). Poor diets, behavior risk factors, physical inactivity as well as smoking conducts are core contributors to a prevalent of chronic conditions including chronic illness with high expenses in relation to the human suffering as well as healthcare costs (ibid). Until now, these conditions are largely preventable and many recent mobile health technologies have focused on helping patients to improve their health by adopting healthier behaviors (Klasnja & Pratt, 2014). Mobile health technology applications use four major approaches to encourage healthy habits such as social influence, goal setting, gamification, tracking, and feedback (ibid).

Interestingly, the main features of almost all MHealth applications are currently being used in tracking health-related habits and offering feedback on those habits (ibid). This process is mainly referred to as self-monitoring and has been largely used to support healthy habits change ever since the 1970s and can be efficient for changing an extensive array of habits, from obsessive cogitation to physical activities (Klasnja & Pratt, 2014). Mobile health applications are building a strong and practical self-monitoring practice by simplifying the collection of habit data and by offering individuals with real-time feedback on how they are operating with respect to their behavior change objectives (ibid).

In addition, MHealth is a promising and insightful tool for timely and scalable aid of wellness activities and continuity of users care outside the healthcare center (ibid). According to Klasnja & Pratt (2014), physical activity trackers such as the Fitbit technology, Bluetooth equipped devices for monitoring the heart rate among other emerging sensors are driving the mHealth applications to track data about users' habits and gives feedback that places a minimal burden thus greatly easing the self-monitoring process (ibid). Almost all the wellness applications offer feedback often in the daily or weekly data of tracked activities (ibid). Some applications even go to an extra mile of providing the user with charts of more than one type of activity, allowing users to look for patterns in their information and formulate hypotheses in regards to how their activities are connected to each other (Klasnja & Pratt, 2014). This feedback does not only offer the charts but also encourage physical activities (ibid). Applications such as the UbiFit offers patients with feedback in the flower garden format on the phone's wallpaper, allowing them to view how active they have been that period of monitoring every time they use their smartphones (ibid). Notably, nearly all sensing mobile technologies offer feedback directly on the sensing device allowing users to quickly view how they are progressing without reaching for their smartphones (Klasnja & Pratt, 2014). Such advancements to tracking and receiving feedback are assisting patients to monitor their health activities more efficiently, more easily, and over long periods of time (ibid).

The ability to track progress allows MHealth applications to apply a number of other approaches for inspiring healthy activities (ibid). One common approach is goal setting. In most of the mobile health applications, patients are able to set goals and to monitor how they are progressing towards those goals (ibid). Recent mobile applications discover how to set such medical behavioral goals most efficiently (ibid). For instance, such applications such as GoalPost allow patients to set two physical activity aims, the main aim, and a backup aim. Including the backup aim can aid patients to stay inspired and active even during times when they are too busy to attain their primary aim (Klasnja & Pratt, 2014). Such inventions can assist individuals to deal with the chaos of everyday life that result in perfectly regular routines which are hard even for those with the best of intentions (ibid).

Along with inspiring healthier behaviors, mobile health applications have a remarkable potential to help patient care outside the healthcare center, where, in due course, users manage their health conditions (ibid). Much of the efforts in this area have paid attention to three strategies including, automated decision support, symptom monitoring, as well as self-management training (ibid). MHealth applications thus help the care providers to coach patients on how to effectively manage their health conditions (ibid). According to Klasnja & Pratt (2014), management of numerous conditions necessitates that patient's symptoms are constantly tracked so that worsening in the individual's state is at the appointed time sensed and treated. MHealth applications make continuous tracking of conditions through the use of sensors or regular self-report possible (ibid). This increases the possibility of timely attention and treatment to the worsening of health conditions (ibid). By monitoring patient's data such as blood pressure, heart rate, and weight management, health professionals are capable of reducing the rate of patient's hospitalization significantly (ibid). In addition, the length of hospitalization is reduced at cases when the individuals are hospitalized (ibid). Symptom monitoring technologies can assist users to gain care when the necessity first arises, offering them peace of mind and aiding in preventing grave or even fatal health occurrences (Klasnja & Pratt, 2014).

Furthermore, MHealth applications can contain medical knowledge and offer patients with immediate decision support anytime that they need irrespective of whether a caregiver is available (ibid). For instance, a health application for management of chemotherapy side effects offers individuals tailored management plans for their reported symptoms (ibid). Depending on the reported severity of the patient, they are advised to take different measures such as drinking a lot of fluids, taking certain medication, and rehydration sachets (Klasnja & Pratt, 2014). Such applications help in detecting when the user's condition is worsening and offers immediate advice on what the patient ought to do, increasing the likelihood that the symptoms are dealt with a suitable and timely manner (ibid).

In light of the above discussion, it is evident that the MHealth applications offer a great promise for outpatient care as it goes beyond monitoring of symptoms and training (ibid). The emergence of the portable sensors that connect to smartphones, such as the electrocardiograms makes it probable for the healthcare system to considerably increase access to high-quality care even in the rural as well as in the underprivileged societies (ibid). Equipped with mobile phones and several pocket-size devices, and linked to the regional health center through a video call, community caregivers can act as the observers for the high health professionals in areas where access to the health specialty care is limited (ibid). When implemented at a scale, mobile health models could aid in closing the divide in access to care faced by numerous communities across the state and globally (ibid).

Precision Post-Operative Wellness Monitoring Solutions

Recent studies have clearly depicted that nearly one-third of deaths after surgical procedure happens in the wards in a situation commonly referred to as failure to rescue (Subble et al., 2017). It has been proposed to offer explanations as to why health centers with comparable postoperative morbidity rates may have varying mortality rates (ibid). The outcomes heavily rely on the capability to detect early and to properly treat postoperative complications than in the occurrence of difficulties after surgery (ibid). Notably, many types of research have also proven that most postoperative patients start deteriorating hours before medical teams are called in to rescue or to carry out an intensive care unit transfer (ibid). In this case, various scholars have already illustrated the value of early detection with continuous post-operative monitoring when it comes to the recovery of patients (ibid).

In a recent research by the International Surgical on the dynamics of surgery across the globe, the findings indicated that over 320 million people globally have undergone surgical procedures (ibid). ISOS Group (2016) contend that approximately 17% of these patients develop several complications and among them nearly 2.8% pass away due to these complications. It can, therefore, be estimated that approximately 1.5 million patients annually or three patients per day die due to post-operative complications (ibid). For instance, Bartels et al (2013) argue that in America, if the postoperative mortality was to be included in the official statistics as per the data from the Centers for Disease Control and Prevention, it would depict the third leading cause of death after heart illness and cancer (ibid). Essentially, many patients die in the wards, where the doctors or patients ratio is low and where the individuals are not continuously monitored (ibid). Monitoring patients beyond the operating room and ICU may enable early detection of medical deterioration and timely interventions. Michard et al (2015) argues that the postoperative complications are not only a human burden but also a dramatic increase in the hospital expenses. As a result of this clinical and economic burden, a number of initiatives have been developed to offer an advanced quality of surgical care, from the surgical safety specification to negligibly invasive surgical procedure, protecting mechanical ventilation, and improved recovery initiatives (ibid). Thanks to the recent technological advancements and innovations in healthcare systems (ibid). These innovations now offer a closer, better as well as easier monitoring of postoperative patients and it helps in improving the overall outcome (ibid).

Prehabilitation is one of the elements that are thought to have a great influence on the postoperative outcome (Bartels et al., 2013). Ideally, preoperative changes in the physical status in addition to better control of risk factors can be enhanced by digital tools and smart applications which are downloaded on smartphones and in tablets (ibid). According to Michard et al (2017), the connected devices including brachial cuffs as well as electronic scales are often used for self-monitoring of weight and blood pressure, better control of hypertension, and overweight, and the visualization of the surgical trends over time (ibid). Digital games have also been invented for smoking cessation, and for a number of activity trackers (ibid). Presently, apps exist to invite postoperative patients to monitor and increase their physical activity (ibid). These tools appear to be effective in dealing with post-surgical procedures (ibid).

Numerous sensors and monitoring systems are currently available for proactive post operated patients as well as ambulatory patients (ibid). According to Michard et al (2017), smart software has been developed to prevent alarm fatigue, to filter artifacts, and to fuse vital signs into the postoperative wellness indexes or the warning scores that are used for easy and visual identification of health deterioration, or even the prediction of hostile events beforehand (Pinsky et al. 2016).

Rehabilitation and Intraoperative Monitoring

Intraoperative fluid monitoring is one of the major determinants of postoperative outcome (Michard et al., 2017). Over the years, fluid overload has been known to be a major factor responsible for complications that are related to tissue oeadema such as prolonged mechanical ventilation along with anastomotic leak (ibid). Thus, fluid restrictions have been encouraged to some extent. Nevertheless, recent researches such as the one by Thacker et al (2016) have clearly illustrated that insufficient fluid administration is linked to a considerable increase in postoperative complications. According to Michard et al (2017), titrating and modifying fluid management to patient's needs is highly desirable to make certain that patients receive the accurate amount of fluid at the appropriate time. Multiple noninvasive hemodynamic monitoring interventions are currently available from the bio-impedance tracheal tubes, volume clamp approaches, applanation tonometry all the way to bio-reactance surface electrodes (ibid). They offer physicians an opportunity to measure and track any change in the blood flow during the therapeutic programs and to rationalize fluid management (ibid). Benes et al (2014) state that precluding unjustified fluid management by detecting fluid unresponsiveness has been considered to be important to minimize postoperative morbidity, hospitalization time and costs. Some of the noninvasive parameters including pulse pressure variation from volume clamp approaches, and pleth variability index from the pulse oximeters are helpful in detecting fluid unresponsiveness (ibid).

Pulse oximeters are used to continuously monitor the SpO2 as well as heart rate among the 2,841 orthopedic patients (ibid). According to Taenzer et al (2010), this use is linked to a significant decline in the number of rescue events as well as ICU transfers. Piezoelectric contact-free sensors placed under the mattress aids in the continuous monitoring of heart rate and respiratory rate among 2,314 medico-surgical patients (ibid). This patients' population has been linked to a significant decrease in the number of calls for hospitalization and cardiac arrest (Brown et al. 2014).

Subbe et al (2017) contend that wireless sensors have been invented recently to help in monitoring vital signs such as the heart rate, respiratory rate, SpO2, and blood pressure. It automatically calculates an early warning score and later alerts nurses in a case where deterioration has been detected (ibid). It is associated with a considerable decrease in the number of cardiac arrests as well as the mortality rates (ibid).

Blood Pressure Monitoring

There has been a strong correlation between intraoperative hypotension and postoperative difficulties such as acute kidney injury, stroke, and myocardial injury (Michard et al., 2017). It has been established that intermittent blood pressures measurements fail to allow the capture all of the hypotension happenings in a timely manner. According to Chen et al (2012) research, it suggests that patients may miss nearly seven minutes of hypertension per hour during a three hour orthopedic as well as abdominal procedures, especially when using the intermittent measures of blood pressure from a brachial cuff (ibid). Recently, it has been suggested that only a minimal number of minutes of hypertension are vulnerable to affect the postoperative outcome (ibid). Thus, though fatality between intraoperative hypotension and postoperative difficulties has not yet been developed, it appears reasonable for patients to avoid hypotension as much as they can (Salmasi et al. 2017). This may need a more rational as well as controlled use of the anesthetic agents, and especially during induction (ibid). It may also require continuous monitoring of blood pressure with the non-invasive methods for the immediate detection and correction of any considerable blood pressure drop (ibid).

Activity Trackers

Early mobilization is one of the core elements of postoperative recovery (ibid). Subbe et al (2017) argue that multiple sensors such as the waist, ankle or wrist sensors with gyroscopes and accelerometers are currently available to detect any movement or a body posture and thus quantify physical activity. Some of these sensors have been used with achievement for the objective valuations of early mobilization (ibid). Wearable sensors tailored to monitor cardio-respiratory function may aid in the early detection of medical deterioration during the postoperative recovery and to address the failure to rescue the issue (ibid).

Postoperative recovery outcomes are mainly evaluated by procedure specific quality of life scores with varying patient-reported outcome measures as well as satisfactory scores (ibid). However, several types of research have shown some difference between objective functional assessment and varying patient-reported outcome measures (ibid). Hence, activity levels do not always improve after a total hip and knee arthroplasty (ibid). According to (Salmasi et al. 2017), objective functionality assessments are desirable to better understand the reasons behind. Therefore, future efforts need to be put in place to optimize functional recovery and ought to include an objective assessment of functions through actigraphy (ibid). Activity trackers, as well as wearable accelerometers, are currently ubiquitous (ibid). However, as argued by several studies, it has been found out that some of the consumer products such as the sensors worn on the wrists, ankles, and waist are accurate enough for the objective purpose of assessment for mobility (Subbe et al. 2017). Nonetheless, caution ought to be undertaken especially when monitoring slow walking speed patients, which is often the case after a surgical procedure (ibid).

Electronic Checklists

Electronic checklists applications have been developed to optimize communication between healthcare experts and patients during the entire surgical journey (ibid). Before surgery, they are used to make sure that patients follow preoperative recommendations, especially in regards to medications (ibid). Checklists have been depicted to be helpful in implementing processes and in improving quality of care (ibid). Electronic checklists have been established to make certain that none of the ERP aspects are omitted during the surgical process (Michard et al. 2017). Most of them are available as applications and have been tailored both for patients and caregivers (ibid). Moreover, they have been designed to improve communication between patients and physicians (ibid). After surgery, and when a patient has been discharged from the healthcare center, they can aid in detecting and describing complications such as sharing of wound pictures and can help in offering guidance to patients (ibid).

Pain Monitoring

The optimal management of chronic postoperative pain is a major component of the Electronic Recovery Programs (Bartels et al., 2017). Important to understand is the fact that pain prolongs time to recovery and it delays discharge from the ward after surgery (ibid). Another important thing to note is the fact that opioids are still the backbone of most postoperative analgesic regimens (ibid). They are effective for severe pains (ibid). However, their use often prolongs the length of stay in the hospital due to dose-dependent side effects such as vomiting, sedation, respiratory depression, urinary retention, and postoperative nausea (Michard et al. 2017). Some physicians prescribe postoperative analgesia (ibid). This is defined as the use of multiple pain control modality to attain efficient analgesia while minimizing opioid-related side effects (ibid). Though multimodal analgesia is a core element of EPRs it is challenging to determine what the optimal doses and combinations are (ibid). Several technologies have however emerged to quantify the degree of nociception using a wide range of physiological variables (Bartels et al, 2013). Heart rate variability, blood pressure changes, and pulse wave amplitude, electroencephalographic and skin conductance signals have been widely proposed to help in the objective assessment of pain (ibid).

Facilitators

A postoperative patient after discharge can receive care from a community of pharmacists who make home visits (Michard et al., 2017). These pharmacists are able to secure continuity of care and have the capacity to prevent drug-related complications (ibid). Presently, this kind of care is not standard practice and thus its implementation poses a challenge (ibid). Thus, mapping of the aspects impacting the implementation of this new form of healthcare is essential to make certain that successful embedding takes place (ibid). Pharmaceutical facilitators aid in the implementation of home visits and offer the post discharged patients' daily routine (Daliri et al. 2019). Thus, ensuring that the postoperative process after discharge is a success and the patients fully recover from the surgical procedure (ibid).

Additionally, caregivers can collaborate with patients and family members in offering care after the surgical process (ibid). The ultimate aim of patient and family engagement is to establish better conditions for patients, relatives, the kindred members, clinicians, and members of the clinical team to work together as partners towards improving the quality and safety of care at home after surgery (Daliri et al. 2019). This collaboration is vital since healthcare quality and safety directly affects the individual as well as the family (ibid).

Furthermore, patients are more likely to participate in their care if they are invited to take part in it. Sanger et al (2014) claim that many individuals do not apprehend that they have the right to actively be involved in their case after surgery until given permission or an invitation to do so. Additionally, the lack of information may hinder patients from asking questions about their diagnosis and procedures for their wellness after being discharged from surgery (ibid). Thus, giving patients clear and accessible information can aid engagement (ibid). Individuals with self-efficacy and perceived capability to engage in their own care, are more likely to recover successfully after being discharged from a surgical procedure (Sanger et al. 2014). Similarly, family members and friends with higher levels of self-efficacy are also more probable to take part in the care of their loved ones after they are discharged from the hospital (ibid). It is thus important for caregivers, pharmacists' community and physicians to understand the vital role of family involvement in the wellness and monitoring of postoperative care (ibid).

Barriers

Though the interventions in precision postoperative wellness monitoring systems have been considered effective over the years, their implementation has been a challenge due to several barriers. According to Daliri et al (2019), some of the most common barriers include problems in a healthcare organization, insufficient information, and lack of personalized care within the care continuum. However, for facilitators to overcome these barriers, they have to include a personal counselor within the care continuum in order to counsel patients with medication use, post-discharge follow-up care such as home visits from the caregivers, and guide in overcoming communication barriers (ibid).

Lack of resources including the cost of a procedure, buying wireless and wearable devices and support resources for postsurgical care at home acts as a barrier for patients and families to engage in the postoperative wellness monitoring interventions (Sanger et al. 2014). Literacy levels are another barrier to the implementation of post-discharge wellness programs (ibid). A patient's or family's capability to comprehend healthcare information is crucial to engagement (ibid). Dwindled cognitive capabilities may impede commitment and age-related comorbidities (Daliri et al. 2019). Literacy levels such as non-native English speakers and low literacy may further deter communication with the caregivers at the desired level, in spite of the use of translators (ibid).

Clearly, postoperative complications are a key clinical and economic burden. Each year, postoperative complications are responsible for a million number of death cases (ibid). Most of these complications after surgical procedures and the mortality rate would be prevented with better intraoperative management (ibid). Early detection of adverse events helps in the making of informed therapeutic decisions (ibid). The technological revolution is transforming the health sector, and physiologic monitoring ought to dramatically benefit the ongoing software and hardware inventions (ibid). Novel and future monitoring tools have the capability to assist us in bettering the quality of surgical care from pre-habilitation (ibid). Especially wireless and wearable sensors can aid in detecting clinical deterioration at a very early stage in hospitalized patients (ibid). Through the triggering of timely interventions, they have the capacity to decline the number of ICU admissions, postoperative mortality rates, and cardiac arrests (ibid).

DISCUSSION AND CONCLUSION

Given the advances in mobile health and the plethora of Apps now available, it is clear that mobile health is an integral part of healthcare delivery today and needs to be managed so that the benefits of mobile can be enjoyed and the limitations can be minimized. It is clear that clinician and care team involvement is important. It is equally vital that privacy and security aspects are considered at all times. Without a doubt mobile is certainly showing the potential to enhance the patient experience and support high quality and high value care to ensue.

REFERENCES

Abaza, H., & Marschollek, M. (2017). mHealth Application Areas and Technology Combinations. *Methods of Information in Medicine, 56*(S1), e105-e122.

Anshari, M., & Almunawar, M. N. (2016). Mobile health (mhealth) services and Online health educators. *Biomedical Informatics Insights, 8*, BII-S35388.

Bartels, K., Karhausen, J., Clambey, E. T., Grenz, A., & Eltzschig, H. K. (2013). Perioperative organ injury. *Anesthesiology*, *119*(6), 1474–1489. doi:10.1097/ALN.0000000000000022 PMID:24126264

Benes, J., Giglio, M. T., Brienza, N., & Michard, F. (2014). The effects of goal-directed fluid therapy based on dynamic parameters on post-surgical outcome: A meta-analysis of randomized controlled trials. *Critical Care (London, England)*, *18*(5), 584. doi:10.118613054-014-0584-z PMID:25348900

Brown, H., Terrence, J., Vasquez, P., Bates, D. W., & Zimlichman, E. (2014). Continuous monitoring in an inpatient medical-surgical unit: A controlled clinical trial. *The American Journal of Medicine*, *127*(3), 226–232. doi:10.1016/j.amjmed.2013.12.004 PMID:24342543

Carroll, J. K., Moorhead, A., Bond, R., LeBlanc, W. G., Petrella, R. J., & Fiscella, K. (2017). Who uses mobile phone health apps and does use matter? A secondary data analytics approach. *Journal of Medical Internet Research*, *19*(4), e125. doi:10.2196/jmir.5604 PMID:28428170

Chen, G., Chung, E., Meng, L., Alexander, B., Vu, T., Rinehart, J., & Cannesson, M. (2012). Impact of non-invasive and beat-to-beat arterial pressure monitoring on intraoperative hemodynamic management. *Journal of Clinical Monitoring and Computing*, *26*(2), 133–140. doi:10.100710877-012-9344-2 PMID:22382920

Daliri, S., Bekker, C. L., Buurman, B. M., Scholte op Reimer, W. J. M., van den Bemt, B. J. F., & Karapinar - Çarkit, F. (2019). Barriers and facilitators with medication use during the transition from hospital to home: A qualitative study among patients. *BMC Health Services Research*, *19*(1), 204. doi:10.118612913-019-4028-y PMID:30925880

International Surgical Outcomes Study Group. (2016). Global patient outcomes after elective surgery: Prospective cohort study in 27 low-, middle-, and high-income countries. *British Journal of Anaesthesia*, *117*(5), 601–609. doi:10.1093/bja/aew316 PMID:27799174

Källander, K., Tibenderana, J. K., Akpogheneta, O. J., Strachan, D. L., Hill, Z., ten Asbroek, A. H., ... Meek, S. R. (2013). Mobile health (mHealth) approaches and lessons for increased performance and retention of community health workers in low-and-middle-income countries: A review. *Journal of Medical Internet Research*, *15*(1), e17. doi:10.2196/jmir.2130 PMID:23353680

Klasnja, P. V., & Pratt, W. (2014). Managing health with mobile technology. *Interactions, 21*(1), 66-69.

Michard, F., Gan, T. J., & Kehlet, H. (2017a). Digital innovations and emerging technologies for enhanced recovery programmes. *British Journal of Anaesthesia*, *9*. doi:10.1093/bja/aex140 PMID:28605474

Michard, F., Mountford, W. K., Krukas, M. R., Ernst, F. R., & Fogel, S. L. (2015). Potential return on investment for implementation of perioperative goal directed fluid therapy in major surgery: A nationwide database study. *Perioperative Medicine (London, England)*, *4*(1), 11. doi:10.118613741-015-0021-0 PMID:26500766

Pinsky, M. R., Clermont, G., & Hravnak, M. (2016). Predicting cardiorespiratory instability. *Critical Care (London, England)*, *20*(1), 70. doi:10.118613054-016-1223-7 PMID:26984263

Robbins, R., Krebs, P., Jagannathan, R., Jean-Louis, G., & Duncan, D. T. (2017). Health app use among US mobile phone users: Analysis of trends by chronic disease status. *JMIR mHealth and uHealth*, *5*(12), e197. doi:10.2196/mhealth.7832 PMID:29258981

Sanger, P. C., Hartzler, A., Han, S. M., Armstrong, C. A., Stewart, M. R., Lordon, R. J., ... Evans, H. L. (2014). Patient perspectives on post-discharge surgical site infections: Towards a patient-centered mobile health solution. *PLoS One*, *9*(12), e114016. doi:10.1371/journal.pone.0114016 PMID:25436912

Stephanie, W. Y., Hill, C., Ricks, M. L., Bennet, J., & Oriol, N. E. (2017). The scope and impact of mobile health clinics in the United States: A literature review. *International Journal for Equity in Health*, *16*(1), 178. doi:10.118612939-017-0671-2 PMID:28982362

Subbe, C. P., Duller, B., & Bellomo, R. (2017). Effect of an automated notification system for deteriorating ward patients on clinical outcomes. *Critical Care (London, England)*, *21*(1), 52. doi:10.118613054-017-1635-z PMID:28288655

Thacker, K., Moutford, W. K., & Ernst, F. R. (2016). Perioperative fluid utilization variability and association with outcomes: Considerations for enhanced recovery efforts in sample US surgical patients. *Annals of Surgery*, *263*(3), 502–510. doi:10.1097/SLA.0000000000001402 PMID:26565138

Chapter 26
Facilitating Mobile Initiatives in Healthcare and Wellness Management

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ABSTRACT

Arguably, the most prevailing chronic disease today is diabetes. The World Health Organization (WHO) notes that diabetes is a silent epidemic, and by 2020, there will be a 54% rise in the total number of individuals diagnosed with this disease. These are distressing figures. Many are turning to technology solutions to assist. What becomes important is the ability to rapidly design and develop appropriate digital health and wellness solutions.

INTRODUCTION

Today chronic conditions such as diabetes, cancer and obesity are increasing exponentially and dominate healthcare budgets globally (Lancet, 2016). At the same time, technology and digital health continue to advance. We see this as an opportunity to design and develop suitable technology solutions to support digital health and wellness initiatives. A key success factor in this regard is to have a suitably robust business model and delivery framework as the following presents.

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Diabetes and its Management

Diabetes Mellitus is characterised by a lack of endogenous insulin and resulting in hyperglycaemia and the excretion of excess glucose in urine (Krall and Beaser,1989). The basic defect appears to be an absolute or relative lack of insulin production from the pancreas, which leads to abnormalities mainly in carbohydrate metabolism, as well as in protein and fat metabolisms (ibid). Severe untreated diabetes, of which hyperglycaemia is just one aspect of metabolic derangement, can lead to both macro and microvascular complications (ibid). A relatively simple and non-invasive method of preventing these complications is to recognise the impact of diet on insulin production and maintenance and thus follow a healthy diet and regular exercise regimen or wellness plan (Hu et al., 2001). Therefore, people with diabetes mellitus need help in planning and accepting a daily diet which contains the appropriate amounts of carbohydrates, protein, fat and fibre, together with adequate amounts of vitamins and minerals (ibid). It is important to distinguish that Type I Diabetes Mellitus (T1DM) is characterised as an autoimmune disease, while Type II Diabetes Mellitus is an acquired chronic disease characterised by decreased insulin secretion and an increase in insulin resistance (Krall and Beaser,1989). Although diet plays a role in T1DM, it has a greater impact in the management of T2DM (Hu et al., 2001).

Early diabetes management needs to focus on lifestyle modification, specifically modest weight loss and increased physical activity (ibid). Even for people with advanced stages of diabetes, lifestyle and diet intervention are likely to be beneficial in limiting the complications of sustained hyperglycaemia (ibid). Lifestyle changes including daily exercise and appropriate diet can be applied broadly, or can be directed to individuals who are thought to be at increased genetic risk for diabetes as ascertained by information such as family history of diabetes (ibid). When individuals transfer from a pre-diabetic to a diabetic phase then the focus to addressing the problem changes from a wellness management to a healthcare management issue ibid).

According to Davidson et al.(1986), there are three streams of lifestyle and medical interventions:

i) Diet (Kepf et al., 2014): Prolonged dietary treatment of diabetes is the very baseline of all forms of anti-diabetic treatment (ibid). An important cornerstone and the aim of dietary treatment is a well designed meal, taking account of the total calorie content and nature of diet (ibid).
ii) Diet and oral hypoglycemic agents (Kohnert et al., 2009): Diet combined with oral hypoglycaemic agents is the next tier in diabetes treatment. There are several classes of orally administered anti-diabetic agents available for use in patients with T2DM,
iii) Diet and insulin (ibid): When a person with T2DM cannot be managed with diet and oral hypoglycemic agents alone, insulin is introduced for better management of the condition. Insulin therapy in T2DM supplements endogenous insulin and is often given as a single injection before breakfast or at bedtime.

Key Issues Emerging Due to Diabetes

Diabetes can lead to a number of health issues e.g., blindness, amputation, heart disease, kidney, nerves and blood vessels problems (Krall and Beaser, 1989).

Vision impairment and Blindness

Diabetes has been blamed to cause impairment in vision and blindness, it has affected around 1 in 3 Australians for diabetic retinopathy whereas 1 in 6 Australians suffer from diabetic macula edema, which costs around $2 billion in Australia (ibid).

Kidney Damage

People suffering from diabetes have higher chances of developing kidney disease, especially people suffering from type 2 diabetes, abnormality in serum creatinine may indicate the renal arterial disease (ibid).

Ischaemic Heart Disease and Arterial Damage

A diabetic person is likely to develop heart problems 2- 4 times than a non-diabetic person (ibid). Around 65-75% of people suffering from type 2 diabetes have been found affected by heart issues (ibid). The heart problems occurring due to diabetes mostly go unnoticed and results in death of half of such population (ibid). Type 2 diabetes has been associated with major cause of death and physical disability due to arterial damage (ibid). Diabetic people are at more risk for an early age heart attack than a non-diabetic person, every year around 33, 000 Australians experience a diabetes related heart attack(ibid).

Amputation

Diabetic foot ulcer has claimed around 10,000 hospital admissions each year and resulted in complete or part amputation of limb for around 4,400 Australians (ibid). In addition hospitalization and amputation, diabetic foot ulcer costs Australia $ 875 million each year (ibid). It is predicted that research investment for diabetic foot ulcer might save Australia around $ 2.7 billion (ibid).

Thus, the management of type 2 diabetes is very complex and needs a team of people to help manage the disease. The most important factors are blood parameters, diet, exercise and stress. However, as diabetes is a chronic condition and thus typically once a person has diabetes they rarely recover, it is important that they continue to be vigilant and manage their condition carefully. With this in mind, we foucssed on the design and development of a mobile solution for supporting people with diabetes so they can self-manage and be more empowered (Goldberg, 2002a; 2002b; 2002c; 2002d; 2002e; Wickramasinghe and Goldberg, 2004).

THE DIAMOND SOLUTION

The DiaMonD solution was developed by Inet Intl. Inc, a Canadian company to provide diabetes elf-management and monitoring to all patients suffering from diabetes (ibid). The goal of the solution is to support people at different stages of diabetes to self-manage and feel more empowered and yet where necessary have their clinical care team involved and presented with the germane information necessary to make sound clinical decisions that will in turn lead to optimal clinical outcomes. The solution has been demonstrated to support better levels of HbA1C in clinical trials (Wickramasinghe et al., 2019) Succinctly figure 1 shows the basic solution as developed by inet. Key aspects of the solution include

Figure 1

it is fully HIPAA compliant, totally pervasive which means it works on any mobile platform (Android, IOS etc) and it requires co-use or co-adoption of patient and their clinical care team.

Design Science, User Centred Design and Co-Creation

An important consideration to designing digital solutions is to include the user. This becomes more complex in healthcare when there are often different user groups (patients and clinicians) who have different requirements, likes and preferences. Design Science research Methodology is often touted as an appropriate approach to ensure full engagement of the user in the design of the solution. We also believe it should be combined with user-centred design principles and co-creation to fully capture user enthusiasm, buy-in and likelihood of using the developed solution.

Design science is an important and legitimate research paradigm in information systems (Gregor & Hevner, 2013). Basically, it involves creating a wide range of socio-technical artefacts, such as new software, processes, algorithms or systems intended to improve or solve an identified problem (Myers & Venable, 2014). The design science procedures initiated from information-systems design theory originally proposed by Walls et al. (1992) as a prescriptive theory which integrates normative and descriptive theories into design paths intended to produce more effective information systems. Eventually, Peffers et al. (2007) expanded design theory into a design science research methodology by incorporating the principles, practices and procedures required to carry out research by applying design science theory. Importantly it was propsoed that design science theory as a methodology, needs to be consistent with prior literature, provide a nominal process model for doing design science research, and provide a mental model for presenting and evaluating design science research (Peffers et al. 2007). Moreover, Hevner and Wickramasinghe (2017) note that in healthcare contexts use of design science research methodology is especially prudent when fine tuning innovative solutions.

Hevner et al. (2004) presented seven strategies for understanding, executing, and evaluating design science research. Various healthcare studies (Nguyen and Wickramasinghe 2017) have used these principles for building algorithms and systems. The three-cycle view captures the design science research idea to refine the artefact design iteratively through several interconnected *design*, *relevance*, and *rigor* cycles as illustrated by Hevner (2007). The improved four-cycle model of IS design science research for capturing the dynamic nature of IS artefact design was developed later (Drechsler & Hevner 2016). This refinement is intended to increase both the artefact's effectiveness to address the real-world problem as well as its knowledge contributions over several iterations. The fourth cycle in the DSR model, termed as *change and impact* cycle, is to better capture the dynamic nature of artefact design for dynamic real-world contexts. Applying the change and impact cycle to a mobile healthcare application like DiaMonD, the app itself, the mobile device(s), and the patients and/or clinicians that use the app, we believed is prudent and greatly assists to ensure that the solution is fit for purpose in the specific healthcare context.

The Adaptive Mapping to Realization

However, and in addition to designing a solution that subscribes to design science principles, what is a critical success factor for this solution is the delivery framework and business model that were also developed in order to progress this solution from idea to design, development and successful deployment. Figure 2 presents this unique adaptive mapping to realization model.

Successful digital health solutions require a consideration of many components. As can be seen in Figure 2, the presented integrative model brings together all key factors that we have identified through our research that are necessary in order to achieve a superior patient experience and better outcomes. Specifically, the inputs fall into three main categories physical resources, intellectual resources and financial resources. As with all IT projects people, process and technology inputs are vital, however in healthcare the protection (security aspects), especially in light of HIPAA in the US (and other similar regulations in other countries), is also a key input. Hence, it is best to address these considerations as inputs to the system than after the fact trying to assess compliance.

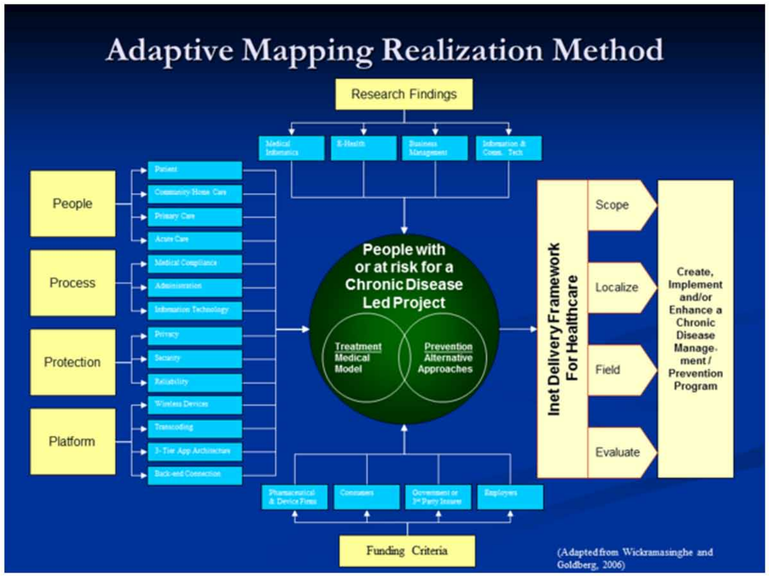
Given the dynamic nature of healthcare, new discoveries are being made continuously. Any digital health solution must then try to capture these latest findings and apply them to the project. It is for this reason that the presented model has research findings drawn from medical informatics, e-health, business and information technology areas as inputs to the specific mobile e-health project.

The last component of the inputs is funding. Given that the goal of solution is to be sustainable and provide ongoing support to the person with diabetes it is crucial to realize funding and sustainability are important considerations.

Finally, it is important to notice that the model consists of two parts; a health solution and a wellness solution. We make this important distinction because we believe that a health solution must be grounded in a medical model and subscribe to health privacy rules and policies such as HIPAA while a wellness solution may not necessarily fall under the same level of rigor but should still be systematically and responsibly designed, developed and deployed.

Central to the success of any digital health solution is that it is patient centricity led (Leescher, 2012). This differs from patient centered in that the information and interactions emanate from the patient-user (ibid). The digital health technologies are then built around the premise that personalized data and interactions are prompted by the patient and managed by both the patient and provider (Leescher, 2012; Wickramasinghe et al., 2019). What makes this model unique and most beneficial is its focus on

Figure 2.



enabling and supporting all areas necessary for the actualization of Information and Communication Technology initiatives in healthcare. By design, since fundamentally this is a business model, the model identifies the inputs necessary to bring an innovative chronic disease management solution to market. These solutions are developed and implemented through a physician-led digital health focus. Hence, at the heart of the model to bridge the needs and requirements of many different players into a final (output) deliverable a better health outcome and patient experience. To accomplish this, the model is continually updated to identify, select and prioritize the Information and Communication Technology (ICT) project inputs that will:

a) Accelerate healthcare system enhancements and achieve rapid healthcare benefits. The model identifies the key healthcare system inputs with the four Ps 1) People that deliver healthcare, 2) Process to define the current healthcare delivery tasks, 3) Platform used in the healthcare technology infrastructure and 4) Protection of patient data.
b) Close the timing gaps between information research studies and its application in healthcare operational settings.
c) Shorten the time cycle to fund an ICT project and receiving a return on the investment

DISCUSSION AND CONCLUSION

Today, chronic diseases have replaced infectious diseases as one of the top global causes of deaths and morbidity [Centre for Diseases Control http://www.cdc.gov/]. Diabetes is one of the five major chronic diseases and has been termed by the WHO as the silent epidemic [WHO, http://www.who.int/topics/diabetes_mellitus/en/]. By definition, for most sufferers of diabetes (or other chronic diseases), there is no likely cure, which makes prudent management of their condition key to living a quality life. Good management is predicated on pertinent information and germane knowledge (Wickramasinghe et al. 2014), which at times is not always easy for these patients to access and/or acquire.

Digital solutions offer the promise of a better, higher quality of life for such individuals. These solutions now span the wellness to healthcare continuum and need to be designed, developed and deployed responsibly. We contend that the presented adaptive mapping to realization (AMR) model enables and supports the responsible design, development and deployment of such solutions.

In todays current high paced knowledge economy commercialization of a good idea is important. Especially in healthcare too many innovative ideas never make it to successful commercialization due to the inherent risks and lengthy development stages. The presented AMR model provides an opportunity to have a robust methodology that also supports rapid commercialization. Moreover, the dynamic nature of the model facilitates the continuous incorporation of prior lessons and knowledge into the project process; thereby making it a truly knowledge-based methodology.

We note in closing that our AMR model can and should be adopted for all digital health and wellness initiatives and we urge for further application of the methodology in non-healthcare initiatives as well.

REFERENCES

Davidson, S. S., Passmore, R., & Eastwood, M. A. (1986). *Human Nutrition and Dietetics* (8th ed.). English Language Book Society.

Drechsler, A., & Hevner, A. (2016). A four-cycle model of IS design science research: capturing the dynamic nature of IS artifact design. In *Proceedings of the 11th International Conference on Design Science Research in Information Systems and Technology*. St. John, Canada: DESRIST 2016.

Goldberg, S. (2002a). *Building the Evidence for a Standardized Mobile Internet (wireless) Environment in Ontario, Canada*. January Update, internal INET documentation.

Goldberg, S. (2002b). *HTA Presentational Selection and Aggregation Component Summary.* internal documentation.

Goldberg, S. (2002c). *Wireless POC Device Component Summary*. internal INET documentation.

Goldberg, S. (2002d). *HTA Presentation Rendering Component Summary*. internal INET documentation.

Goldberg, S. (2002e). *HTA Quality Assurance Component Summary*. internal INET documentation.

Gregor, S., & Hevner, A.R. (2013). Positioning and presenting design science research for maximum impact. *MIS Quarterly, 37*(2), 337-355.

Hevner, A., March, S., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS Quarterly, 28*(1), 75-105.

Hevner, A., & Wickramasinghe, N. (2017). Design Science Research Opportunities in Healthcare. *Theories for Health Informatics Research.*

Hevner, A. R. (2007). A three cycle view of design science research. *Scandinavian Journal of Information Systems, 19*(2), 4.

Hu, F. B., Manson, J. E., Stampfer, M. J., Colditz, G., Liu, S., Solomon, C. G., & Willett, W. C. (2001). Diet, Lifestyle, and the Risk of Type 2 Diabetes Mellitus in Women. *The New England Journal of Medicine*, *345*(11), 790–797. doi:10.1056/NEJMoa010492 PMID:11556298

Kempf, K., Schloot, N.C., Gärtner, B., Keil, R., Schadewaldt, P., & Martin, S. (2014). Meal replacement reduces insulin requirement, HbA1c and weight long-term in type 2 diabetes patients with >100 U insulin per day. *Journal of Human Nutrition & Dietetics, 21*(7).

Kohnert, K. D., Augstein, P., Zander, E., Heinke, P., Peterson, K., Freyse, E. J., . . . Salzsieder, E. (2009). Glycemic variability correlates strongly with postprandial beta-cell dysfunction in a segment of type 2 diabetic patients using oral hypoglycemic agents. Diabetes Care, 32(6), 1058-62.

Krall, L. P., & Beaser, R. S. (1989). *Joslin's Diabetic Manual* (12th ed.). Philadelphia: Lea and Febiger.

Leescher, D. (2012). *How patient-centric care differs from patient-centered care*. Available at: https://davidleescher.wordpress.com/2012/03/03/how-patient-centric-care-differs-from-patient-centered-care-2/

Myers, M., & Venable, J. (2014). A set of ethical principles for design science research in information systems. *Information & Management, 51*(6), 801-809.

Nguyen, L., & Wickramasinghe, N. (2017). An examination of the mediating role for a nursing information system. *AJIS. Australasian Journal of Information Systems*, *21*. doi:10.3127/ajis.v21i0.1387

Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A design science research methodology for information systems research. *Journal of Management Information Systems, 24*(3), 45-77.

Walls, J. G., Widmeyer, G. R., & El Sawy, O. A. (1992). Building an information system design theory for vigilant EIS. *Information Systems Research, 3*(1), 36-59.

Wickramasinghe, C. S., Kliman, L., Vogel, D., & Goldberg, S. (2014). *Exploring the Possibility for a Pervasive Technology Solution to Facilitate Effective Diabetes Selfcare for Patients with GDM*. Paper presented at 2014 ECIS, Tel Aviv, Israel.

Wickramasinghe, N., & Goldberg, S. (2004). How M=EC2 in Healthcare. *International Journal of Mobile Communications*, *2*(2), 140–156. doi:10.1504/IJMC.2004.004664

Wickramasinghe, N., John, B., George, J., & Vogel, D. (2019). *Achieving Value-Based Care in Chronic Disease Management: The DiaMonD (diabetes monitoring device)*. Solution JMIR Diabetes.

Chapter 27
Technology's Enabling Role to Improve Care Coordination

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ABSTRACT

The U.S. healthcare system has been often characterized as fragmented and disconnected. Lack of effective and concurrent adoption of information technology has been known to be a factor that contributes to the decentralization of healthcare systems. Fragmented systems are also responsible for creating silos that operate with minimal coordination. Clinicians in such systems are providing duplicate services because they are not aware of patient care plans set by other practitioners. These duplications could lead to prescription drug errors due to inconsistencies and lack of coordination in the treatment services and in some cases drug-drug interactions. The following suggests a role for technology to facilitate better care coordination.

INTRODUCTION

Improving coordination between clinical settings will minimize fragmentation. With Medicare patients visiting on average close to seven providers in four settings annually, a large number of clinicians are linked to each other within patient-care networks (Kern, et al., 2019). Primary care providers positioned in these care networks are required to communicate with more than two hundred physicians and coordinate their Medicare patients care plans (Kern, et al., 2019). This amount of communication and care coordination requires accuracy and robust information systems that will optimize the data integration process. The process of care coordination will ideally include all patient needs, preferences, and capabilities (Pham, O'Malley, Bach, Saiontz-Martinez, & Schrag, 2009) which are gathered from different care settings to assist clinicians with the decision making process . The coordination of care also relies

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on active and accurate interaction between providers and patients. Patients with multiple chronic conditions and complex needs require a higher level of coordination to improve the quality of care services provided and control the cost of these services (Berenson & Horvath, 2003).

Enabling Role for Technology

The implementation of health information systems (HIS) can have vast and diverse indications on care measures. Different clinical settings could impose a wide range of requirements on health information systems. In complex clinical encounters with high-risk patients, clinical settings are required to assess a large volume of health information in a short period of time and carefully manage the appropriate health data to deliver to applicable clinicians. While health information management is highly relevant for providers, patients with multiple chronic illnesses require care services from different practitioners in a coordinated environment with an effective integration of care information (McCullough, Parente, & Town, 2016). In addition to these distinctions in processing health data (that are associated with different care settings), there also remains a high demand on health data reporting associated with regulations and value-based reimbursement models (McCullough, Parente, & Town, 2016). Several important factors influence the success of HIS implementations. One of these components is the degree of integration between implemented health information technology and clinical workflow which in turn relies on the complexity of the care facility and the level of investment and commitment displayed by the organizational leadership. Health information technology improves the communication and coordination of clinical care in addition to supporting information management.

Current Challenges

Delivering cost-effective and value-enhancing care to a growing aging population is a substantial challenge for the healthcare systems. The rate of health care services consumption by patients who have one or more chronic conditions or multiple concurrent chronic conditions (MCC) is rising. Chronic conditions included in research studies are arthritis, asthma, chronic respiratory conditions, diabetes, heart disease, human immunodeficiency virus infection, and hypertension. According to the Agency for Healthcare Research and Quality (AHRQ) in 2009, 21% of total health expenditure was consumed by only one percent of the population and 30% of the population were responsible for about 89% of healthcare expenditure (Cohen & Yu, 2012). In the same year the average expenditure of these top consumers was close to $100,000 annually (Cohen & Yu, 2012). Medicare beneficiaries with two or more chronic conditions are considered the heaviest users of care services that consume close to 93% of Medicare spending (Lochner & Cox, 2013).The rising cost of treating Medicare beneficiaries with chronic conditions is a major contributor to the overall growth in Medicare spending (Thorpe, Ogden, & Galactionova, 2010). Several important indicators such as patient mortality, poor functional status, unnecessary hospitalizations, adverse drug events, duplicative tests, functional limitations, need for assistance with daily activities, and conflicting medical advice do increase with the increased number of chronic conditions in patients (U.S. Department of Health and Human Services, 2010). These indicators directly impact healthcare cost and patient care quality.

According to the Institute of Medicine (IOM), patients with MCCs require coordinated care that does not focus solely on one of the conditions. One of the challenges that providers encounter when designing care services for chronic patients is designing care services that encompass all patient needs and not a single condition (U.S. Department of Health and Human Services, 2010). The IOM introduced a framework for chronic care treatment models that included healthcare system requirements, community support resources, self-management support, innovative care delivery design, decision support systems, and clinical information systems (U.S. Department of Health and Human Services, 2010). Factors such as number of chronic conditions, severity of each illness, patient overall status, clustering of conditions contribute to the clinical heterogeneity (characteristic) of chronic conditions (U.S. Department of Health and Human Services, 2010). Several initiatives for improving the quality of care for chronically-ill patients have emphasized on stakeholder engagement by empowering providers, patients, and community support groups. Unfortunately, limited effort has been made to detect the natural clustering of chronic conditions (Vogeli, et al., 2007). The presence of different illnesses in given patient group sets, could have a varying impact on patient's disability and quality of life.

Lack of coordinated care could have profound adverse impact on MCC patients. Patient functional impairment could be impacted by certain chronic conditions more than others. There exists a stronger association between certain chronic conditions or certain clusters of chronic conditions and patient functional impairments (Dunlop, Lyons, Manheim, Song, & Chang, 2004). Furthermore, MCC that included a given set of diseases displayed a strong association with patient functional impairment than the association of the individual illnesses (within the MCC) with patient functional impairment (Fried, Bandeen-Roche, Kasper, & Guralnik, 1999). MCC patients could also encounter difficulty in following instructions from multiple providers and effectively engage in the care process. To ensure the quality of care delivered to MCC patients, care facilities must systematically explore the relationship between quality care programs and clusters of chronic conditions (Vogeli, et al., 2007).

Changes to Leverage the Benefits of Technology

To improve quality of care and reduce cost, the Centers of Medicare and Medicaid Services (CMS) initiated several programs that incentivized healthcare facilities for the effective adoption of information technology. The meaningful use programs (one, two and three) were designed to assist providers and hospitals in adopting and implementing EHR systems through grants in the form of incentive payments (Centers for Disease Control and Prevention, n.d.). The third stage of meaningful use programs emphasized on the effective use of health technology in clinical workflow such as electronic prescribing, decision support systems, computerized provider order entry (CPOE), and coordinated care by engaging patients. In summary, the stage three meaningful use regulations were designed to improve health information exchange between clinical settings and overall health outcomes (Gruessner, 2015). In 2015 the Medicare Access and CHIP Reauthorization Act (MACRA) was introduced by ending the Sustainable Growth Rate (SGR) formula and promoting two quality payment programs:

- Advanced Alternative Payment models (APM)
- Merit-based Incentive Payment System (MIPS)

These two programs promoted incentive payments and performance-based payment adjustments respectively (Office of the National Coordinator for Health Information Technology, n.d.). The release of the MIPS regulations motivated vendors to develop certified EHR systems that are offering built-in monitoring tools for the performance categories (quality, improvement activities, cost, advancing care information) established by the Centers for Medicare & Medicaid Services (CMS) (Office of the

Table 1. MACRA

MACRA		
	MIPS	*APM*
1	Quality	Care Coordination
2	Improvement Activities	Quality measurement
3	Cost	Improving patient-clinician relationship
4	Advancing Care Information	

National Coordinator for Health Information Technology, n.d.). A main difference between MIPS and previous quality programs such as physician quality reporting system (PQRS) is that MIPS scores are calculated based on the performance of a measure versus receiving scores in PQRS merely due to clinicians reporting on a measure (Hirsch, Rosenkrantz, Ansari, Manchikanti, & Nicola, 2016). In APMs clinicians are provided with an opportunity of participation within initiatives that improve care quality, promote coordinated care, and enhance cost-efficiency and in many cases exclude these clinicians from the MIPS program (Office of the National Coordinator for Health Information Technology, n.d.). APM programs although designed differently for each care setting, they could benefit from certified health IT features. Concepts such as care coordination, quality measurement, and engaging patients within the care process. The main goals of MACRA (Table 1) were to engage patients in the process of care and enhance care coordination (Hirsch, Rosenkrantz, Ansari, Manchikanti, & Nicola, 2016).

Many healthcare initiatives have tried over the past several decades to minimize cost and improve quality by detecting value in care processes. Many studies have been completed to address what is known as the "the cost disease" or "Baumol's disease" (Baumol, et al.). Healthcare reform could be divided in three main categories:

- Alternative payment models used as incentives to improve value delivered in care tasks.
- Encouraging coordinated care through integrated health systems.
- Implement information systems in healthcare to improve quality of care (Hirsch J. A., et al., 2015).

The MACRA initiative was an effort to develop a program that includes physician quality reporting system (by CMS), Value-Based Payment Modifier Program, and Meaningful Use initiative (Hirsch J., et al., 2016).

MIPS and APM programs were designed to improve care quality by engaging stakeholders through effective reporting/monitoring of clinical processes. Providers however are concerned about several factors that could impact the performance of the MACRA initiatives. Practitioners who participated in a survey that was conducted to assess their understanding about the MIPS program, expressed lack of familiarity with the policy details and displayed disagreement with the ranking system that associated weight to different domains of the program (Liao, Shea, Weissman, & Navathe, 2018). Through MIPS programs, clinicians are required to participate in four distinct practice improvement sections:

- Developing clinical quality measure reports.
- Participating in activities that improve clinical practice
- Minimizing cost by controlling the use of resources
- Improving the use of care information (Liao, Shea, Weissman, & Navathe, 2018).

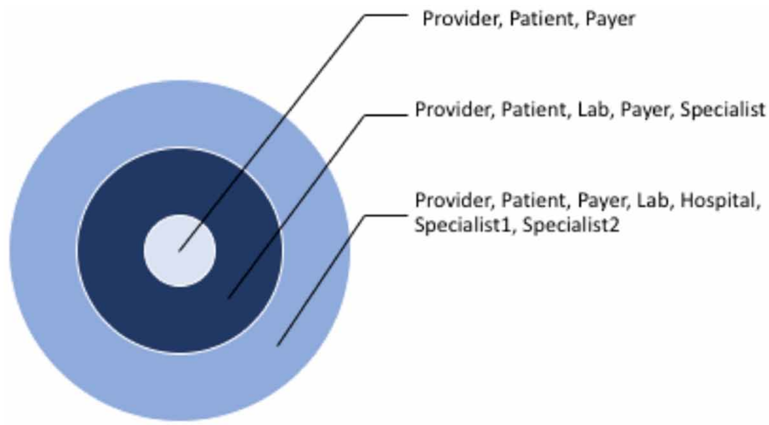
Based on the findings from the same survey, policy makers are encouraged to engage physicians in the development of value-based initiatives. This engagement could include both training and educating practitioners about the initiative and its link to improving value within care services in addition to incorporating physicians' input in developing value-based care policies (Liao, Shea, Weissman, & Navathe, 2018). It is essential for policy makers to consider the unintended consequences that could follow adopting new policies and include patient satisfaction and experience in the domains that are considered to produce the final score (Liao, Shea, Weissman, & Navathe, 2018). Advanced tracking/monitoring features added to health systems could track clinical practice changes and stakeholder input.

DISCUSSION AND CONCLUSION

Value-based models link care delivery system outcomes to payment models to promote efficiency and effectiveness in healthcare systems. To improve the quality of care services, these models must incorporate accurate and timely health data in comprehensive models to include all clinical practice dynamics and impactful factors. The main focus of newly developed payment models is to measure the performance of the care services. However, many existing performance measures do not assess the quality of the clinical activities comprehensively (Clough & McClellan, 2016). Several important factors such as the severity of individual patient condition, health literacy, and access to follow-up care that will directly impact the care outcome are usually not tracked with performance measures. Measures that are designed to capture care details from patients who visit several clinical settings will create opportunities for improving care and minimizing cost (Clough & McClellan, 2016). Care performance measuring systems must monitor developments from all heterogeneous participating stakeholders to detect patterns that impact the quality of care outcomes. To evaluate performance-based payment models for quality improvement, health IT systems must identify the care activity scope and all participant's contributions (Marjoua & Bozic, 2012). A structured evaluation approach that systematically monitors all facets of an identified care activity(scope) and extends through a time period will be required to create a baseline for comparison and standardization.

One of the main challenges in assessing the quality of care activities is the broad scope (stakeholder diversity) of healthcare systems. Another important concept in designing quality measures is the prioritization of the ideal outcome per care activity. According to a study that was funded by Pfizer Inc. to compare patient treatments, seventy two percent of the cases included in the study showed that the most cost-effective treatment option was not the most effective care routine (clinically) (McElligott, et al., 2015). Selecting the ideal outcome for care activities requires in-depth understanding of the value and the relationship between cost and clinical efficacy (Leu, et al., 2016). Incorporating value in healthcare decision-making process requires a balanced combination of cost, outcomes, and patient specifications (Weeks & Wwinstein, 2015). Health IT systems must monitor measures from all aspects involved in care activities, including impact on all beneficiaries, cost of the treatment, and gathering all stakeholder inputs during the time periods that generate care outcomes (Baxter, et al., 2015). These information

Figure 1. Comprehensive care measuring model



systems must comprehensively gather information from all participants but link outcomes to their exact participating contributors to avoid imprecise risk sharing. Existing alternative payment models that rely on fixed payments and capitation, usually group patients and practitioners into payment initiatives that receive a fixed amount (Porter & Kaplan, 2016). The recommended model is one that is able to incorporate stakeholder contributions using health IT systems. EHR systems are a good candidate to be integrated with such health systems. The Enclosed Stakeholder Share Measure system (ESM) will track clinical services and stakeholder input in form of quality measures. This system will classify clinical encounter (care activities) to be aligned with certain goals/outcomes. Numeric values allocated to each participating stakeholder in the care activity will sum up to a value of one. As several encounters could be considered per each outcome, the mean value of a stakeholder's contribution in all encounters could be normalized and considered as their total contribution towards the outcome. This approach is intended to function as a stakeholder shared measure and could be later identified in two main areas of expected and reported. Expected measures will be based on previous data gathered for conditions that are closely resembling the care activity. While estimated measures will form the expected performance measures for each stakeholder.

REFERENCES

Baumol, W. J., Ferranti, D. d., Malach, M., Pablos-Mendez, A., Tabish, H., & Wu, L. G. (n.d.). The Cost Disease Why Computers Get Cheaper and Health Care Doesn't. *Yale University Press.*

Baxter, P. E., Hewko, S. J., Pfaff, K. A., Cleghorn, L., Cunningham, B. J., Elston, D., & Cummings, G. G. (2015). Leaders' experiences and perceptions implementing activity-based funding and pay-for-performance hospital funding models: A systematic review. *Health Policy (Amsterdam)*, *119*(8), 1096–1110. doi:10.1016/j.healthpol.2015.05.003 PMID:26004845

Berenson, R., & Horvath, J. (2003). Confronting The Barriers To Chronic Care Management In Medicare. *Health Affairs*, 22. PMID:14527234

Centers for Disease Control and Prevention. (n.d.). *Public Health and Promoting Interoperability Programs (formerly, known as Electronic Health Records Meaningful Use)*. Retrieved from cdc.gov: https://www.cdc.gov/ehrmeaningfuluse/introduction.html

Clough, J. D., & McClellan, M. (2016). Implementing MACRA Implications for Physicians and for Physician Leadership. *Journal of the American Medical Association*, *315*(22), 2397. doi:10.1001/jama.2016.7041 PMID:27213914

Cohen, S. B., & Yu, W. (2012, January). The Concentration and Persistence in the Level of Health Expenditures over Time: Estimates for the U.S. Population, 2008-2009. *The Concentration and Persistence in the Level of Health Expenditures over Time: Estimates for the U.S. Population*, 2008–2009.

Dunlop, D. D., Lyons, J. S., Manheim, L. M., Song, J., & Chang, R. W. (2004, June). Arthritis and Heart Disease as Risk Factors for Major Depression: The Role of Functional Limitation. *Medical Care*, *42*(6), 502–511. doi:10.1097/01.mlr.0000127997.51128.81 PMID:15167318

Fried, L. P., Bandeen-Roche, K., Kasper, J. D., & Guralnik, J. M. (1999, January). Association of Comorbidity with Disability in Older Women: The Women's Health and Aging Study. *Journal of Clinical Epidemiology*, *52*(1), 27–37. doi:10.1016/S0895-4356(98)00124-3 PMID:9973071

Gruessner, V. (2015, March). *Top 8 Goals of Stage 3 Meaningful Use Proposed Rule*. Retrieved from EHR INTELLIGENCE: https://ehrintelligence.com/news/top-8-goals-of-stage-3-meaningful-use-proposed-rule

Hirsch, J., Leslie-Mazwi, T., Nicola, G., Bhargavan-Chatfield, M., Seidenwurm, D., Silva, E., & Manchikanti, L. (2016). PQRS and the MACRA: Value-Based Payments Have Moved from Concept to Reality. *AJNR. American Journal of Neuroradiology*, *37*(12), 2195–2200. doi:10.3174/ajnr.A4936 PMID:27659194

Hirsch, J., Rosenkrantz, A. B., Ansari, S. A., Manchikanti, L., & Nicola, G. N. (2016). MACRA 2.0: Are you ready for MIPS? *Journal of Neurointerventional Surgery*, *9*(7), 714–716. doi:10.1136/neurintsurg-2016-012845 PMID:27884928

Hirsch, J. A., Leslie-Mazwi, T., Barr, R. M., McGinty, G., Nicola, G. N., Patel, A. B., & Manchikanti, L. (2015). The Burwell roadmap. *Journal of Neurointerventional Surgery*. PMID:25744382

Kern, M. L., Safford, M. M., Makovkina, E., Slavin, M. J., Fudl, A., Carrillo, J. E., & Abramson, E. L. (2019, February). Patients' and Providers' Views on Causes and Consequences of Healthcare Fragmentation in the Ambulatory Setting: A Qualitative Study. *Journal of General Internal Medicine*, *34*(6), 899–907. doi:10.100711606-019-04859-1 PMID:30783883

Leu, M. G., Austin, E., Foti, J. L., Hrachovec, J., Poplisky, J., Spencer, S. M., . . . Migita, D. S. (2016). A Framework for Evaluating Value of New Clinical Recommendations. *Hospital Pediatirics, 6*(10).

Liao, J. M., Shea, J. A., Weissman, A., & Navathe, A. S. (2018). THE PRACTICE OF MEDICINE: Physician Perspectives In Year 1 Of MACRA And Its Merit-Based Payment System: A National Survey. *Health Affairs*, *37*(7), 1079–1086. doi:10.1377/hlthaff.2017.1485 PMID:29985697

Lochner, K., & Cox, C. S. (2013, April 25). Prevalence of Multiple Chronic Conditions Among Medicare Beneficiaries, United States, 2010. *Preventive Chronic Disease*.

Marjoua, Y., & Bozic, K. J. (2012). Brief history of quality movement in US healthcare. *Current Reviews in Musculoskeletal Medicine*, *5*(4), 265–273. doi:10.100712178-012-9137-8 PMID:22961204

McCullough, J., Parente, S., & Town, R. (2016). Health information technology and patient outcomes: The role of information and labor coordination. *The Rand Journal of Economics*, *47*(1), 207–236. doi:10.1111/1756-2171.12124

McElligott, S., Pauly, M. V., Willke, R. J., Bergquist, H., Doshi, J., Fleisher, L. A., ... Glick, H. A. (2015). Comparative Effectiveness And Cost-Effectiveness Analyses Frequently Agree on Value. *Health Affairs*, 34. PMID:25941282

Office of the National Coordinator for Health Information Technology. (n.d.). *Merit-based Incentive Payment System*. Retrieved from HealthIT: https://www.healthit.gov/topic/federal-incentive-programs/MACRA/merit-based-incentive-payment-system

Pham, H. H., O'Malley, A. S., Bach, P. B., Saiontz-Martinez, C., & Schrag, D. (2009). Primary Care Physicians' Links to Other Physicians through Medicare Patients: The Scope of Care Coordination. *Annals of Internal Medicine*, *150*(4), 236–242. doi:10.7326/0003-4819-150-4-200902170-00004 PMID:19221375

Porter, M. E., & Kaplan, R. S. (2016). How to Pay for Health Care. *Economics & Society*. PMID:27526565

Thorpe, K. E., Ogden, L. L., & Galactionova, K. (2010, April). Chronic Conditions Accout For Rise In Medicare Spending From 1987 To 2006. *Health Affairs*, 29.

U.S. Department of Health and Human Services. (2010). *Multiple Chronic Conditions—A Strategic Framework: Optimum Health and Quality of Life for Individuals with Multiple Chronic Conditions*. U.S. Department of Health and Human Services.

Vogeli, C., Shields, A. E., Lee, T. A., Gibson, T. B., Marder, W. D., Weiss, K. B., & Blumenthal, D. (2007, November). Multiple Chronic Conditions: Prevalence, Health Consequences, an Implications for Quality, Care Management, and Costs. *Journal of General Internal Medicine*, *22*(S3), 391–395. doi:10.100711606-007-0322-1 PMID:18026807

Weeks, W. B., & Wwinstein, J. (2015). Caveats to Consider When Calculating Healthcare Value. *The American Journal of Medicine*, *128*(8), 802–803. doi:10.1016/j.amjmed.2014.11.012 PMID:25433299

Compilation of References

Aaron, H. J. (1991). *Serious and Unstable condition: Financing America's Healthcare*. Washington, DC: Brooking Institutions.

Abaza, H., & Marschollek, M. (2017). mHealth Application Areas and Technology Combinations. *Methods of Information in Medicine, 56*(S1), e105-e122.

Abbasi, A., Chen, H., Thoms, S., & Fu, T. (2008). Affect analysis of web forums and blogs using correlation ensembles. *IEEE Transactions on Knowledge and Data Engineering*, *20*(9), 1168-1180.

Abera, A. A., Mengesha, G. H., & Musa, P. F. (2014). Assessment of Ethiopian health facilities readiness for implementation of telemedicine. *Communications of the Association for Information Systems*, *34*(67), 1209–1234. doi:10.17705/1CAIS.03465

About the PBS. (2018). Available: http://www.pbs.gov.au/info/about-the-pbs

Abrahamson, E. (1991). Managerial fads and fashions: The diffusion and rejection of innovations. *Academy of Management Review*, *16*(3), 586–612. doi:10.5465/amr.1991.4279484

Abrahamson, E., & Rosenkopf, L. (1993). Institutional and competitive bandwagons: Using mathematical modeling as a tool to explore innovation diffusion. *Academy of Management Review*, *18*(3), 487–517. doi:10.5465/amr.1993.9309035148

ACCORD Study Group and ACCORD Eye Study Group. (2010). Effects of medical therapies on retinopathy progression in type 2 diabetes. *The New England Journal of Medicine*, *363*(3), 233–244. doi:10.1056/NEJMoa1001288 PMID:20587587

ADHA. (2019). What is digital health? *Australian Digital Health Agency*. Retrieved from https://www.digitalhealth.gov.au/get-started-with-digital-health/what-is-digital-health

Adriaans, P., & Zantinge, D. (1996). *Data Mining*. New York, NY: Addison-Wesley.

Agarwal, R., Gao, G., Des Roches, C., & Jha, A. K. (2010). Research commentary—The digital transformation of healthcare: Current status and the road ahead. *Information Systems Research*, *21*(4), 796–809. doi:10.1287/isre.1100.0327

Agarwal, S., & Lau, C. T. (2010). Remote health monitoring using mobile phones and Web services. *Telemedicine Journal and e-Health*, *16*(5), 603–607. doi:10.1089/tmj.2009.0165 PMID:20575728

Agbo, C. C., Mahmoud, Q. H., & Eklund, J. M. (2019, June). Blockchain Technology in Healthcare: A Systematic Review. In Healthcare (Vol. 7, No. 2, p. 56). Multidisciplinary Digital Publishing Institute. doi:10.3390/healthcare7020056

Agrawal, A., Rastogi, R., Chaturvedi, D. K., Sharma, S., & Bansal, A. (2018g). Audio Visual EMG & GSR Biofeedbac Analysis for Effect of Spiritual Techniques on Human Behavior and Psychic Challenges. *Proceedings of the 12th INDIACom*, 252-258.

AHA. (2011). *Examining the Drivers of Readmissions and Reducing Unnecessary Readmissions for Better Patient Care.* Retrieved from https://www.aha.org/guidesreports/2018-02-09-examining-drivers-readmissions-and-reducing-unnecessary-readmissions

AIHW. (2017). *Cancer in Australia*. Available: https://www.cancer.org.au/about-cancer/what-is-cancer/facts-and-figures.html

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179–211. doi:10.1016/0749-5978(91)90020-T

Ajzen, I., & Driver, B. L. (1991). Prediction of leisure participation from behavioural, normative, and control beliefs: An application of the theory of planned behavior. *Leisure Sciences*, *13*(3), 185–204. doi:10.1080/01490409109513137

Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior*. Englewood Cliffs, NJ: Prentice-Hall.

Akinsola, H. A. (2007). *The Principles of Health Services Administration and Management: Perspectives from Clinical and Public Health Practices*. Ibadan: College Press and Publishers Ltd.

Akst, J. (2013). *The elixir tragedy, 1937*. Retrieved June 29, 2015, from http://www.the-scientist.com/?articles.view/articleNo/35714/title/The-Elixir-Tragedy--1937/

Alam, M. R., Reaz, M. B. I., & Ali, M. A. M. (2012). A review of smart homes—Past, present, and future. *IEEE Transactions on Systems, Man and Cybernetics. Part C, Applications and Reviews*, *42*(6), 1190–1203. doi:10.1109/TSMCC.2012.2189204

Alavi, M., & Leidner, D. (2001). Review: knowledge management and knowledge management systems: conceptual foundations and research issues. *Management Information Systems Quarterly*, *25*(1), 107–136. doi:10.2307/3250961

Alba, J. W., & Hutchinson, W. (1987). Dimensions of consumer expertise. *The Journal of Consumer Research*, *13*(4), 411–454. doi:10.1086/209080

Albright, T. L., Parchman, M., & Burge, S. K. (2001). Predictors of self-care behavior in adults with type 2 diabetes: An RRNeST study. *Family Medicine-Kansas City*, *33*(5), 354–360. PMID:11355645

Alharthi, H. (2018). Healthcare predictive analytics: An overview with a focus on Saudi Arabia. *Journal of Infection and Public Health*, *11*(6), 749–756. doi:10.1016/j.jiph.2018.02.005 PMID:29526444

Al-khafajiy, M., Baker, T., Chalmers, C., Asim, M., Kolivand, H., Fahim, M., & Waraich, A. (2019). Remote health monitoring of elderly through wearable sensors. *Multimedia Tools and Applications*, *78*(17), 1–26. doi:10.100711042-018-7134-7

Amarasingham, R., Patzer, R. E., Huesch, M., Nguyen, N. Q., & Xie, B. (2014). Implementing electronic health care predictive analytics: Considerations and challenges. *Health Affairs*, *33*(7), 1148–1154. doi:10.1377/hlthaff.2014.0352 PMID:25006140

American Cancer Society. (2014). *Can pancreatic cancer be found early?* Retrieved June 29, 2015, from http://www.cancer.org/cancer/pancreaticcancer/detailedguide/pancreatic-cancer-detection

American Diabetes Association (ADA). (1989). Standards of medical care for patients with diabetes mellitus. *Diabetes Care*, *12*(5), 365–368. doi:10.2337/diacare.12.5.365 PMID:2721345

Amin, A., Rahim, F., Ali, I., Khan, C., & Anwar, S. (2015). *A comparison of two oversampling techniques (smote vs mtdf) for handling class imbalance problem: A case study of customer churn prediction. In New Contributions in Information Systems and Technologies* (pp. 215–225). Springer.

Anagnostelis, B. (2002). *A guide to healthcare resources on the internet*. Academic Press.

Ancker, J. S., Barrón, Y., Rockoff, M. L., Hauser, D., Pichardo, M., Szerencsy, A., & Calman, N. (2011). Use of an electronic patient portal among disadvantaged populations. *Journal of General Internal Medicine*, *26*(10), 1117–1123. doi:10.100711606-011-1749-y PMID:21647748

Andersen, R.M. (1995). Revisiting the behavioral model and access to medical care: does it matter? *Journal of Health and Social Behavior*, 1–10. DOI: 11 doi:10.2307/2137284

Anderson, G., & Sotir, H. (2006). Influencing government policy. In D. Pencheon, C. Guest, D. Melzer, & J. A. Gray (Eds.), *Oxford Handbook of Public Health*. Oxford University Press.

Anderson, J. C., & Gerbing, D. W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin*, *103*(3), 411–423. doi:10.1037/0033-2909.103.3.411

Anderson, J. R. (1983). *The architecture of cognition*. Cambridge, MA: Harvard University Press.

Anderson-Lewis, C., Darville, G., Mercado, R. E., Howell, S., & Di Maggio, S. (2018). mHealth Technology Use and Implications in Historically Underserved and Minority Populations in the United States: Systematic Literature Review. *JMIR mHealth and uHealth*, *6*(6), e128. doi:10.2196/mhealth.8383 PMID:29914860

André, B., Inger Ringdal, G., Loge, J. H., Rannestad, T., Laerum, H., & Kaasa, S. (2008). Experiences with the Implementation of Computerized Tools in Health Care Units: A Review Article. *International Journal of Human-Computer Interaction*, *24*(8), 753–775. doi:10.1080/10447310802205768

Ang, S., & Cummings, L. L. (1997). Strategic response to institutional influences on information systems outsourcing. *Organization Science*, *8*(3), 235–256. doi:10.1287/orsc.8.3.235

Angst, C. M., & Agarwal, R. (2009). Adoption of electronic health records in the presence of privacy concerns: The elaboration likelihood model and individual persuasion. *Management Information Systems Quarterly*, *33*(2), 339–370. doi:10.2307/20650295

Anshari, M., & Almunawar, M. N. (2016). Mobile health (mhealth) services and Online health educators. *Biomedical Informatics Insights, 8*, BII-S35388.

Applebaum, S. H., & Wohl, L. (2000). Transformation or change: Some prescriptions for health care organizations. *Managing Service Quality*, *10*(5), 279–298. doi:10.1108/09604520010345768

Arenaza, J. C. (2009). Predictors of health-related quality-of-life change after total hip arthroplasty. *Clinical Orthopaedics and Related Research*, *467*(11), 2886–2894. doi:10.100711999-009-0868-9 PMID:19412646

Argote, L. (1999). *Organizational Learning: Creating, Retaining and Transferring Knowledge*. Berlin: Springer.

Argyris, C. (1982). *Reasoning, Learning and Action: Individual and Organizational*. San Francisco: Jossy-Bass, Inc.

Argyris, C., & Schon, D. (1978). *Organizational Learning: a Theory of Action Perspective*. Reading: Addison-Wesley Publishing Co.

Arnold, C. (2014). *NOVA Next: Can the Crowd solve medical mysteries?* Retrieved June 26, 2015, from http://www.pbs.org/wgbh/nova/next/body/crowdsourcing-medical-diagnoses

Artetxe, A., Beristain, A., & Graña, M. (2018). Predictive models for hospital readmission risk: A systematic review of methods. *Computer Methods and Programs in Biomedicine*, *164*, 49–64. doi:10.1016/j.cmpb.2018.06.006 PMID:30195431

Asamoah, D., Sharda, R., & Thandapani Kumarasamy, A. (2015). Can Social Media Support Public Health? Demonstrating Disease Surveillance using Big Data Analytics. *Proceedings of the Twenty-first Americas Conference on Information Systems*.

Asuero, A. G., Sayago, A., & González, A. G. (2007). The Correlation Coefficient: An Overview. *Critical Reviews in Analytical Chemistry*, *36*(1), 41–59. doi:10.1080/10408340500526766

Atzori, L., Iera, A., & Morabito, G. (2010). The internet of things: A survey. *Computer Networks*, *54*(15), 2787–2805. doi:10.1016/j.comnet.2010.05.01014

Australia's National Digital Health Strategy. (2019). Retrieved from https://conversation.digitalhealth.gov.au/sites/default/files/adha-strategy-doc-2ndaug_0_1.pdf

Award, E., & Ghaziri, H. (2004). *Knowledge Management*. Upper Saddle River, NJ: Prentice Hall.

Baig, M. M. (2014). *Smart vital signs monitoring and novel falls prediction system for older adults* (Doctoral dissertation). Auckland University of Technology, New Zealand.

Bali, R. K., Wickramasinghe, N., & Lehaney, B. (2009). *Knowledge management primer*. Routledge. doi:10.4324/9780203894712

Bangert, D. C., Doktor, R., Choi, M. H., Warren, J. S., Garshnek, V., & Logan, J. S. (2000). Enhancing medical decision-making through Telemedicine. *International Journal of Healthcare Technology and Management*, *2*(1/2/3/4), 255–270. doi:10.1504/IJHTM.2000.001069

Barak-Corren, Y., Israelit, S. H., & Reis, B. Y. (2017). Progressive prediction of hospitalisation in the emergency department: Uncovering hidden patterns to improve patient flow. *Emergency Medicine Journal*, *34*(5), 308–314. doi:10.1136/emermed-2014-203819 PMID:28188202

Barclay, D., Higgins, C., & Thomson, R. (1995). The partial least squares approach to causal modeling, personal computer adoption and use as an illustration. *Technology Studies*, *2*(2), 285–309.

Barrow, M. (2018). How 3D printing is transforming healthcare. *Raconteur*. Retrieved from https://www.raconteur.net/healthcare/3d-printing-transforming-healthcare

Bartels, K., Karhausen, J., Clambey, E. T., Grenz, A., & Eltzschig, H. K. (2013). Perioperative organ injury. *Anesthesiology*, *119*(6), 1474–1489. doi:10.1097/ALN.0000000000000022 PMID:24126264

Basch, P. (2005). Electronic health records and the national health information network: Affordable, adoptable, and ready for prime time? *Annals of Internal Medicine*, *143*(3), 227. doi:10.7326/0003-4819-143-3-200508020-00009 PMID:16061921

Bashshur, R. L., Reardon, T. G., & Shannon, G. W. (2000). Telemedicine: A new health care delivery system. *Annual Review of Public Health*, *21*(1), 613–637. doi:10.1146/annurev.publhealth.21.1.613 PMID:10884967

Baskerville, R., Baiyere, A., Gregor, S., Hevner, A., & Rossi, M. (2018). Design science research contributions: finding a balance between artifact and theory. *Journal of the Association for Information Systems, 19*(5), 358-376.

Bauer, M. S., Damschroder, L., Hagedorn, H., Smith, J., & Kilbourne, A. M. (2015). An introduction to implementation science for the non-specialist. *BMC Psychology*, *3*(1), 32. doi:10.118640359-015-0089-9 PMID:26376626

Baumol, W. J., Ferranti, D. d., Malach, M., Pablos-Mendez, A., Tabish, H., & Wu, L. G. (n.d.). The Cost Disease Why Computers Get Cheaper and Health Care Doesn't. *Yale University Press.*

Baxter, P. E., Hewko, S. J., Pfaff, K. A., Cleghorn, L., Cunningham, B. J., Elston, D., & Cummings, G. G. (2015). Leaders' experiences and perceptions implementing activity-based funding and pay-for-performance hospital funding models: A systematic review. *Health Policy (Amsterdam)*, *119*(8), 1096–1110. doi:10.1016/j.healthpol.2015.05.003 PMID:26004845

Beardsley, G., & Goldstein, M. G. (1993). Psychological factors affecting physical condition: Endocrine disease literature review. *Psychosomatics*, *34*(1), 12–19. doi:10.1016/S0033-3182(93)71923-4 PMID:8426887

Becerra-Fernandez, I., & Sabherwal, R. (2001). Organizational knowledge management: A contingency perspective. *Journal of Management Information Systems*, *18*(1), 23–55. doi:10.1080/07421222.2001.11045676

Becker, J., Knackstedt, R., & Pöppelbuß, J. (2009). Developing Maturity Models for IT Management. *Business & Information Systems Engineering*, *1*(3), 213–222. doi:10.100712599-009-0044-5

Beckers, J., Dolmans, D., & Van Merriënboer, J. (2016). e-Portfolios enhancing students' self-directed learning: A systematic review of influencing factors. *Australasian Journal of Educational Technology*, *32*(2).

Bedeley, R. T., Ghoshal, T., Iyer, L. S., & Bhadury, J. (2018). Business analytics and organizational value chains: A relational mapping. *Journal of Computer Information Systems*, *58*(2), 151–161. doi:10.1080/08874417.2016.1220238

Behnke, J. (2014). *Logistische Regressionsanalyse: Eine Einführung*. Springer-Verlag.

Behrendt, K., & Groene, O. (2016). Mechanisms and effects of public reporting of surgeon outcomes: A systematic review of the literature. *Health Policy (Amsterdam)*, *120*(10), 1151–1161. doi:10.1016/j.healthpol.2016.08.003 PMID:27638232

Bellazzi, R., & Zupan, B. (2008). Predictive data mining in clinical medicine: Current issues and guidelines. *International Journal of Medical Informatics*, *77*(2), 81–97. doi:10.1016/j.ijmedinf.2006.11.006 PMID:17188928

Benbasat, I., & Weber, R. (1996). Research commentary: Rethinking "diversity" in information systems research. *Information Systems Research*, *7*(4), 389–399. doi:10.1287/isre.7.4.389

Bendoly, E. (2003). Theory and support for process frameworks of knowledge discovery and data mining from ERP systems. *Information & Management*, *40*(7), 639–647. doi:10.1016/S0378-7206(02)00093-9

Benes, J., Giglio, M. T., Brienza, N., & Michard, F. (2014). The effects of goal-directed fluid therapy based on dynamic parameters on post-surgical outcome: A meta-analysis of randomized controlled trials. *Critical Care (London, England)*, *18*(5), 584. doi:10.118613054-014-0584-z PMID:25348900

Benigeri, M., & Pluye, P. (2003). Shortcomings of health information on the Internet. *Health Promotion International*, *18*(4), 381–386. doi:10.1093/heapro/dag409 PMID:14695369

Bennenbroek, F. T., Buunk, B. P., van der Zee, K. I., & Grol, B. (2002). Social comparison and patient information: What do cancer patients want? *Patient Education and Counseling*, *47*(1), 5–12. doi:10.1016/S0738-3991(02)00018-6 PMID:12023095

Berenguer, A., Goncalves, J., Hosio, S., Ferreira, D., Anagnostopoulos, T., & Kostakos, V. (2017). Are Smartphones Ubiquitous? An in-depth survey of smartphone adoption by seniors. *IEEE Consumer Electronics Magazine*, *6*(1), 104–110. doi:10.1109/MCE.2016.2614524

Berenson, R., & Horvath, J. (2003). Confronting The Barriers To Chronic Care Management In Medicare. *Health Affairs*, 22. PMID:14527234

Bergstra, J., & Bengio, Y. (2012). Random Search for Hyper-Parameter Optimization. *Journal of Machine Learning Research*, *13*(Feb), 281–305. Retrieved from http://www.jmlr.org/papers/volume13/bergstra12a/bergstra12a.pdf

Bertakis, K. D., & Azari, R. (2010). Patient gender differences in the prediction of medical expenditures. *Journal of Women's Health*, *19*(10), 1925–1932. doi:10.1089/jwh.2009.1448 PMID:20831429

Bertsimas, D., Bjarnadóttir, M. V., Kane, M. A., Kryder, J. C., Pandey, R., Vempala, S., & Wang, G. (2008). Algorithmic prediction of health-care costs. *Operations Research*, *56*(6), 1382–1392. doi:10.1287/opre.1080.0619

Berwick, D. M. (2003). Disseminating innovations in health care. *Journal of the American Medical Association*, *289*(15), 1969–1975. doi:10.1001/jama.289.15.1969 PMID:12697800

Bhattacherjee, A., & Sanford, C. (2006). Influence processes for information technology acceptance: An elaboration likelihood model. *Management Information Systems Quarterly*, *30*(4), 805–825. doi:10.2307/25148755

Bierman, A. S. (2012). Averting an impending storm: Can we reengineer health systems to meet the needs of aging populations? *PLoS Medicine*, *9*(7), e1001267. doi:10.1371/journal.pmed.1001267 PMID:22815655

Billings, J., Georghiou, T., Blunt, I., & Bardsley, M. (2013). Choosing a model to predict hospital admission: An observational study of new variants of predictive models for case finding. *BMJ Open*, *3*(8), e003352. doi:10.1136/bmjopen-2013-003352 PMID:23980068

Bitter, S., Grabner-Kräuter, S., & Breitenecker, R. J. (2014). Customer engagement behaviour in online social networks–the Facebook perspective. *International Journal of Networking and Virtual Organisations*, *14*(1-2), 197–220. doi:10.1504/IJNVO.2014.065088

Blumenthal, D., Chernof, B., Fulmer, T., Lumpkin, J., & Selberg, J. (2016). Caring for high-need, high-cost patients—An urgent priority. *The New England Journal of Medicine*, *375*(10), 909–911. doi:10.1056/NEJMp1608511 PMID:27602661

Blumenthal, D., & Tavenner, M. (2010). The 'Meaningful Use' regulation for electronic health records. *The New England Journal of Medicine*, *363*(6), 501–504. doi:10.1056/NEJMp1006114 PMID:20647183

Boland, R. Jr, & Tenkasi, R. (1995). Perspective making perspective taking. *Organization Science*, *6*(4), 350–372. doi:10.1287/orsc.6.4.350

Bolin, K., Lindgren, B., & Lundborg, P. (2008). Your next of kin or your own career? Caring and working among the 50+ of Europe. *Journal of Health Economics*, *27*(3), 718–738. doi:10.1016/j.jhealeco.2007.10.004 PMID:18207265

Bonelli, B., & Souza, T. (2018a, June 13). *MS implanta excelência operacional nas emergências do SUS em Tocantins*. Brasília: Ministério da Saúde. Retrieved from http://portalms.saude.gov.br/noticias/sas/43552-ms-implanta-excelencia-operacional-nas-emergencias-do-sus-em-tocantins

Bonelli, B., & Souza, T. (2018b, June 13). *MS implanta excelência operacional nas emergências do SUS em Minas Gerais*. Brasília: Ministério da Saúde. Retrieved from http://portalms.saude.gov.br/noticias/sas/43548-ms-implanta-excelencia-operacional-nas-emergencias-do-sus-em-minas-gerais

Bonomi, S. (2016). *The Electronic Health Record: A Comparison of Some European Countries*. Available from: https://www.researchgate.net/publication/303364932_The_Electronic_Health_Record_A_Comparison_of_Some_European_Countries

Boonstra, A., & van Offenbeek, M. (2010). Towards consistent modes of e-health implementation: Structurational analysis of a telecare programme's limited success. *Information Systems Journal*, *20*(6), 537–561. doi:10.1111/j.1365-2575.2010.00358.x

Bornia, A., & Rocha Neto, A. (2001). *A utilização da ferramenta árvore da realidade atual para a identificação do problema raiz em uma instituição de ensino superior*. Salvador, BA, Brasil: Anais do Encontro Nacional de Engenharia De Produção.

Botwinick, J. (1973). *Aging and behavior*. New York: Springer.

Boyd, J. R. (1987). In Patterns of Conflict. Retrieved from Essence of Winning and Losing: http://www.d-n-i.net

Boyd, J. R. (2002). Destruction and Creation. In *R Coram 'Boyd' Little*. New York: Brown & Co.

Boyd, R., & Richerson, P. J. (2005). *Solving the puzzle of human cooperation. Evolution and Culture*. Cambridge, MA: MIT Press.

Boynton, A. C., Zmud, R. W., & Jacobs, G. C. (1994). The influence of IT management practice on IT use in large organizations. *Management Information Systems Quarterly*, *18*(3), 299–318. doi:10.2307/249620

Bozan, K., & Berger, A. (2019). Revisiting the technology challenges and proposing enhancements in ambient assisted living for the elderly. In *Proceedings of the 52nd Hawaii International Conference on System Sciences*. Piscataway, NJ: IEEE. 10.24251/HICSS.2019.520

Bozan, K., Davey, B., & Parker, K. (2017). Social forces that influence health IT use behavior of the elderly. In N. Wickramasinghe (Ed.), *Handbook of research on healthcare administration*. Hershey, PA. doi:10.4018/978-1-5225-0920-2.ch021

Bozan, K., Davey, B., & Parker, K. R. (2015). Social influence on health IT adoption patterns of the elderly: An institutional theory based use behavior approach. *Procedia Computer Science*, *63*, 517–523. doi:10.1016/j.procs.2015.08.378

Brasil. Ministério da Saúde. (2002). *Tempo de espera na urgência e emergência.* Retrieved from http://www.ans.gov.br/images/stories/prestadores/E-ACE-02.pdf

Brasil. Ministério da Saúde. Pesquisa para saúde: por que pesquisa em saúde? Textos para tomada de decisão. (2007). *Council on Health Research for Development and Global Forum for Health Research.* Secretaria de Ciência, Tecnologia e Insumos Estratégicos Departamento de Ciência e Tecnologia, Brasília.

Breiman, L. (1996). Bagging Predictors. *Machine Learning*, *24*(2), 123–140. doi:10.1007/BF00058655

Broens, T. H. F., Huis in't Veld, R. M. H. A., Vollenbroek-Hutten, M. M. R., Hermens, H. J., van Halteren, A. T., & Nieuwenhuis, L. J. M. (2007). Determinants of successful telemedicine implementations: A literature study. *Journal of Telemedicine and Telecare*, *13*(6), 303–309. doi:10.1258/135763307781644951 PMID:17785027

Brown, S.A. (1999). Interventions to promote diabetes self-management: state of the science. *The Diabetes Educator, 25*(6_suppl), 52-61.

Brown, H., Terrence, J., Vasquez, P., Bates, D. W., & Zimlichman, E. (2014). Continuous monitoring in an inpatient medical-surgical unit: A controlled clinical trial. *The American Journal of Medicine*, *127*(3), 226–232. doi:10.1016/j.amjmed.2013.12.004 PMID:24342543

Bruyère, O., Ethgen, O., Neuprez, A., Zégels, B., Gillet, P., Huskin, J.-P., & Reginster, J.-Y. (2012). Health-related quality of life after total knee or hip replacement for osteoarthritis: A 7-year prospective study. *Archives of Orthopaedic and Trauma Surgery*, *132*(11), 1583–1587. doi:10.100700402-012-1583-7 PMID:22842917

Bryant, M. (2018). 3D printing poised to disrupt healthcare. *MEDTECHDIVE*. Retrieved from https://www.medtechdive.com/news/3d-printing-poised-to-disrupt-healthcare/541540/

Budescu, D. V., & Chen, E. (2015). Identifying expertise to extract the wisdom of crowds. *Management Science*, *61*(2), 267–280. doi:10.1287/mnsc.2014.1909

Budgaga, W., Malensek, M., Pallickara, S., Harvey, N., Breidt, F. J., & Pallickara, S. (2016). Predictive analytics using statistical, learning, and ensemble methods to support real-time exploration of discrete event simulations. *Future Generation Computer Systems*, *56*, 360–374. doi:10.1016/j.future.2015.06.013

Buechley, L., & Eisenberg, M. (2008). The LilyPad Arduino: Toward wearable engineering for everyone. *Pervasive Computing*, *7*(2), 12–15. doi:10.1109/MPRV.2008.38

Buechley, L., Eisenberg, M., Catchen, J., & Crockett, A. (2008). The LilyPad Arduino: Using computational textiles to investigate engagement, aesthetics, and diversity in computer science education. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 423–432). Florence, Italy: ACM. 10.1145/1357054.1357123

Buhalis, D., & Amaranggana, A. (2015). Smart tourism destinations enhancing tourism experience through personalisation of services. In *Information and communication technologies in tourism 2015* (pp. 377–389). Cham: Springer. doi:10.1007/978-3-319-14343-9_28

Buhl, H. U., Röglinger, M., Moser, F., & Heidemann, J. (2013). *Big data*. Springer.

Burstin, H., Leatherman, S., & Goldmann, D. (2016). The evolution of healthcare quality measurement in the United States. *Journal of Internal Medicine*, *279*(2), 154–159. doi:10.1111/joim.12471 PMID:26785953

Buse, K., Mays, N., & Watts, G. (2005). *Making Health Policy: Understanding Public Health Series*. Open University Press.

Bush, G. (2004). State of the Union Address. *The White House*. Available at http://www.whitehouse.gov/news/release/2004/01/20040120-7.html

Cabena, P., Hadjinian, P., Stadler, R., Verhees, J., & Zanasi, A. (1988). *Discovering Data Mining from Concept to Implementation*. Upper Saddle River, NJ: Prentice Hall.

Cacace, M., & Geraedt, M. (2017). Public reporting as a quality strategy. *European Journal of Public Health, 27*(suppl_3).

Cacace, M., Ettelt, S., Brereton, L., Pedersen, J. S., & Nolte, E. (2011). How health systems make available information on service providers: Experience in seven countries. *Rand Health Quarterly, 1*.

Cadilhac, D. A., Moloczij, N., Denisenko, S., Dewey, H., Disler, P., Winzar, B., ... Bladin, C. (2014). Establishment of an effective acute stroke telemedicine program for Australia: Protocol for the Victorian Stroke Telemedicine project. *International Journal of Stroke*, *9*(2), 252–258. doi:10.1111/ijs.12137 PMID:24148281

Campanella, P., Vukovic, V., Parente, P., Sulejmani, A., Ricciardi, W., & Specchia, M. L. (2016). The impact of public reporting on clinical outcomes: A systematic review and meta-analysis. *BMC Health Services Research*, *16*(1), 296. doi:10.118612913-016-1543-y PMID:27448999

Campbell, J. D., Harris, K. D., & Hodge, R. (2001). Introducing telemedicine technology to rural physicians and settings. *The Journal of Family Practice*, *50*(5), 419–424. PMID:11350706

Cancer in Australia. (2017). Canberra: Australian Institute of Health and Welfare.

Capkun, V., Messner, M., & Rissbacher, C. (2012). Service specialization and operational performance in hospitals. *International Journal of Operations & Production Management*, *32*(4), 468–495. doi:10.1108/01443571211223103

Caritas Project. (n.d.). Retrieved from http://www.thecaritasproject.info/aplacetoflourish/awardWinner_2014.html

Carley, K. M., & Kaufer, D. S. (1993). Semantic connectivity: An approach for analyzing symbols in semantic networks. *Communication Theory*, *3*(3), 183–213. doi:10.1111/j.1468-2885.1993.tb00070.x

Carr, A. J., Robertsson, O., Graves, S., Price, A. J., Arden, N. K., Judge, A., & Beard, D. J. (2012). Knee replacement. *Lancet*, *379*(9823), 1331–1340. doi:10.1016/S0140-6736(11)60752-6 PMID:22398175

Carroll, J. K., Moorhead, A., Bond, R., LeBlanc, W. G., Petrella, R. J., & Fiscella, K. (2017). Who uses mobile phone health apps and does use matter? A secondary data analytics approach. *Journal of Medical Internet Research*, *19*(4), e125. doi:10.2196/jmir.5604 PMID:28428170

Castelfranchi, C. (2003). The micro–macro constitution of power. *Protosociology*, *18*, 208–268. doi:10.5840/protosociology200318/198

Cattan, M., White, M., Bond, J., & Learmouth, A. (2005). Preventing social isolation and loneliness among older people: A systematic review of health promotion interventions. *Ageing and Society*, *25*(1), 41–67. doi:10.1017/S0144686X04002594

Cavallari, R., Martelli, F., Rosini, R., Buratti, C., & Verdone, R. (2014). A survey on wireless body area networks: Technologies and design challenges. *IEEE Communications Surveys and Tutorials*, *16*(3), 1635–1657. doi:10.1109/SURV.2014.012214.00007

Centers for Disease Control and Prevention (CDC). (2013). *The state of aging and health in America 2013*. Atlanta, GA: Centers for Disease Control and Prevention, US Dept of Health and Human Services. Available at: http://www.cdc.gov/features/agingandhealth/state_of_aging_and_health_in_america_2013.pdf

Centers for Disease Control and Prevention. (n.d.). *Public Health and Promoting Interoperability Programs (formerly, known as Electronic Health Records Meaningful Use)*. Retrieved from cdc.gov: https://www.cdc.gov/ehrmeaningfuluse/introduction.html

Chaffin, A. J., & Harlow, S. D. (2005). Cognitive learning applied to older adult learners and technology. *Educational Gerontology*, *3*(4), 301–329. doi:10.1080/03601270590916803

Chang, W.-J., & Chang, Y.-H. (2013, September). Patient satisfaction analysis: Identifying key drivers and enhancing service quality of dental care. *Journal of Dental Sciences*, *8*(3), 239–247. doi:10.1016/j.jds.2012.10.006

Chan, M., Campo, E., & Estève, D. (2005). Assessment of activity of elderly people using a home monitoring system. *International Journal of Rehabilitation Research. Internationale Zeitschrift fur Rehabilitationsforschung. Revue Internationale de Recherches de Readaptation*, *28*(1), 69–76. doi:10.1097/00004356-200503000-00010 PMID:15729100

Chatterjee, S., Deng, S., & Liu, J. (2017). Improving Opinion Mining by Classifying Facts and Opinions in Twitter. *Proceedings of the American Conference on Information Systems*, 2017

Chaturvedi D.K. (2015). Dayalbagh Way of Life for Better Worldliness. *Quest Journals, Journal of Research in Humanities and Social Science, 3*(5), 16-23.

Chaturvedi, D. K. (2012). Human Rights and Consciousness, International Seminar on Prominence of Human Rights in the Criminal Justice System. *Proceedings of Organized Ambedkar Chair, Dept. of Contemporary Social Studies & Law,* 33.

Chaturvedi, D. K. (2013). Correlation between Human Performance and Consciousness. *Proceedings of Saveetha School of Engineering, Saveetha University*.

Chaturvedi, D. K. (2013). The Correlation between Student Performance and Consciousness Level. *Proceedings of International Conference on Advanced Computing and Communication Technologies (ICACCT™-2013)*, 200-203.

Chaturvedi, D. K. (2014). Correlation between Energy Distribution profile and Level of Consciousness. *Shiakshk Parisamvad, International Journal of Education, 4*(1), 1-9.

Chaturvedi, D. K. (2014). The correlation between Student Performance and Consciousness Level. *International Journal of Computing Science and Communication Technologies, 6*(2), 936-939.

Chaturvedi, D. K. (2019). Relationship between Chakra Energy and Consciousness. *Biomedical Journal of Scientific and Technical Research, 15*(3), 1-3. Doi:10.26717/BJSTR.2019.15.002705

Chaturvedi, D. K. (2004). *Science, Religion and Spiritual Quest*. DEI Press.

Chaturvedi, D. K. (2013). A Study of Correlation between Consciousness Level and Performance of Worker. *Industrial Engineering Journal*, *6*(8), 40–43.

Chaturvedi, D. K., Kumar, J., & Bhardwaj, R. (2015, September). Jyoti Kumar Arora and Ravindra Bhardwaj(2015). Effect of meditation on Chakra Energy and Hemodynamic parameters. *International Journal of Computers and Applications*, *126*(12), 52–59. doi:10.5120/ijca2015906304

Chatzoglou, P. D., Sarigiannidis, L., Vraimaki, E., & Diamantidis, A. (2009). Investigating Greek employees' intention to use web-based training. *Computers & Education*, *53*(3), 877–889. doi:10.1016/j.compedu.2009.05.007

Chauhan, S., Rastogi, R., Chaturvedi, D. K., Arora, N., & Trivedi, P. (2017a). Framework for Use of Machine Intelligence on Clinical Psychology to study the effects of Spiritual tools on Human Behavior and Psychic Challenges. *Proceedings of NSC-2017(National system conference)*.

Chawla, N. (2005). Data Mining for Imbalanced Datasets: An Overview. In O. Z. Maimon & L. Rokach (Eds.), *Data mining and knowledge discovery handbook* (pp. 853–867). New York, NY: Springer. doi:10.1007/0-387-25465-X_40

Chawla, N., Bowyer, K., Hall, L., & Kegelmeyer, W. P. (2011). SMOTE: Synthetic Minority Over-sampling Technique. *Journal of Artificial Intelligence Research*; Advance online publication. doi:10.1613/jair.953

Chechulin, Y., Nazerian, A., Rais, S., & Malikov, K. (2014). Predicting patients with high risk of becoming high-cost healthcare users in Ontario (Canada). *Healthcare Policy*, *9*(3), 68. PMID:24726075

Cheng, H. C., Wu, V. W., Liu, E. S. & Kwong, D. L. (2011). Evaluation of radiation dose and image quality for the Varian cone beam computed tomography system. *International Journal of Radiation Oncology, Biology, Physics, 80*, 291-300.

Chen, G., Chung, E., Meng, L., Alexander, B., Vu, T., Rinehart, J., & Cannesson, M. (2012). Impact of non-invasive and beat-to-beat arterial pressure monitoring on intraoperative hemodynamic management. *Journal of Clinical Monitoring and Computing*, *26*(2), 133–140. doi:10.100710877-012-9344-2 PMID:22382920

Chen, H., Hailey, D., Wang, N., & Yu, P. (2014). A Review of Data Quality Assessment Methods for Public Health Information Systems. *International Journal of Environmental Research and Public Health*, *11*(5), 5170–5207. doi:10.3390/ijerph110505170 PMID:24830450

Chen, S., Duckworth, K., & Chaiken, S. (1999). Motivated heuristic and systematic processing. *Psychological Inquiry*, *10*(1), 44–49. doi:10.120715327965pli1001_6

Chen, Y., & Xie, J. (2008). Online consumer review: Word-of-mouth as a new element of marketing communication mix. *Management Science*, *54*(3), 477–491. doi:10.1287/mnsc.1070.0810

Cheung, Y. T. D., Chan, C. H. H., Lai, C. K. J., Chan, W. F. V., Wang, M. P., Li, H. C. W., ... Lam, T.-H. (2015). Using WhatsApp and Facebook online social groups for smoking relapse prevention for recent quitters: A pilot pragmatic cluster randomized controlled trial. *Journal of Medical Internet Research*, *17*(10), e238. doi:10.2196/jmir.4829 PMID:26494159

Chin, W. W. (1998). Issues and opinion on structural equation modeling. *Management Information Systems Quarterly*, *22*(1), vii–xvi.

Chin, W. W. (2010). How to Write Up and Report PLS Analyses. In V. E. Vinzi, W. W. Chin, J. Henseler, & H. Wang (Eds.), *Handbook of Partial Least Squares Concepts, Methods and Applications* (pp. 650–690). Berlin: Springer-Verlag. doi:10.1007/978-3-540-32827-8_29

Chin, W. W., Marcolin, B. L., & Newsted, P. R. (2003). A partial least squares latent variable modeling approach for measuring interaction effects: Results from a Monte Carlo simulation study and an electronic-mail emotion/adoption study. *Information Systems Research*, *14*(2), 189–217. doi:10.1287/isre.14.2.189.16018

Chipps, J., & Mars, M. (2012). Readiness of health-care institutions in KwaZulu-Natal to implement telepsychiatry. *Journal of Telemedicine and Telecare*, *18*(3), 133–137. doi:10.1258/jtt.2012.SFT103 PMID:22362834

Choe, E., Lee, N., Lee, B., Pratt, W., & Kientz, J. (2014). Understanding quantified-selfers' practices in collecting and exploring personal data. *Proceedings of the 32nd Annual ACM Conference on Human Factors in Computing Systems (CHI '14)*, 1143–1152. 10.1145/2556288.2557372

Choi, B., & Lee, H. (2003). An empirical investigation of KM styles and their effect on corporate performance. *Information & Management*, *40*(5), 403–417. doi:10.1016/S0378-7206(02)00060-5

Chrischilles, E. A., Hourcade, J. P., Doucette, W., Eichmann, D., Gryzlak, B., Lorentzen, R., ... Levy, B. (2014). Personal health records: A randomized trial of effects on elder medication safety. *Journal of the American Medical Informatics Association*, *21*(4), 679–686. doi:10.1136/amiajnl-2013-002284 PMID:24326536

Chung, W., He, S., & Zeng, D. (2015). emood: Modeling emotion for social media analytics on Ebola disease outbreak. *Proceedings of the International Conference on Information Systems.*

Chung, M., & Gray, P. (1999). Special section: Data mining. *Journal of Management Information Systems*, *16*(1), 11–16. doi:10.1080/07421222.1999.11518231

Chwif, L. (1999). Redução de modelos de simulação de eventos discretos na sua concepção: uma abordagem causal. São Paulo: Academic Press.

Ciani, O., Tarricone, R., & Torbica, A. (2012). Diffusion and use of health technology assessment in policy making: What lessons for decentralised healthcare systems? *Health Policy (Amsterdam)*, *108*(2–3), 194–202. doi:10.1016/j.healthpol.2012.09.017 PMID:23093020

Clough, J. D., & McClellan, M. (2016). Implementing MACRA Implications for Physicians and for Physician Leadership. *Journal of the American Medical Association*, *315*(22), 2397. doi:10.1001/jama.2016.7041 PMID:27213914

Cochran, C. E., Mayer, L. C., Carr, T. R., & Cayer, N. J. (1986). *American Public Policy: An introduction* (2nd ed.). New York: St Martins Press.

Coelho, C., Coelho, D., & Wolf, M. (2015, December). An IoT smart home architecture for long-term care of people with special needs. In *IEEE 2nd World Forum on Internet of Things (WF-IoT)*, 2015 (pp. 626–627). IEEE. 10.1109/WF-IoT.2015.7389126

Cohen, S. B., & Yu, W. (2012, January). The Concentration and Persistence in the Level of Health Expenditures over Time: Estimates for the U.S. Population, 2008-2009. *The Concentration and Persistence in the Level of Health Expenditures over Time: Estimates for the U.S. Population*, 2008–2009.

Connell, Martin, Bartlett, & Harvey. (2017). Cancer in Australia 2017. Canberra: Australian Institute of Health and Welfare Canberra Cat.

Considine, J., Kropman, M., Kelly, E., & Winter, C. (2008). Effect of emergency department fast track on emergency department length of stay: A case–control study. *Emergency Medicine Journal*, *25*(12), 815–819. doi:10.1136/emj.2008.057919 PMID:19033498

Considine, J., Lucas, E., Martin, R., Stergiou, H., Kropman, M., & Chiu, H. (2012, January 18). Rapid intervention and treatment zone: Redesigning nursing services to meet increasing emergency department demand. *International Journal of Nursing Practice*, *18*(1), 60–67. doi:10.1111/j.1440-172X.2011.01986.x PMID:22257332

Coulter, H. L. (1995). An update on the history of homeopathic and allopathic medicine. *Journal of the American Institute of Homeopathy*, *88*(3), 122–126.

Courtney, K. L., Demiris, G., Rantz, M., & Skubic, M. (2008). Needing smart home technologies: The perspectives of older adults in continuing care retirement communities. *Informatics in Primary Care*, *16*, 195–201. PMID:19094406

Crawford Albert, G., Fuhr Joseph, P., & Hubbs Brandon, O. (2005). *Comparative Effectiveness of Total Population versus Disease-Specific Neural Network Models in Predicting Medical Costs*. Department of Health Policy of Jefferson Medical College.

Crawford, S. (2013). Is it time for a new paradigm for systemic cancer treatment? Lessons from a century of cancer chemotherapy. *Frontiers in Pharmacology*, *4*, 68. doi:10.3389/fphar.2013.00068 PMID:23805101

Cripps, H., & Standing, C. (2012). Building patient trust in electronic health records. In *Australian eHealth Informatics and Security Conference*. Edith Cowan University Research Online. Retrieved from https://ro.ecu.edu.au/cgi/viewcontent.cgi?referer=https://www.google.com.au/&httpsredir=1&article=1002&context=aeis

Croasdell, D. C. (2001). IT's role in organizational memory and learning. *Information Systems Management*, *18*(1), 8–11. doi:10.1201/1078/43194.18.1.20010101/31260.2

CrowdMed.com. (2019). Retrieved September 6, 2019, from https://www.crowdmed.com/?utm_medium=cpc&utm_source=bing&utm_campaign=bing-brand&utm_keyword=crowdmed

Cucciare, M. A., & O'Donohue, W. (2006). Predicting future healthcare costs: How well does risk-adjustment work? *Journal of Health Organization and Management*, *20*(2), 150–162. doi:10.1108/14777260610661547 PMID:16869351

Cunningham, P. J. (2017). Predicting high-cost privately insured patients based on self-reported health and utilization data. *The American Journal of Managed Care*, *23*(7), e215–e222. PMID:28850789

CureCrowd.com. (2019). Retrieved September 6, 2019, from https://www.curecrowd.com/

Cutler, D. M., Huckman, R. S., & Landrum, M. B. (2004). The role of information in medical markets: An analysis of publicly reported outcomes in cardiac surgery. *The American Economic Review*, *94*(2), 342–346. doi:10.1257/0002828041301993 PMID:29068186

Dabaj, F. (2009). The role of gender and age on students' perceptions towards online education case study: Sakarya University, Vocational High School. *The Turkish Online Journal of Educational Technology*, *8*(2), 120–123.

Daliri, S., Bekker, C. L., Buurman, B. M., Scholte op Reimer, W. J. M., van den Bemt, B. J. F., & Karapinar - Çarkit, F. (2019). Barriers and facilitators with medication use during the transition from hospital to home: A qualitative study among patients. *BMC Health Services Research*, *19*(1), 204. doi:10.118612913-019-4028-y PMID:30925880

Dameri, R. P. (2012). Defining an evaluation framework for digital cities implementation. In *Information Society (i-Society), 2012 International Conference on* (pp. 466-470). IEEE.

Daousi, C., MacFarlane, I. A., Woodward, A., Nurmikko, T. J., Bundred, P. E., & Benbow, S. J. (2004). Chronic painful peripheral neuropathy in an urban community: A controlled comparison of people with and without diabetes. *Diabetic Medicine*, *21*(9), 976–982. doi:10.1111/j.1464-5491.2004.01271.x PMID:15317601

Darius, P., Boucneau, M., De Greef, P., De Feber, E., & Froeschl, K. (1993). Modelling metadata. *Statistical Journal of the United Nations Economic Commission for Europe*, *10*, 171–179.

Dartmouth College. (2019). Research explains public resistance to vaccination. *Science Daily*. Retrieved June 30, 2019, from https://www.sciencedaily.com/releases/2019/01/190109090933.htm

Darwin, A., & Palmer, E. (2009). Mentoring circles in higher education. *Higher Education Research & Development*, *28*(2), 125–136. doi:10.1080/07294360902725017

Davenport, T. H., Jarvenpaa, S. L., & Beers, M. C. (1996). Improving knowledge work processes. *Sloan Management Review*, *37*, 53–65.

Davenport, T. H., & Prusak, L. (1997). *Working Knowledge: How Organizations Manage What They Know*. Cambridge, MA: Harvard Business School Press.

Davenport, T., & Grover, V. (2001). Knowledge management. *Journal of Management Information Systems*, *18*(1), 3–4. doi:10.1080/07421222.2001.11045674

Davenport, T., & Prusak, L. (1998). *Working Knowledge*. Cambridge, MA: Harvard Business School Press.

Davidson, S. S., Passmore, R., & Eastwood, M. A. (1986). *Human Nutrition and Dietetics* (8th ed.). English Language Book Society.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319-340. Retrieved from http://www.jstor.org/stable/249008

De Bruin, T., Freeze, R., Kaulkarni, U., & Rosemann, M. (2005). Understanding the main phases of developing a maturity assessment model. In B. Campbell, J. Underwood, & D. Bunker (Eds.), *Proceedings of the ACIS 2005* (pp. 8–19). Retrieved from https://eprints.qut.edu.au/25152/

de Cruppé, W., & Geraedts, M. (2017). Hospital choice in Germany from the patient's perspective: A cross-sectional study. *BMC Health Services Research*, *17*(1), 720–720. doi:10.118612913-017-2712-3 PMID:29132430

De Haan, E., Duckworth, A., Birch, D., & Jones, C. (2013). Executive coaching outcome research: The contribution of common factors such as relationship, personality match, and self-efficacy. *Consulting Psychology Journal: Practice and Research*, *65*(1), 40–57. doi:10.1037/a0031635

De Vries, H., Kremers, S. P. J., Smeets, T., Brug, J., & Eijmael, K. (2008). The effectiveness of tailored feedback and action plans in an intervention addressing multiple health behaviors. *American Journal of Health Promotion*, *22*(6), 417–425. doi:10.4278/ajhp.22.6.417 PMID:18677882

Dearness, K. L., & Tomlin, A. (2001). Development of the national electronic library for mental health: Providing evidence-based information for all. *Health Information and Libraries Journal*, *18*(3), 167–174. doi:10.1046/j.0265-6647.2001.00344.x PMID:11780750

Dehmer, G. J., Drozda, J. P. Jr, Brindis, R. G., Masoudi, F. A., Rumsfeld, J. S., Slattery, L. E., & Oetgen, W. J. (2014). Public reporting of clinical quality data: An update for cardiovascular specialists. *Journal of the American College of Cardiology*, *63*(13), 1239–1245. doi:10.1016/j.jacc.2013.11.050 PMID:24509280

Deighton, J., Henderson, C. M., & Neslin, S. A. (1994). The effects of advertising on brand switching and repeat purchasing. *JMR, Journal of Marketing Research*, *31*(1), 28–43. doi:10.1177/002224379403100103

Delgado-Mohatar, O., Fierrez, J., Tolosana, R., & Vera-Rodriguez, R. (2019). *Blockchain and Biometrics: A First Look into Opportunities and Challenges*. arXiv preprint arXiv:1903.05496

Delone, W. H. (1988). Determinants of success for computer usage in small business. *Management Information Systems Quarterly*, *12*(1), 51–61. doi:10.2307/248803

Dempsey, L. A. (2018). *Targeting Ebola*. Nature Microbiology.

Deng, S., Huang, Z., Sinha, AP, & Zhao, H. (2018). The Interaction Between Microblog Sentiment and Stock Returns: An Empirical Examination. *MIS Quarterly*, *42*(3), 895-918.

DesRoches, C. M., Painter, M. W., & Jha, A. K. (2013). *Health information technology in the United States: better information systems for better care, 2013*. Mathematica Policy Research.

Dettmer, H. W. (1997). *Goldratt's Theory of Constraints: a systems approach to continuous improvement*. Milwaukee, WI: ASQC Quality Press.

Dhillon, G., & Backhouse, J. (2000). Information system security management in the new millennium. *Communications of the ACM*, *43*(7), 125–128. doi:10.1145/341852.341877

Dijkman, B., Kooistra, B., Ferguson, T., & Bhandari, M. (2008). Decision making open reduction/internal fixation versus arthroplasty for femoral neck fractures. *Techniques Orthopediques*, *23*(4), 288–295. doi:10.1097/BTO.0b013e318196fb53

DiMaggio, P. J., & Powell, W. W. (1983). The iron cage revisited: Institutional isomorphism in organizational fields. *American Sociological Review*, *48*, 147–160. doi:10.2307/2095101

Dimitrov, D. V. (2019). Blockchain Applications for Healthcare Data Management. *Healthcare Informatics Research*, *25*(1), 51–56. doi:10.4258/hir.2019.25.1.51 PMID:30788182

Ding, Y., Xu, H., Yang, L., & Tan, B. C. (2016). Online Prosocial Microlending Decision Making: A Natural Experiment of Ebola Outbreak. *Proceedings of the International Conference on Information Systems*.

do Brasil, S. F. (1988). *Constituição da república federativa do Brasil*. Brasília: Senado Federal, Centro Gráfico.

Dodge, B. (1991). *Learning in an Organizational Setting: the Public Service Context*. Study prepared for the Canadian Centre for Management Development.

Dodziuk H. (2016). Applications of 3D printing in healthcare. *Kardiochirurgia i torakochirurgia polska, 13*(3), 283–293. doi:10.5114/kitp.2016.62625

Doering, N., & Maarse, H. (2015). The use of publicly available quality information when choosing a hospital or healthcare provider: The role of the GP. *Health Expectations*, *18*(6), 2174–2182. doi:10.1111/hex.12187 PMID:24673801

Do, H. M., Pham, M., Sheng, W., Yang, D., & Liu, M. (2018). RiSH: A robot-integrated smart home for elderly care. *Robotics and Autonomous Systems*, *101*, 74–92. doi:10.1016/j.robot.2017.12.008

Donelly, B. (2017). *International code of practice for planning, commissioning and providing technology enabled care services: A quality framework for procurement and provision of services*. Buckinghamshire, UK: Community Equipment Solutions.

Donnermeyer, J. F., Plested, B. A., Edwards, R. W., Oetting, G., & Littlethunder, L. (1997). Community readiness and prevention programs. *Journal of the Community Development Society*, *28*(1), 65–83. doi:10.1080/15575339709489795

Donzé, J., Aujesky, D., Williams, D., & Schnipper, J. L. (2013). Potentially avoidable 30-day hospital readmissions in medical patients: Derivation and validation of a prediction model. *JAMA Internal Medicine*, *173*(8), 632–638. doi:10.1001/jamainternmed.2013.3023 PMID:23529115

Doremus, B. L. (1976). The Four R's: Social Diagnosis in Health Care. *Health & Social Work*, *1*(4), 120–139. doi:10.1093/hsw/1.4.120 PMID:992495

Dorr, L. D., Thomas, D. J., Zhu, J., Dastane, M., Chao, L., & Long, W. T. (2010). Outpatient total hip arthroplasty. *The Journal of Arthroplasty*, *25*(4), 501–506. doi:10.1016/j.arth.2009.06.005 PMID:19640672

Doty, P. (1986). Family care of the elderly: The role of public policy. *The Milbank Quarterly*, *64*(1), 34–75. doi:10.2307/3350005 PMID:3084932

Doughty, K., Monk, A., Bayliss, C., Brown, S., Dewsbury, L., Dunk, B., ... McAlister, L. (2008). Telecare, telehealth, and assistive technologies: Do we know what we're talking about? Housing. *Care and Support*, *11*(3), 36–41. doi:10.1108/14608790200800023

Doukas, C., Metsis, V., Becker, E., Le, Z., Makedon, F., & Maglogiannis, I. (2011). Digital cities of the future: Extending@ home assistive technologies for the elderly and the disabled. *Telematics and Informatics*, *28*(3), 176–190. doi:10.1016/j.tele.2010.08.001

Drechsler, A., & Hevner, A. (2016). A four-cycle model of IS design science research: capturing the dynamic nature of IS artifact design. In *Proceedings of the 11th International Conference on Design Science Research in Information Systems and Technology*. St. John, Canada: DESRIST 2016.

Dreyer, T. (2014, May). 2014, Care transitions: Best practices and evidence-based programs. *Home Healthcare Nurse*, *32*(5), 309–316. doi:10.1097/NHH.0000000000000069 PMID:24802602

Duckett, S., & Willcox, S. (2015). *The Australian health care system*. Oxford University Press.

Duffy, J. (2000). The KM technology infrastructure. *Information Management Journal*, *34*, 62–66.

Duffy, J. (2001). The tools and technologies needed for knowledge management. *Information Management Journal*, *35*, 64–67.

Duncan, L. D., Gray, K., Lewis, J. M., Bell, J. L., Bigge, J., & Mckinney, J. M. (2010). Clinical integration of picture archiving and communication systems with pathology and hospital information system in oncology. *The American Surgeon*, *76*, 982–986. PMID:20836348

Dunlop, D. D., Lyons, J. S., Manheim, L. M., Song, J., & Chang, R. W. (2004, June). Arthritis and Heart Disease as Risk Factors for Major Depression: The Role of Functional Limitation. *Medical Care*, *42*(6), 502–511. doi:10.1097/01.mlr.0000127997.51128.81 PMID:15167318

Dunne, L. (2010). Smart clothing in practice: Key design barriers to commercialization. *Fashion Practice: The Journal of Design*. *Creative Process & the Fashion Industry*, *2*(1), 41–66.

Dunn, W. N. (2012). *Public Policy Analysis* (5th ed.). Pearson Education.

Du, X., Zhang, X., & Tang, Y. (2016). General practitioners' perceptions of public reporting of institution and individual medicine prescribing data. *BMC Health Services Research*, *16*(1), 641–641. doi:10.118612913-016-1893-5 PMID:27829429

EC. (2015). *European scaling-up Strategy in Active & Healthy Ageing*. European Commission.

Eccles, M. P., & Mittman, B. S. (2006). Welcome to implementation science. *Implementation Science; IS*, *1*(1), 1–3. doi:10.1186/1748-5908-1-1

Edirisinghe, R., Stranieri, A., & Wickramasinghe, N. (2017). A Taxonomy for mHealth. In N. Wickramasinghe (Ed.), *Handbook of research on healthcare administration and management* (pp. 596–615). Hershey, PA: IGI Global. doi:10.4018/978-1-5225-0920-2.ch036

Edwards, R. W., Jumper-Thurman, P., Plested, B. A., Oetting, E. R., & Swanson, L. (2000). Community readiness: Research to practice. *Journal of Community Psychology*, *28*(3), 291–307. doi:10.1002/(SICI)1520-6629(200005)28:3<291::AID-JCOP5>3.0.CO;2-9

Eikelbooma'b, R. H. (2012). The telegraph and the beginnings of telemedicine in Australia. *Global Telehealth 2012: Delivering Quality Healthcare Anywhere Through Telehealth: Selected Papers from Global Telehealth 2012 (GT2012), 182*, 67.

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review*, *14*(4), 532–550. doi:10.5465/amr.1989.4308385

Ellinger, A. D., Watkins, K. E., & Bostrom, R. P. (1999). Managers as facilitators of learning in learning organizations. *Human Resource Development Quarterly*, *10*(2), 105–125. doi:10.1002/hrdq.3920100203

Elliott, M. N., Cohea, C. W., Lehrman, W. G., Goldstein, E. H., Cleary, P. D., Giordano, L. A., ... Zaslavsky, A. M. (2015). Accelerating improvement and narrowing gaps: Trends in patients' experiences with hospital care reflected in HCAHPS public reporting. *Health Services Research*, *50*(6), 1850–1867. doi:10.1111/1475-6773.12305 PMID:25854292

Emmert, M., Sander, U., Esslinger, A. S., Maryschok, M., & Schöffski, O. (2012). Public reporting in Germany: The content of physician rating websites. *Methods of Information in Medicine*, *51*(02), 112–120. doi:10.3414/ME11-01-0045 PMID:22101427

Ensor, T., & Cooper, S. (2002). *Resource Allocation and Purchasing: Influencing the demand side*. York, UK: Centre for Health Economics, University of York. Prepared for the World Bank, Resource Allocation and Purchasing Project.

Evans, W., Ashbury, F. D., Hogue, G., Smith, A., & Pun, J. (2014). Implementing a regional oncology information system: Approach and lessons learned. *Current Oncology (Toronto, Ont.)*, *21*(5), 224. doi:10.3747/co.21.1923 PMID:25302031

Eysenbach, G. (2000). Consumer health informatics. *BMJ (Clinical Research Ed.)*, *320*(7251), 1713–1716. doi:10.1136/bmj.320.7251.1713 PMID:10864552

Eysenbach, G. (2005). The law of attrition. *Journal of Medical Internet Research*, *7*(1), e11. doi:10.2196/jmir.7.1.e11 PMID:15829473

Faber, M., Bosch, M., Wollersheim, H., Leatherman, S., & Grol, R. (2009). Public reporting in health care: How do consumers use quality-of-care information?: A systematic review. *Medical Care*, *47*(1), 1–8. doi:10.1097/MLR.0b013e3181808bb5 PMID:19106724

Faertes, D. (2015). Reliability of supply chains and business continuity management. *Procedia Computer Science*, *55*, 1400–1409. doi:10.1016/j.procs.2015.07.130

Fanjiang, G., Grossman, J. H., Compton, W. D., & Reid, P. P. (Eds.). (2005). *Building a better delivery system: a new engineering/health care partnership*. National Academies Press.

Fasola, G., Aita, M., Marini, L., Follador, A., Tosolini, M., Mattioni, L., ... Aprile, G. (2008). Drug waste minimisation and cost-containment in medical oncology: Two-year results of a feasibility study. *BMC Health Services Research*, *8*(1), 70. doi:10.1186/1472-6963-8-70 PMID:18380901

Fayyad, U., Piatetsky-Shapiro, G., & Smyth, P. (1996). From data mining to knowledge discovery: an overview. In U. Fayyad, G. Piatetsky-Shapiro, & P. S. Uthurusamy (Eds.), *Advances in Knowledge Discovery and Data Mining*. Menlo Park, CA: AAAI Press/The MIT Press.

Ferlie, E. B., & Shortell, S. M. (2001). Improving the quality of health care in the United Kingdom and the United States: A framework for change. *The Milbank Quarterly*, *79*(2), 281–315. doi:10.1111/1468-0009.00206 PMID:11439467

Finando, S., & Finando, D. (2012). Qi, acupuncture and the fascia: A reconsideration the fundamental principles of acupuncture. *Journal of Alternative and Complementary Medicine (New York, N.Y.)*, *18*(9), 880–886. doi:10.1089/acm.2011.0599 PMID:22874011

Fishbein, M. (1980). A theory of reasoned action: Some applications and implications. In H. Howe, & M. Page (Eds.), *Nebraska Symposium on Motivation* (pp. 65-116). Lincoln, NE: University of Nebraska Press.

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention and behavior: An introduction to theory and research*. Reading, MA: Addison-Wesley.

Flavian Blanco, C., Gurrea Sarasa, R., & Orus Sanclemente, C. (2010). Effects of visual and textual information in online product presentations: Looking for the best combination in website design. *European Journal of Information Systems*, *19*(6), 668–686. doi:10.1057/ejis.2010.42

Fleishman, J. A., & Cohen, J. W. (2010). Using information on clinical conditions to predict high-cost patients. *Health Services Research*, *45*(2), 532–552. doi:10.1111/j.1475-6773.2009.01080.x PMID:20132341

Fleming, T. M., Bavin, L., Stasiak, K., Hermansson-Webb, E., Merry, S. N., Cheek, C., ... Hetrick, S. (2017). Serious games and gamification for mental health: Current status and promising directions. *Frontiers in Psychiatry*, *7*, 215. doi:10.3389/fpsyt.2016.00215 PMID:28119636

Fogg, B. J. (2002, Dec.). Persuasive technology: Using computers to change what we think and do. *Ubiquity*, 5.

Fogg, B. J. (2009). A behavior model for persuasive design. *Proceedings of the 4th international conference on persuasive technology*. 10.1145/1541948.1541999

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *JMR, Journal of Marketing Research*, *18*(1), 39–50. doi:10.1177/002224378101800104

Fowler, B. L. J., Johns, J., Tanniru, M. R., Ballijepally, V., Roumani, Y. F., Bobryk, D., & Mitchell, K. (2018). Engaging patients through Multi-Disciplinary Rounding – The case study at a Michigan hospital. *Journal of Hospital Administration*, *7*(5), 17–26. doi:10.5430/jha.v7n5p17

Fragidis, L., & Chatzoglou, P. (2018). Implementation of a Nationwide Electronic Health Record (EHR): The International Experience in 13 Countries. *International Journal of Health Care Quality Assurance*, *31*(2), 116–13. doi:10.1108/IJHCQA-09-2016-0136 PMID:29504871

Frandsen, B. R., & Joynt, K. E. (2015). Care fragmentation, quality, and costs among chronically ill patients. *The American Journal of Managed Care*, *21*(5), 355–362. PMID:26167702

Fraser, P., Moultrie, J., & Gregory, M. (2002). The use of maturity models/grids as a tool in assessing product development capability. *IEEE International Engineering Management Conference*, *1*, 244–249. 10.1109/IEMC.2002.1038431

Freitas, D. J., Marcondes, T. B., Nakamura, L. H., & Meneguette, R. I. (2015, June). A health smart home system to report incidents for disabled people. In *International Conference on Distributed Computing in Sensor Systems (DCOSS)* (pp. 210–211). IEEE. 10.1109/DCOSS.2015.28

Freund, Y., & Schapire, R. E. (1997). A Decision-Theoretic Generalization of On-Line Learning and an Application to Boosting. *Journal of Computer and System Sciences*, *55*(1), 119–139. doi:10.1006/jcss.1997.1504

Fried, L. P., Bandeen-Roche, K., Kasper, J. D., & Guralnik, J. M. (1999, January). Association of Comorbidity with Disability in Older Women: The Women's Health and Aging Study. *Journal of Clinical Epidemiology*, *52*(1), 27–37. doi:10.1016/S0895-4356(98)00124-3 PMID:9973071

Fuhrman, J. (2005). *Eat to live: the revolutionary formula for fast and sustained weight loss*. New York: Little, Brown and Company.

Funge, I., Zion, T., Chi-Ngai, C., Adriana, S., & King-Wa, F. (2014). Ebola and the social media. *Lancet*, *384*, 207.

Galar, M., Fernandez, A., Barrenechea, E., Bustince, H., & Herrera, F. (2012). A Review on Ensembles for the Class Imbalance Problem: Bagging-, Boosting-, and Hybrid-Based Approaches. *IEEE Transactions on Systems, Man and Cybernetics. Part C, Applications and Reviews*, *42*(4), 463–484. doi:10.1109/TSMCC.2011.2161285

Ganguly, A., Mostashari, A., & Mansouri, M. (2012). *Measuring Knowledge Management/Knowledge Sharing KM/KS Efficiency and Effectiveness in Enterprise Networks*. Dynamic Models for Knowledge-Driven Organizations.

Gefen, D., & Straub, D. W. (2005). A practical guide to factorial validity using PLS-Graph: Tutorial and annotated example. *Communications of the Association for Information Systems*, *16*, 91–109. doi:10.17705/1CAIS.01605

Geraedts, M., Hermeling, P., & de Cruppé, W. (2012). Communicating quality of care information to physicians: A study of eight presentation formats. *Patient Education and Counseling*, *87*(3), 375–382. doi:10.1016/j.pec.2011.11.005 PMID:22177585

Gerich, J. E. (2003, April). Contributions of insulin-resistance and insulin-secretory defects to the pathogenesis of type 2 diabetes mellitus. *Mayo Clinic Proceedings*, *78*(4), 447–456. doi:10.4065/78.4.447 PMID:12683697

Gessnitzer, S., & Kauffeld, S. (2015). The working alliance in coaching: Why behavior is the key to success. *The Journal of Applied Behavioral Science*, *51*(2), 177–197. doi:10.1177/0021886315576407

Gholamhosseini, L., & Ayatollahi, H. (2016). The design and application of an e-health readiness assessment tool. *The HIM Journal*, *46*(1), 32–41. doi:10.1177/1833358316661065 PMID:27486183

Gholipour, R., & Rouzbehani, Kh. (2016). *Social, Economic and political perspective on public health policymaking*. IGI Global publishing house.

Ghorai, K., Jahan, S., Ray, P., & Chylinski, M. (2014). mHealth for behaviour change: Role of a smartphone-based multi-intervention service for hypertension and diabetes in Bangladesh. *International Journal of Biomedical Engineering and Technology*, *16*(2), 135–155. doi:10.1504/IJBET.2014.065655

Gibbons, M. C. (2011). Use of health information technology among racial and ethnic underserved communities. *Perspectives in Health Information Management, 8*.

Gibbons, M. C., Bali, R. K., & Wickramasinghe, N. (2010). *Perspectives of knowledge management in urban health* (Vol. 1). Springer. doi:10.1007/978-1-4419-5644-6

Gibson, I., Rosen, D., & Stucker, B. (2015). *Additive Manufacturing Technologies*. New York: Springer. doi:10.1007/978-1-4939-2113-3

Gijsen, R., Hoeymans, N., Schellevis, F. G., Ruwaard, D., Satariano, W. A., & van den Bos, G. A. (2001). Causes and consequences of comorbidity: A review. *Journal of Clinical Epidemiology*, *54*(7), 661–674. doi:10.1016/S0895-4356(00)00363-2 PMID:11438406

Gillespie, M. (2010). Using the Situated Clinical Decision-Making framework to guide analysis of nurses' clinical decision-making. *Nurse Education in Practice*, *10*(6), 333–340. doi:10.1016/j.nepr.2010.02.003 PMID:20356794

Gill, J. S., Wright, A. J., Delmonico, F. L., & Newell, K. A. (2017). Towards improving the transfer of care of kidney transplant recipients. *American Journal of Transplantation*, *17*(1), 54–59. doi:10.1111/ajt.13997 PMID:27495956

Gilmour, J. A. (2007). Reducing disparities in the access and use of Internet health information. A discussion paper. *International Journal of Nursing Studies*, *44*(7), 1270–1278. doi:10.1016/j.ijnurstu.2006.05.007 PMID:16828775

Gino, F., & Pisano, G. (2008). Toward a theory of behavioral operations. *Manufacturing & Service Operations Management: M & SOM*, *10*(4), 676–691. doi:10.1287/msom.1070.0205

Ginsburg, P., Loera-Brust, A., Brandt, C., & Durak, A. (2018). *The opportunities and challenges of data analytics in health care*. Report Produced by Artificial Intelligence and Emerging Technologies Initiative The Brookings Initiative on artificial intelligence and emerging technologies seeks to establish a proper societal framework for the impending "digitalization of everything." Retrieved from https://www.brookings.edu/research/the-opportunities-and-challenges-of-data-analytics-in-health-care/

Glanville, J., Wilson, P., & Richardson, R. (2003). Accessing the online evidence: A guide to key sources of research information on clinical and cost effectiveness. *Quality & Safety in Health Care*, *12*(>3), 229–231. doi:10.1136/qhc.12.3.229 PMID:12792016

Global Public Health Intelligence Network (GPHIN). (2019). Retrieved September 6, 2019, from https://gphin.canada.ca/cepr/listarticles.jsp?language=en_CA

Glombiewski, J A., Bernardy, K., & Häuser, W. (2013). Efficacy of EMG- and EEG-Biofeedback in Fibromyalgia Syndrome: A Meta-Analysis and a Systematic Review of Randomized Controlled Trials. *Vid Based Complement Alternat Med., 962741*.

Goel, M., Brown, T., Williams, A., Hasnain-Wynia, R., Thompson, J., & Baker, D. (2011). Disparities in enrollment and use of an electronic patient portal. *Journal of General Internal Medicine*, *26*(10), 1112–1116. doi:10.100711606-011-1728-3 PMID:21538166

Goldberg, S. (2002a). *Building the Evidence for a Standardized Mobile Internet (wireless) Environment in Ontario, Canada*. January Update, internal INET documentation.

Goldberg, S. (2002b). *HTA Presentational Selection and Aggregation Component Summary.* internal documentation.

Goldberg, S. (2002c). *Wireless POC Device Component Summary*. internal INET documentation.

Goldberg, S. (2002d). *HTA Presentation Rendering Component Summary*. internal INET documentation.

Goldberg, S. (2002e). *HTA Quality Assurance Component Summary*. internal INET documentation.

Goldberg, S. (2018). *These are the health concerns facing Chicago youth*. Retrieved from: https://www.chicagobusiness.com/health-care/these-are-health-concerns-facing-chicago-youth

Goldratt, E. M. (1990). *What is This Thing Called Theory of Constraints and How Should it be Implemented?* New York, NY: North River Press.

Goldratt, E. M. (1994). *It's Not Luck*. Gower.

Goldratt, E. M., & Cox, J. (1984). *The Goal: An Ongoing Improvement Process*. Aldershot, UK: Gower.

Goldzweiq, C. L., Orshansky, G., Paiqe, N. M., Towfiqh, A. A., Haqqstrom, D. A., Miake-Lye, I., & ... . (2013). Electronic patient portals: evidence on health outcomes, satisfaction, efficiency, and attitudes: a systematic review. *Annals of Internal Medicine*, *159*(10), 677–687. doi:10.7326/0003-4819-159-10-201311190-00006 PMID:24247673

Gonsalves, G., & Staley, P. (2014, December). Panic, Paranoia, and Public Health— The AIDS Epidemic's Lessons for Ebola. *The New England Journal of Medicine*, *371*(25), 2348–2349. doi:10.1056/NEJMp1413425 PMID:25372947

Gopalan, A., Makelarski, J. A., Garibay, L. B., Escamilla, V., Merchant, R. M., Wolfe, M. B. Sr, ... Lindau, S. T. (2016). Health-Specific Information and Communication Technology Use and Its Relationship to Obesity in High-Poverty, Urban Communities: Analysis of a Population-Based Biosocial Survey. *Journal of Medical Internet Research*, *18*(6), e182. doi:10.2196/jmir.5741 PMID:27352770

Gordon, W. J., & Catalini, C. (2018). Blockchain Technology for Healthcare: Facilitating the Transition to Patient-Driven Interoperability. *Computational and Structural Biotechnology Journal*, *16*, 224–230. doi:10.1016/j.csbj.2018.06.003 PMID:30069284

Gostin, L.O., & Friedman, E.A. (2015). A retrospective and prospective analysis of the west African Ebola virus disease epidemic: robust national health systems at the foundation and an empowered WHO at the apex. *Lancet*, *385*(9980), 1902-1909.

Gould, J. S., Tong, C., Ly, J., Vazirian, S., Windt, A., & Khan, K. (2019). Process evaluation of team-based care in people aged> 65 years with type 2 diabetes mellitus. *BMJ Open*, *9*(8), e029965. doi:10.1136/bmjopen-2019-029965 PMID:31377711

Gov2020. (2019). *Explore the future of government*. Retrieved from https://www2.deloitte.com/au/en/pages/public-sector/articles/gov2020.html

Grant, A. M. (2017). The third 'generation'of workplace coaching: creating a culture of quality conversations. *Coaching: An International Journal of Theory*. *Research and Practice*, *10*(1), 37–53.

Gregor, S., & Hevner, A.R. (2013). Positioning and presenting design science research for maximum impact. *MIS Quarterly, 37*(2), 337-355.

Gregor, S., & Hevner, A. R. (2013). Positioning and presenting design science research for maximum impact. *Management Information Systems Quarterly*, *37*(2), 337–355. doi:10.25300/MISQ/2013/37.2.01

Grol, R., & Grimshaw, J. M. (1999). Evidence-based implementation of evidence based medicine. *The Joint Commission Journal on Quality Improvement*, *25*(10), 503–513. doi:10.1016/S1070-3241(16)30464-3 PMID:10522231

Grossman, M. (2000). The human capital model. In Handbook of Health economics: volume 1A. Amsterdam: North-Holland.

Gruessner, V. (2015, March). *Top 8 Goals of Stage 3 Meaningful Use Proposed Rule*. Retrieved from EHR INTELLIGENCE: https://ehrintelligence.com/news/top-8-goals-of-stage-3-meaningful-use-proposed-rule

Grzyb, M., Zhang, A., Good, C., Khalil, K., Guo, B., Tian, L., ... Gu, Q. (2017). Multi-task cox proportional hazard model for predicting risk of unplanned hospital readmission. In *2017 Systems and Information Engineering Design Symposium (SIEDS)* (pp. 265–270). IEEE. 10.1109/SIEDS.2017.7937729

Guah, M. W. (2017). Resilience in the Gaze of Ebola: Analysis from a Developing Country. *Proceedings of the 50th Hawaii International Conference on System Sciences.* 10.24251/HICSS.2017.304

Gubbi, J., Buyya, R., Marusic, S., & Palaniswami, M. (2013). Internet of Things (IoT): A vision, architectural elements, and future directions. *Future Generation Computer Systems*, *29*(7), 1645–1660. doi:10.1016/j.future.2013.01.010

Guénette, J., Belzile, G., & Hjertqvist, J. (2017). *Health care in Sweden: Decentralized, autonomous, competitive, and universal*. MEI.

Gulati, M., Rastogi, R., Chaturvedi, D. K., Satya, S., Arora, N., & Singhal, P. (2018f). Statistical Resultant Analysis of Spiritual & Psychosomatic Stress Survey on Various Human Personality Indicators. *The International Conference proceedings of ICCI 2018.*

Gulati, M., Rastogi, R., Chaturvedi, D. K., Sharma, P., Yadav, V., Chauhan, S., . . . Singhal, P. (2019e). Statistical Resultant Analysis of Psychosomatic Survey on Various Human Personality Indicators: Statistical Survey to Map Stress and Mental Health. In *Handbook of Research on Learning in the Age of Transhumanism* (pp. 363-383). Hershey, PA: IGI Global. doi:10.4018/978-1-5225-8431-5.ch022

Günal, M. M., & Pidd, M. (2010). Discrete event simulation for performance modelling in health care: A review of the literature. *Journal of Simulation*, *4*(1), 42–51. doi:10.1057/jos.2009.25

Guo, H., Gao, S., Tsui, K. L., & Niu, T. (2017). Simulation optimization for medical staff configuration at emergency department in Hong Kong. *IEEE Transactions on Automation Science and Engineering*, *14*(4), 1655–1665. doi:10.1109/TASE.2017.2697899

Gupta, M., Rastogi, R., Chaturvedi, D. K., Satya, S. A., Verma, H., Singhal, P., & Singh, A. (2019a). Comparative Study of Trends Observed During Different Medications by Subjects under EMG & GSR Biofeedback. *IJITEE, 8*(6S), 748-756. Retrieved from https://www.ijitee.org/download/volume-8-issue-6S/

Gupta, J. N. D., Sharma, S. K., & Hsu, J. (2003). An Overview of Knowledge Management. In *Creating Knowledge based Organization*. Idea Group Publishing.

Guyon, I., & Elisseeff, A. (2003). An introduction to variable and feature selection. *Journal of Machine Learning Research*, *3*, 1157–1182. Retrieved from http://dl.acm.org/ft_gateway.cfm?id=944968&type=pdf

Haddad, P., Schaffer, J., & Wickramasinghe, N. (2015). Evaluating Business Value of IT in Healthcare: Three Clinical Practices from Australia and the US. *Proceedings of the 15th World Congress on Health and Biomedical Informatics*.

Hainstock, T., Cloutier, D., & Penning, M. (2017). From home to 'home': Mapping the caregiver journey in the transition from home care into residential care. *Journal of Aging Studies*, *43*, 32–39. doi:10.1016/j.jaging.2017.09.003 PMID:29173512

Haixiang, G., Yijing, L., Shang, J., Mingyun, G., Yuanyue, H., & Bing, G. (2017). Learning from class-imbalanced data: Review of methods and applications. *Expert Systems with Applications*, *73*, 220–239. doi:10.1016/j.eswa.2016.12.035

Hall, R. (2013). *Patient flow: reducing delay in healthcare delivery*. Berlin: Springer Science & Business Media. doi:10.1007/978-1-4614-9512-3

Hamari, J., Koivisto, J., & Pakkanen, T. (2014, May). Do persuasive technologies persuade?-a review of empirical studies. *International conference on persuasive technology*, 118-136. 10.1007/978-3-319-07127-5_11

Hambleton, S., & Aloizos, J. (2019). Australia's digital health journey. *The Medical Journal of Australia*, *210*(6), S5–S6. doi:10.5694/mja2.50039 PMID:30927473

Hammond, C. (2001). The intelligent enterprise. *InfoWorld*, *23*, 45–46.

Harcourt, M., Lam, H., & Harcourt, S. (2005). Discriminatory practices in hiring: Institutional and rational economic perspectives. *International Journal of Human Resource Management*, *16*(11), 2113–2132. doi:10.1080/09585190500315125

Hardy, D., & Smith, B. (2008). Decision making in clinical practice. *British Journal of Anaesthetic & Recovery Nursing*, *9*(1), 19–21. doi:10.1017/S1742645608000028

Harper, L. (2013). The top 5 sites crowdsourcing for your health. *Milken Institute School of Public Health*. Retrieved September 6, 2019, from https://publichealthonline.gwu.edu/top-5-sites-crowdsourcing-health/

Hartmann, J., Jacobs, S., Eberhard, S., von Lengerke, T., & Amelung, V. (2016). Analysing predictors for future high-cost patients using German SHI data to identify starting points for prevention. *European Journal of Public Health*, *26*(4), 549–555. doi:10.1093/eurpub/ckv248 PMID:26850904

Hasan, O., Meltzer, D. O., Shaykevich, S. A., Bell, C. M., Kaboli, P. J., Auerbach, A. D., ... Schnipper, J. L. (2010). Hospital readmission in general medicine patients: A prediction model. *Journal of General Internal Medicine*, *25*(3), 211–219. doi:10.100711606-009-1196-1 PMID:20013068

Hayek, F. A. (1945). The use of knowledge in society. *The American Economic Review*, *35*(4), 519–530.

Health Insurance Association of America. (1993). *Source Book on Health Insurance*. Washington, DC: The Association.

Healthmap.org. (2019). Retrieved September 7, 2019, from https://healthmap.org/en/

Heggestad, T. (2002). Do Hospital Length of Stay and Staffing Ratio Affect Elderly Patients' Risk of Readmission? A Nation-wide Study of Norwegian Hospitals. *Health Services Research*, *37*(3), 647–665. doi:10.1111/1475-6773.00042 PMID:12132599

He, H., & Garcia, E. A. (2009). Learning from Imbalanced Data. *IEEE Transactions on Knowledge and Data Engineering*, *21*(9), 1263–1284. doi:10.1109/TKDE.2008.239

Heisler, M., Piette, J. D., Spencer, M., Kieffer, E., & Vijan, S. (2005). The relationship between knowledge of recent HbA1c values and diabetes care understanding and self-management. *Diabetes Care*, *28*(4), 816–822. doi:10.2337/diacare.28.4.816 PMID:15793179

Herre, H., & Heller, B. (2004). Ontological foundations of medical information systems. *New Trends in Software Methodologies, Tools and Techniques: Proceedings of the Third SoMeT_W04, 111*.

Hertwig, R., & Hoffrage, U. (2012). Simple heuristics: The foundations of adaptive social behavior. *Simple Heuristics in a Social World*, *3*. doi:10.1093/acprof:oso/9780195388435.003.0001

Herzig, J. L., Schnipper, J. L., Doctoroff, L., Kim, C. S., Flanders, S. A., Robinson, E. J., ... Auerbach, A. D. (2016). Physician Perspectives on Factors Contributing to Readmissions and Potential Prevention Strategies: A Multicenter Survey Shoshana. *Journal of General Internal Medicine*, *31*(11), 1287–1293. doi:10.100711606-016-3764-5 PMID:27282857

Hevner, A. R. (2007). A three cycle view of design science research. *Scandinavian Journal of Information Systems, 19*(2), 4.

Hevner, A., March, S., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS Quarterly, 28*(1), 75-105.

Hevner, A., March, S.T., Park, J., & Ram, S. (2004). Design science research in information systems. *MIS Quarterly, 28*(1), 75-105.

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. *Management Information Systems Quarterly*, *28*(1), 75–105. doi:10.2307/25148625

Hevner, A., & Wickramasinghe, N. (2017). Design Science Research Opportunities in Healthcare. *Theories for Health Informatics Research*.

Hevner, A., & Wickramasinghe, N. (2018). *Design Science Research Methodology in Healthcare* (W. a. Schaffer, Ed.). New York: Springer.

Hewson, D. J., Duchêne, J., Charpillet, F., Saboune, J., Michel-Pellegrino, V., Amoud, H., ... Hogrel, J. Y. (2007). The PARAChute project: Remote monitoring of posture and gait for fall prevention. *EURASIP Journal on Applied Signal Processing*, (1): 109–109.

Hibbard, J. H., & Peters, E. (2003). Supporting informed consumer health care decisions: Data presentation approaches that facilitate the use of information in choice. *Annual Review of Public Health*, *24*(1), 413–433. doi:10.1146/annurev.publhealth.24.100901.141005 PMID:12428034

Hibbard, J. H., Slovic, P., Peters, E., & Finucane, M. L. (2002). Strategies for reporting health plan performance information to consumers: Evidence from controlled studies. *Health Services Research*, *37*(2), 291–313. doi:10.1111/1475-6773.024 PMID:12035995

Hibbard, J. H., Stockard, J., & Tusler, M. (2003). Does publicizing hospital performance stimulate quality improvement efforts? *Health Affairs*, *22*(2), 84–94. doi:10.1377/hlthaff.22.2.84 PMID:12674410

Hibbard, J., & Sofaer, S. (2010). *Best practices in public reporting no. 1: How to effectively present health care performance data to consumers*. Rockville, MD: Agency for Healthcare Research and Quality.

Hillestad, R., Bigelow, J., Bower, A., Girosi, F., Meili, R., Scoville, R., & Taylor, R. (2005). Can electronic medical record systems transform health care? Potential health benefits, savings, and costs. *Health Affairs*, *24*(5), 1103–1117. doi:10.1377/hlthaff.24.5.1103 PMID:16162551

Hirsch, J. A., Leslie-Mazwi, T., Barr, R. M., McGinty, G., Nicola, G. N., Patel, A. B., & Manchikanti, L. (2015). The Burwell roadmap. *Journal of Neurointerventional Surgery*. PMID:25744382

Hirsch, J., Leslie-Mazwi, T., Nicola, G., Bhargavan-Chatfield, M., Seidenwurm, D., Silva, E., & Manchikanti, L. (2016). PQRS and the MACRA: Value-Based Payments Have Moved from Concept to Reality. *AJNR. American Journal of Neuroradiology*, *37*(12), 2195–2200. doi:10.3174/ajnr.A4936 PMID:27659194

Hirsch, J., Rosenkrantz, A. B., Ansari, S. A., Manchikanti, L., & Nicola, G. N. (2016). MACRA 2.0: Are you ready for MIPS? *Journal of Neurointerventional Surgery*, *9*(7), 714–716. doi:10.1136/neurintsurg-2016-012845 PMID:27884928

Hjelm, N. M. (2005). Benefits and drawbacks of telemedicine. *Journal of Telemedicine and Telecare*, *11*(2), 60–70. doi:10.1258/1357633053499886 PMID:15829049

Hofmann, M., & Klinkenberg, R. (2013). *RapidMiner: Data mining use cases and business analytics applications*. CRC Press.

Hogan, C., Lunney, J., Gabel, J., & Lynn, J. (2001). Medicare beneficiaries' cost of care in the last year of life. *Health Affairs*, *20*(4), 189–195. doi:10.1377/hlthaff.20.4.188 PMID:11463076

Hollnagel, E., Braithwaite, J., & Wears, R. L. (2013). *Resilient health care*. Surrey, UK: Ashgate Publishing Limited.

Holsapple, C., & Joshi, K. (2002). Knowledge manipulation activities: Results of a Delphi study. *Information & Management*, *39*(6), 477–419. doi:10.1016/S0378-7206(01)00109-4

Holt, G. D., Love, P. E. D., & Li, H. (2000). The learning organization: Toward a paradigm for mutually beneficial strategic construction alliances. *International Journal of Project Management*, *18*(6), 415–421. doi:10.1016/S0263-7863(99)00066-6

Honigsbaum, M. (2017). Between securitisation and neglect: managing Ebola at the borders of global health. *Medical History*, *61*(2), 270-294.

Hopp, W. J., & Lovejoy, W. S. (2013). *Hospital operations: principles of high efficiency health care*. FT Press.

Horton, E. S. (1988). Role and management of exercise in diabetes mellitus. *Diabetes Care*, *11*(2), 201–211. doi:10.2337/diacare.11.2.201 PMID:3289869

Hoyt, R. E., & Yoshihashi, A. K. (2014). *Health informatics: Practical guide for healthcare and information technology professionals*. Academic Press.

Hsiao, C. J., & Hing, E. (2014). Use and characteristics of electronic health record systems among office-based physician practices: United States, 2001–2013. *NCHS data brief, no 143*. Hyattsville, MD: National Center for Health Statistics. Retrieved from http://www.cdc.gov/nchs/data/databriefs/db143.htm

Hu, M., & Liu. (2004). *Mining and summarizing customer reviews*. Paper presented at the ACM SIGKDD International Conference on Knowledge Discovery and Data Mining, Seattle, WA.

Huber, G. (1991). Organization science organizational learning: The contributing processes and the literatures. *Organization Science*, *2*(1), 88–115. doi:10.1287/orsc.2.1.88

Hu, F. B., Manson, J. E., Stampfer, M. J., Colditz, G., Liu, S., Solomon, C. G., & Willett, W. C. (2001). Diet, Lifestyle, and the Risk of Type 2 Diabetes Mellitus in Women. *The New England Journal of Medicine*, *345*(11), 790–797. doi:10.1056/NEJMoa010492 PMID:11556298

Hunt, B. R., Whitman, S., & Henry, C. A. (2014). *Age-adjusted diabetes mortality rates vary in local communities in a metropolitan area: racial and spatial disparities and correlates*. Diabetes Care.

Hunter, D. J., & Lo, G. H. (2008). The management of osteoarthritis: An overview and call to appropriate conservative treatment. *Rheumatic Diseases Clinics of North America*, *34*(3), 689–712. doi:10.1016/j.rdc.2008.05.008 PMID:18687278

Hurley, J. (2001). Ethics, economics, and public financing of health care. *Journal of Medical Ethics*, *27*(4), 234–239. doi:10.1136/jme.27.4.234 PMID:11479353

Huttunen, H.-L., & Halonen, R. (2018). Willingness to use smartphone application assistant to support migraine treatment. *BLED 2018 Proceedings*. Retrieved from https://aisel.aisnet.org/bled2018/15

Huttunen, H.-L., Halonen, R., & Ferreira, D. (2018, May). Identifying bottlenecks in work processes: Elderly care. In *2018 IEEE 6th International Conference on Serious Games and Applications for Health (SeGAH)* (pp. 1–8). IEEE. doi:10.1109/SeGAH.2018.8401385

Huttunen, H.-L., Klakegg, S., Van Berkel, N., Visuri, A., Ferreira, D., & Halonen, R. (2017, December). Understanding elderly care: a field-study for designing future homes. In *Proceedings of the 19th International Conference on Information Integration and Web-based Applications & Services* (pp. 390–394). ACM. 10.1145/3151759.3151835

iCOPS. (2017). *Commissioning Technology Enabled Care Services*. Retrieved November 15, 2018, from CECOPS & TECS Products | iCOPS® website: http://www.icops.co.uk/products/cecops-tecs-products/

Imamura, F., O'Connor, L., Ye, Z., Mursu, J., Hayashino, Y., Bhupathiraju, S. N., & Forouhi, N. G. (2015). Consumption of sugar sweetened beverages, artificially sweetened beverages, and fruit juice and incidence of type 2 diabetes: Systematic review, meta-analysis, and estimation of population attributable fraction. *BMJ (Clinical Research Ed.)*, *351*, h3576. doi:10.1136/bmj.h3576 PMID:26199070

International Surgical Outcomes Study Group. (2016). Global patient outcomes after elective surgery: Prospective cohort study in 27 low-, middle-, and high-income countries. *British Journal of Anaesthesia*, *117*(5), 601–609. doi:10.1093/bja/aew316 PMID:27799174

Irvine, B. (2003). *Computers for caregiving*. Paper presented at SPRY National Conference, Computer-based Technology and Caregiving for Older Adults, Betheseda, MD.

Ivers, N. M., Taljaard, M., Giannakeas, V., Reis, C., Williams, E., & Bronskill, S. (2019). Public reporting of antipsychotic prescribing in nursing homes: Population-based interrupted time series analyses. *BMJ Quality & Safety*, *28*(2), 121–131. doi:10.1136/bmjqs-2018-007840 PMID:30061102

Jain, R. (2010, August). Investigation of Governance Mechanisms for Crowdsourcing Initiatives. In *Americas Conference for Information Systems Conference Proceedings* (p. 557). Academic Press.

Jamei, M., Nisnevich, A., Wetchler, E., Sudat, S., & Liu, E. (2017). Predicting all-cause risk of 30-day hospital readmission using artificial neural networks. *PLoS One*, *12*(7), e0181173. doi:10.1371/journal.pone.0181173 PMID:28708848

Jämsen, E., Varonen, M., Huhtala, H., Lehto, M. U., Lumio, J., Konttinen, Y. T., & Moilanen, T. (2010). Incidence of prosthetic joint infections after primary knee arthroplasty. *The Journal of Arthroplasty*, *25*(1), 87–92. doi:10.1016/j.arth.2008.10.013 PMID:19056210

Janke, A. T., Overbeek, D. L., Kocher, K. E., & Levy, P. D. (2016). Exploring the potential of predictive analytics and big data in emergency care. *Annals of Emergency Medicine*, *67*(2), 227–236. doi:10.1016/j.annemergmed.2015.06.024 PMID:26215667

Jan, P. T., Lu, H. P., & Chou, T. C. (2012). The adoption of e-learning: An institutional theory perspective. *The Turkish Online Journal of Education Technology*, *11*(3), 326–343.

Janssen, A., Brunner, M., Keep, M., Hines, M., Nagarajan, S. V., Kielly-Carroll, C., ... Shaw, T. (2017). Interdisciplinary eHealth Practice in Cancer Care: A Review of the Literature. *International Journal of Environmental Research and Public Health*, *14*(11), 1289. doi:10.3390/ijerph14111289 PMID:29068377

Jenkin, R. A., Frommer, M. S., & Rubin, G. L. (2006). Translating indicators and targets into public health action. In D. Pencheon, C. Guest, D. Melzer, & J. A. Muir Gray (Eds.), *Oxford Handbook of Public Health*. Oxford University Press.

Jennett, P., Jackson, A., Healy, T., Ho, K., Kazanjian, A., Woollard, R., ... Bates, J. (2003). A study of a rural community's readiness for telehealth. *Journal of Telemedicine and Telecare*, *9*(5), 259–263. doi:10.1258/135763303769211265 PMID:14599328

Jensen, L. K., Knarvik, U., Pedersen, C. D., Tangene, W., & Whitehouse, D. (2015). *Deliverable 3.4 Personalised Blueprint for telemedicine deployment: Validated and tested version*. Retrieved from http://www.telemedicine-momentum.eu/

Jensen, M. C., & Meckling, W. H. (1992). Specific and general knowledge, and organizational structure. In L. Werin & H. Wijkander (Eds.), *Contract Economics* (pp. 251–274). Oxford, UK: Blackwell.

Jha, A. K., Doolan, D., Grandt, D., Scott, T., & Bates, D. W. (2008). The use of health information technology in seven nations. *International Journal of Medical Informatics*, *77*(12), 848–854. doi:10.1016/j.ijmedinf.2008.06.007 PMID:18657471

Johnson, C., Dowd, T. J., & Ridgeway, C. L. (2006). Legitimacy as a social process. *Annual Review of Sociology*, *32*(1), 53–78. doi:10.1146/annurev.soc.32.061604.123101

Johns, P. M. (1997). Integrating information systems and health care. *Logistics Information Management*, *10*(4), 140–145. doi:10.1108/09576059710187555

Jones, D. B., Sung, C., Weinberg, C., Korelitz, T., & Andrews, R. (2016). Three-dimensional modeling may improve surgical education and clinical practice. *Surgical Innovation*, *23*(2), 189–195. doi:10.1177/1553350615607641 PMID:26423911

Jowett, S. (2017). Coaching effectiveness: The coach–athlete relationship at its heart. *Current Opinion in Psychology*, *16*, 154–158. doi:10.1016/j.copsyc.2017.05.006 PMID:28813341

Jung, C., Padman, R., Shevchik, G., & Paone, S. (2011). Who are portal users vs. early e-visit adopters? A preliminary analysis. *AMIA Annual Symposium Proceedings*, 1070–1079.

Källander, K., Tibenderana, J. K., Akpogheneta, O. J., Strachan, D. L., Hill, Z., ten Asbroek, A. H., ... Meek, S. R. (2013). Mobile health (mHealth) approaches and lessons for increased performance and retention of community health workers in low-and-middle-income countries: A review. *Journal of Medical Internet Research*, *15*(1), e17. doi:10.2196/jmir.2130 PMID:23353680

Kamel Boulos, M. N., Giustini, D. M., & Wheeler, S. (2016). Instagram and WhatsApp in health and healthcare: An overview. *Future Internet*, *8*(3), 37. doi:10.3390/fi8030037

Kanaya, A. M., Herrington, D., Vittinghoff, E., Ewing, S. K., Liu, K., Blaha, M. J., . . . Kandula, N. R. (2014). Understanding the high prevalence of diabetes in the US south Asians compared with four racial/ethnic groups: the MASALA and MESA studies. Diabetes Care, 132656.

Kandemirli, B. (2018). What makes a helpful online review? A study of customer reviews on Amazon.com. *Research Gate*, 185–200.

Kankanhalli, A., Hahn, J., Tan, S., & Gao, G. (2016). Big data and analytics in healthcare: An introduction to the special section. *Information Systems Frontiers*, *18*(2), 233–235. doi:10.100710796-016-9641-2

Kansagara, D., Englander, H., Salanitro, A., Kagen, D., Theobald, C., Freeman, M., & Kripalani, S. (2011). Risk prediction models for hospital readmission: A systematic review. *Journal of the American Medical Association*, *306*(15), 1688–1698. doi:10.1001/jama.2011.1515 PMID:22009101

Kaplan, R. S., & Porter, M. E. (2011). How to solve the cost crisis in health care. *Harvard Business Review*, *89*(9), 46–52. PMID:21939127

Kapp, K. M. (1999). Transforming your manufacturing organization into a learning organization. *Hospital Materiel Management Quarterly*, *20*, 46–54. PMID:10387780

Karlson, E. W., Mandl, L. A., Aweh, G. N., Sangha, O., Liang, M. H., & Grodstein, F. (2003). Total hip replacement due to osteoarthritis: The importance of age, obesity, and other modifiable risk factors. *The American Journal of Medicine*, *114*(2), 93–98. doi:10.1016/S0002-9343(02)01447-X PMID:12586227

Karwalajtys, T., Kaczorowski, J., Chambers, L., Levitt, C., Dolovich, L., McDonough, B., & ... . (2005). A randomized trial of mail vs. telephone invitation to a community-based cardiovascular health awareness program for older family practice patients. *BMC Family Practice*, 6–35. PMID:16111487

Kasiske, B. L., Wey, A., Salkowski, N., Zaun, D., Schaffhausen, C. R., Israni, A. K., & Snyder, J. J. (2019). Seeking new answers to old questions about public reporting of transplant program performance in the United States. *American Journal of Transplantation*, *19*(2), 317–323. doi:10.1111/ajt.15051 PMID:30074680

Katuu, S. (2016). Transforming South Africa's health sector: The eHealth Strategy, the implementation of electronic document and records management systems (EDRMS) and the utility of maturity models. *Journal of Science and Technology Policy Management*, *7*(3), 330–345. doi:10.1108/JSTPM-02-2016-0001

Katz, J. N., Barrett, J., Mahomed, N. N., Baron, J. A., Wright, R. J., & Losina, E. (2004). Association Between Hospital and Surgeon Procedure Volume and the Outcomes of Total Knee Replacement. *The Journal of Bone and Joint Surgery (American)*, *86*(9), 1909–1916. doi:10.2106/00004623-200409000-00008 PMID:15342752

Kautzky-Willer, A., Harreiter, J., & Pacini, G. (2016). Sex and gender differences in risk, pathophysiology and complications of type 2 diabetes mellitus. *Endocrine Reviews*, *37*(3), 278–316. doi:10.1210/er.2015-1137 PMID:27159875

Keener, J. D., Callaghan, J. J., Goetz, D. D., Pederson, D. R., Sullivan, P. M., & Johnston, R. C. (2003). Twenty-five-Year Results After Charnley Total Hip Arthroplasty in Patients Less than Fifty Years Old A Concise Follow-up of a Previous Report*. *The Journal of Bone & Joint Surgery*, *85*(6), 1066–1072. doi:10.2106/00004623-200306000-00013 PMID:12784004

Kelaher, M., Prang, K. H., Sabanovic, H., & Dunt, D. (2018). The impact of public performance reporting on health plan selection and switching: A systematic review and meta-analysis. *Health Policy (Amsterdam)*. PMID:30340906

Keltner, D., Van Kleef, G. A., Chen, S., & Kraus, M. (2008). A reciprocal influence model of social power: Emerging principles and lines of inquiry. *Advances in Experimental Social Psychology*, *40*, 151–19. doi:10.1016/S0065-2601(07)00003-2

Kempf, K., Schloot, N.C., Gärtner, B., Keil, R., Schadewaldt, P., & Martin, S. (2014). Meal replacement reduces insulin requirement, HbA1c and weight long-term in type 2 diabetes patients with >100 U insulin per day. *Journal of Human Nutrition & Dietetics, 21*(7).

Kern, M. L., Safford, M. M., Makovkina, E., Slavin, M. J., Fudl, A., Carrillo, J. E., & Abramson, E. L. (2019, February). Patients' and Providers' Views on Causes and Consequences of Healthcare Fragmentation in the Ambulatory Setting: A Qualitative Study. *Journal of General Internal Medicine*, *34*(6), 899–907. doi:10.100711606-019-04859-1 PMID:30783883

Kern, S. E., & Jaron, D. (2003). Healthcare Technology, Economics and Policy: An Evolving Balance. *IEEE Engineering in Medicine and Biology*, *1*(22), 16–19. doi:10.1109/MEMB.2003.1191444 PMID:12683057

Khalfan, A. M. (2004). Information security considerations in IS/IT outsourcing projects: A descriptive case study of two sectors. *International Journal of Information Management*, *24*(1), 29–42. doi:10.1016/j.ijinfomgt.2003.12.001

Khan, M. L. (2017). Social media engagement: What motivates user participation and consumption on YouTube? *Computers in Human Behavior*, *66*, 236–247. doi:10.1016/j.chb.2016.09.024

Khoja, S., Durrani, H., Scott, R. E., Sajwani, A., & Piryani, U. (2013). Conceptual framework for development of comprehensive e-Health evaluation tool. *Telemedicine Journal and e-Health*, *19*(1), 48–53. doi:10.1089/tmj.2012.0073 PMID:22957502

Khoja, S., Scott, R. E., Casebeer, A. L., Mohsin, M., Ishaq, A. F. M., & Gilani, S. (2007). E-Health Readiness Assessment Tools for Healthcare Institutions in Developing Countries. *Telemedicine Journal and e-Health*, *13*(4), 425–431. doi:10.1089/tmj.2006.0064 PMID:17848110

Khuntia, J., Tanniru, M., Fragoli, F., & Nawrocki, M. (2016). Mindfulness Differences in Hospital Unit Operations: Analysis of Response to Nurse Call Systems. *Pacific Asia Journal of the Association for Information Systems*, *8*(1), 33–64. doi:10.17705/1pais.08102

Khuntia, J., Tanniru, M., & Weiner, J. (2015). Juggling Digitization and Technostress: The Case of Alert Fatigues due to Intelligent Care System Implementation at a Hospital. *Health Policy and Technology*, *4*, 364–377. doi:10.1016/j.hlpt.2015.08.005

Khuntia, J., Tanniru, M., & Weiner, J. (2017). Dimensions of Patient Experience and Overall Satisfaction in Emergency Units. *Journal of Patient Satisfaction, SAGE Publications*, *4*(3), 95–100.

Khunti, K., Gray, L. J., Skinner, T., Carey, M. E., Realf, K., Dallosso, H., ... Davies, M. J. (2012). Effectiveness of a diabetes education and self management programme (DESMOND) for people with newly diagnosed type 2 diabetes mellitus: Three year follow-up of a cluster randomised controlled trial in primary care. *BMJ (Clinical Research Ed.)*, *344*(apr26 2), e2333. doi:10.1136/bmj.e2333 PMID:22539172

Klakegg, S., van Berkel, N., Visuri, A., Huttunen, H.-L., Hosio, S., Luo, C., ... Ferreira, D. (2017, September). Designing a context-aware assistive infrastructure for elderly care. In *Proceedings of the 2017 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2017 ACM International Symposium on Wearable Computers* (pp. 563–568). 10.1145/3123024.3124403

Klasnja, P. V., & Pratt, W. (2014). Managing health with mobile technology. *Interactions, 21*(1), 66-69.

Klein, R. (2007). An empirical examination of patient-physician portal acceptance. *European Journal of Information Systems*, *16*(6), 751–760. doi:10.1057/palgrave.ejis.3000719

Kleinwechter, H., Schäfer-Graf, U., Bührer, C., Hoesli, I., Kainer, F., & Kautzky-Willer, A. (2011). *Gestationsdiabetes mellitus (GDM). Evidenzbasierte Leitlinie zu Diagnostik, Therapie u. Nachsorge der Deutschen Diabetes-Gesellschaft (DDG) und der Deutschen Gesellschaft für Gynäkologie und Geburtshilfe (DGGG).* Retrieved from www. deutsche-diabetes-gesellschaft. de

Klimko, G., & Remenyi, D. (2001). Knowledge management and maturity models: Building common understanding. Academic Press.

Kohavi, R., & John, G. H. (1997). Wrappers for feature subset selection. *Artificial Intelligence*, *97*(1-2), 273–324. doi:10.1016/S0004-3702(97)00043-X

Koh, K. W., Wang, W., Richards, A. M., Chan, M. Y., & Cheng, K. F. (2016). Effectiveness of advanced practice nurse-led telehealth on readmissions and health-related outcomes among patients with post-acute myocardial infarction: ALTRA Study Protocol. *Journal of Advanced Nursing*, *72*(6), 1357–1367. doi:10.1111/jan.12933 PMID:26915719

Kohnert, K. D., Augstein, P., Zander, E., Heinke, P., Peterson, K., Freyse, E. J., . . . Salzsieder, E. (2009). Glycemic variability correlates strongly with postprandial beta-cell dysfunction in a segment of type 2 diabetic patients using oral hypoglycemic agents. Diabetes Care, 32(6), 1058-62.

Ko, J., Lu, C., Srivastava, M. B., Stankovic, J. A., Terzis, A., & Welsh, M. (2010). Wireless sensor networks for healthcare. *Proceedings of the IEEE*, *98*(11), 1947–1960. doi:10.1109/JPROC.2010.2065210

Kon, B., Lam, A., & Chan, J. (2017). Evolution of smart homes for the elderly. In *Proceedings of the 26th International Conference on World Wide Web Companion* (pp. 1095–1101). Geneva, Switzerland: International World Wide Web Conferences Steering Committee. 10.1145/3041021.3054928

Kotsiantis, S. B., Kanellopoulos, D., & Pintelas, P. E. (2006). *Handling imbalanced datasets: A review.* Retrieved from https://pdfs.semanticscholar.org/95df/dc02010b9c390878729f459893c2a5c0898f.pdf

Koukouvinos, K. D. C. (2016). Proximal support vector machine techniques on medical prediction outcome. *Journal of Applied Statistics*, *44*(3), 533–553.

Kozlowski, D., Hutchinson, M., Hurley, J., Rowley, J., & Sutherland, J. (2017). The role of emotion in clinical decision making: An integrative literature review. *BMC Medical Education*, *17*(1), 255. doi:10.118612909-017-1089-7 PMID:29246213

Krall, L. P., & Beaser, R. S. (1989). *Joslin's Diabetic Manual* (12th ed.). Philadelphia: Lea and Febiger.

Krayenbuehl, J., Norton, I., Studer, G., & Guckenberger, M. (2015). Evaluation of an automated knowledge based treatment planning system for head and neck. *Radiation Oncology (London, England)*, *10*(1), 226. doi:10.118613014-015-0533-2 PMID:26555303

Kreuninger, J. A., Cohen, S. L., Meurs, E. A. I. M., Cox, M., Vitonis, A., Jansen, F. W., & Einarsson, J. I. (2018). Trends in readmission rate by route of hysterectomy - a single-center experience. *Acta Obstetricia et Gynecologica Scandinavica*, *97*(3), 285–293. doi:10.1111/aogs.13270 PMID:29192965

Krishnamachari, B. (2005). *Networking Wireless Sensors*. Cambridge University Press. doi:10.1017/CBO9780511541025

Krist, A. H., Woolf, S. H., Rothemich, S. F., Johnson, R. E., Peele, J. E., Cunningham, T. D., ... Matzke, G. R. (2012). Interactive preventive health record to enhance delivery of recommended care: A randomized trial. *Annals of Family Medicine*, *10*(4), 312–319. doi:10.1370/afm.1383 PMID:22778119

Kristensen, S. R., Bech, M., & Quentin, W. (2015). A roadmap for comparing readmission policies with application to Denmark, England, Germany and the United States. *Health Policy (Amsterdam, Netherlands)*, *119*(3), 264–273. doi:10.1016/j.healthpol.2014.12.009 PMID:25547401

Kruk, M.E., Myers, M., Varpilah, S.T., & Dahn, B.T. (2015). What is a resilient health system? Lessons from Ebola. *Lancet*, *385*(9980), 1910-1912.

Krumholz, H. M. (2014). Big data and new knowledge in medicine: The thinking, training, and tools needed for a learning health system. *Health Affairs*, *33*(7), 1163–1170. doi:10.1377/hlthaff.2014.0053 PMID:25006142

Kulyk, O., op den Akker, R., Klaassen, R., & van Gemert-Pijnen, L. (2014). Personalized Virtual Coaching for Lifestyle Support: Principles for Design and Evaluation. *International Journal on Advances in Life Sciences*, *6*(3-4), 300–309.

Kumar, A., Karmarkar, A. M., Graham, J. E., Resnik, L., Tan, A., Deutsch, A., & Ottenbacher, K. J. (2017). Comorbidity Indices Versus Function as Potential Predictors of 30-Day Readmission in Older Patients Following Postacute Rehabilitation. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, *72*(2), 223–228. doi:10.1093/gerona/glw148 PMID:27492451

Kumpunen, S., Trigg, L., & Rodrigues, R. (2014). *Public reporting in health and long-term care to facilitate provider choice*. Academic Press.

Kuo, T. T., Kim, H. E., & Ohno-Machado, L. (2017). Blockchain distributed ledger technologies for biomedical and health care applications. *Journal of the American Medical Informatics Association*, *24*(6), 1211–1220. doi:10.1093/jamia/ocx068 PMID:29016974

Kurtz, S., Ong, K., Lau, E., Mowat, F., & Halpern, M. (2007). Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. *The Journal of Bone & Joint Surgery*, *89*(4), 780–785. PMID:17403800

Laakso, M., & Kuusisto, J. (2007, August). Cerebrovascular disease in type 2 diabetes. In *International Congress Series* (Vol. 1303, pp. 65–69). Elsevier.

Lagu, T., Norton, C. M., Russo, L. M., Priya, A., Goff, S. L., & Lindenauer, P. K. (2019). Reporting of Patient Experience Data on Health Systems' Websites and Commercial Physician-Rating Websites: Mixed-Methods Analysis. *Journal of Medical Internet Research*, *21*(3), e12007. doi:10.2196/12007 PMID:30916654

Laios, A., Theodorakis, N., & Gargalianos, D. (2003). Leadership and power: Two important factors for effective coaching. *International Sports Journal*, *7*(1), 150–154.

La, J., & Jewkes, E. M. (2013). Defining an optimal ED fast track strategy using simulation. *Journal of Enterprise Information Management*, *26*(1), 109–118. doi:10.1108/17410391311289578

Lak, P., & Turetken, O. (2017). The Impact of Sentiment Analysis Output on Decision Outcomes: An Empirical Evaluation. *AIS Transactions on Human-Computer Interaction*, *1*(9), 1–22. doi:10.17705/1thci.00086

Larsson, S., & Sjöblom, Y. (2010). Perspectives on narrative methods in social work research. *International Journal of Social Welfare*, *19*(3), 272–280. doi:10.1111/j.1468-2397.2009.00672.x

Lau, E., Bozic, K. J., Berry, D., & Parvizi, J. (2010). Prosthetic joint infection risk after TKA in the Medicare population. *Clinical Orthopaedics and Related Research*, *468*(1), 52–56. doi:10.100711999-009-1013-5 PMID:19669386

Lavrač, N., Gamberger, D., Todorovski, L., & Blockeel, H. (Eds.). Chawla, Nitesh, Lazarevic, A., Hall, Lawrence, & Bowyer, Kevin. (2003). Smoteboost: Improving Prediction of the Minority Class in Boosting. In N. Lavrač, D. Gamberger, L. Todorovski, & H. Blockeel (Eds.), Lecture Notes in Computer Science: Vol. 2838. Knowledge Discovery in Databases: PKDD 2003: 7th European Conference on Principles and Practice of Knowledge Discovery in Databases, Cavtat-Dubrovnik, Croatia, September 22-26, 2003. Proceedings (Vol. 2838, pp. 107–119). Berlin: Springer. 10.1007/978-3-540-39804-2_12

Law, A. M., & Kelton, W. D. (2000). *Simulation modeling and analysis*. Singapore: McGraw-Hill.

Leatherman, S., & McCarthy, D. (1999). Public disclosure of health care performance reports: Experience, evidence and issues for policy. *International Journal for Quality in Health Care*, *11*(2), 93–98. doi:10.1093/intqhc/11.2.93 PMID:10442837

Leescher, D. (2012). *How patient-centric care differs from patient-centered care*. Available at: https://davidleescher.wordpress.com/2012/03/03/how-patient-centric-care-differs-from-patient-centered-care-2/

Lee, Y. D., & Chung, W. Y. (2009). Wireless sensor network based wearable smart shirt for ubiquitous health and activity monitoring. *Sensors and Actuators. B, Chemical*, *140*(2), 390–395. doi:10.1016/j.snb.2009.04.040

Légaré, É., Vincent, C., Lehoux, P., Anderson, D., Kairy, D., Gagnon, M.-P., & Jennett, P. (2010). Developing and validating the French-Canadian version of the practitioner and organizational telehealth readiness assessment tools. *Journal of Telemedicine and Telecare*, *16*(3), 140–146. doi:10.1258/jtt.2009.090514 PMID:20386034

Lehto, T., Oinas-Kukkonen, H., Pätiälä, T., & Saarelma, O. (2013). Virtual health coaching for consumers: a persuasive systems design perspective. *International Journal of Networking and Virtual Organisations 4, 13*(1), 24-41.

Leininger, L. J., Saloner, B., & Wherry, L. R. (2015). Predicting high-cost pediatric patients: Derivation and validation of a population-based model. *Medical Care*, *53*(8), 729–735. doi:10.1097/MLR.0000000000000391 PMID:26172939

Lenz, R. M. M. a. H.-J. (2013). *Business Intelligence*. Berlin: eXamen Press, Springer Vieweg.

Leonardi, M. J., McGory, M. L., & Ko, C. Y. (2007). Publicly available hospital comparison web sites: Determination of useful, valid, and appropriate information for comparing surgical quality. *Archives of Surgery*, *142*(9), 863–869. doi:10.1001/archsurg.142.9.863 PMID:17875841

Leu, M. G., Austin, E., Foti, J. L., Hrachovec, J., Poplisky, J., Spencer, S. M., . . . Migita, D. S. (2016). A Framework for Evaluating Value of New Clinical Recommendations. *Hospital Pediatirics, 6*(10).

Levine, L. (2001). Integrating knowledge and processes in a learning organization. *Information Systems Management*, *18*(1), 21–33. doi:10.1201/1078/43194.18.1.20010101/31262.4

Ley, S. H., Hamdy, O., Mohan, V., & Hu, F. B. (2014). Prevention and management of type 2 diabetes: Dietary components and nutritional strategies. *Lancet*, *383*(9933), 1999–2007. doi:10.1016/S0140-6736(14)60613-9 PMID:24910231

Liang, H., Saraf, N., Hu, Q., & Xue, Y. (2007). Assimilation of enterprise systems: The effect of institutional pressures and the mediating role of top management. *Management Information Systems Quarterly*, *31*(1), 59–87. doi:10.2307/25148781

Liao, J. M., Shea, J. A., Weissman, A., & Navathe, A. S. (2018). THE PRACTICE OF MEDICINE: Physician Perspectives In Year 1 Of MACRA And Its Merit-Based Payment System: A National Survey. *Health Affairs*, *37*(7), 1079–1086. doi:10.1377/hlthaff.2017.1485 PMID:29985697

Li, B., Cairns, J., Fotheringham, J., Ravanan, R., & Group, A. S. (2016). Predicting hospital costs for patients receiving renal replacement therapy to inform an economic evaluation. *The European Journal of Health Economics*, *17*(6), 659–668. doi:10.100710198-015-0705-x PMID:26153418

Lin, C. C., Chiu, M. J., Hsiao, C. C., Lee, R. G., & Tsai, Y. S. (2006). Wireless health care service system for elderly with dementia. *Transactions on Information Technology in Biomedicine*, *10*(4), 696–704. doi:10.1109/TITB.2006.874196 PMID:17044403

Lin, C. H., Shih, H. Y., & Sher, P. J. (2007). Integrating technology readiness into technology acceptance: The TRAM model. *Psychology and Marketing*, *24*(7), 641–657. doi:10.1002/mar.20177

Lippke, S., Wiedemann, A. U., Ziegelmann, J. P., Reuter, T., & Schwarzer, R. (2009). Self-efficacy moderates the mediation of intentions into behavior via plans. *American Journal of Health Behavior*, *33*(5), 521–529. doi:10.5993/AJHB.33.5.5 PMID:19296742

Lipworth, W., Little, J. L. M., Markham, P., Gordon, J., & Kerridge, I. (2013). Doctors on status and respect: A qualitative study. *Journal of Bioethical Inquiry*, *10*(2), 205–217. doi:10.100711673-013-9430-2 PMID:23515959

Litvak, E. (2009). *Managing patient flow in hospitals: strategies and solutions* (2nd ed.). Oakbrook Terrace, IL: Illinois Joint Commission Resources.

Liu, Y., Wu, M., & Sun, Z. (2014). Extending the TAM model to explore the factors that affect Intention to Use digital textbooks in primary teachers' views. *Intelligent Environments*, 127-136.

Liu, B. (2015). Sentiment analysis and subjectivity. In N. Indurkhya & F. Dameraua (Eds.), *Handbook of Natural Language Processing* (2nd ed.; pp. 627–666). Boca Raton, FL: CRC.

Liu, C., Tang, Y., Wang, D., & Zhang, X. (2017). The effect of public reporting presentation on patients' decision making: An experimental survey in Yunan Province, China. *Medicine*, *96*(24), e7203. doi:10.1097/MD.0000000000007203 PMID:28614266

Liu, L. S., Shih, P. C., & Hayes, G. R. (2011). Barriers to the adoption and use of personal health record systems. *Proceedings of the 2011 iConference*. 10.1145/1940761.1940811

Lochner, K., & Cox, C. S. (2013, April 25). Prevalence of Multiple Chronic Conditions Among Medicare Beneficiaries, United States, 2010. *Preventive Chronic Disease*.

Loehr, J., & Schwartz, T. (2001). The making of a corporate athlete. *Harvard Business Review*, *79*(1), 120–129. PMID:11189456

Longadge, R., & Dongre, S. (2013). *Class Imbalance Problem in Data Mining Review*. Retrieved from http://arxiv.org/pdf/1305.1707

Lord, M. (2013). *Living Too Large, A Look at the Chicago Childhood Obesity Epidemic*. Retrieved from: https://chicagohealthonline.com/living-too-large/

Lord, K. R., Lee, M. S., & Sauer, P. L. (1995). The combined influence hypothesis: Central and peripheral antecedents of attitude toward the ad. *Journal of Advertising*, *24*(1), 73–85. doi:10.1080/00913367.1995.10673469

Lorenzen-Huber, L., Boutain, M., Camp, L. J., Shankar, K., & Connelly, K. H. (2011). Privacy, technology, and aging: A proposed framework. *Ageing International*, *36*(2), 232–252. doi:10.100712126-010-9083-y

Lubitz, J. D., & Riley, G. F. (1993). Trends in Medicare payments in the last year of life. *The New England Journal of Medicine*, *328*(15), 1092–1096. doi:10.1056/NEJM199304153281506 PMID:8455667

Lubrin, E., Lawrence, E., & Navarro, K. F. (2005). Wireless remote healthcare monitoring with Motes. In *International Conference on Mobile Business* (pp. 235–241). Piscataway, NJ: IEEE. 10.1109/ICMB.2005.115

Lusch, R. F., & Nambisan, S. (2015). Service Innovation: A Service-Dominant Logic Perspective. *Management Information Systems Quarterly*, *39*(1), 155–175. doi:10.25300/MISQ/2015/39.1.07

Lv, Z., Xia, F., Wu, G., Yao, L., & Chen, Z. (2010). iCare: a mobile health monitoring system for the elderly. In *Proceedings of the 2010 IEEE/ACM Internationa'l Conference on Green Computing and Communications & International'l Conference on Cyber, Physical and Social Computing* (pp. 699–705). Piscataway, NJ: IEEE Computer Society. 10.1109/GreenCom-CPSCom.2010.84

Ly, B. A., Labonté, R., Bourgeault, I. L., & Niang, M. N. (2017). The individual and contextual determinants of the use of telemedicine: A descriptive study of the perceptions of Senegal's physicians and telemedicine projects managers. *PLoS One*, *12*(7), e0181070. doi:10.1371/journal.pone.0181070 PMID:28732028

Lyu, S. R., You, W. T., Chen, Y. S., Chiang, H. H., & Chen, Y. L. (2014). Development of robotic walking-aid system with mobility assistance and remote monitoring. In *2014 IEEE International Conference on Automation Science and Engineering (CASE)*, (pp. 830–835). Piscataway, NJ: IEEE. 10.1109/CoASE.2014.6899422

Magnusson, L., Hanson, E., & Borg, M. (2004). A literature review study of information and communication technology as a support for frail older people living at home and their family carers. *Technology and Disability*, *16*(4), 223–235. doi:10.3233/TAD-2004-16404

Mahmud, K., & Lenz, J. (1995). The personal telemedicine system. A new tool for the delivery of health care. *Journal of Telemedicine and Telecare*, *1*(3), 173–177. doi:10.1177/1357633X9500100307 PMID:9375138

Maier, R., & Lehner, F. (2000). Perspectives on Knowledge Management Systems Theoretical Framework and Design of an Empirical Study. *Proceedings of the 8th European Conference on Information Systems (ECIS)*.

Manson, J. E., Greenland, P., LaCroix, A. Z., Stefanick, M. L., Mouton, C. P., Oberman, A., ... Siscovick, D. S. (2002). Walking compared with vigorous exercise for the prevention of cardiovascular events in women. *The New England Journal of Medicine*, *347*(10), 716–725. doi:10.1056/NEJMoa021067 PMID:12213942

March, J. (1981). Decisions in organizations and theories of choice. In A. Van der Ven & W. Joyce (Eds.), *Perspectives on Organization Design and Behavior*. New York: Wiley.

Marjoua, Y., & Bozic, K. J. (2012). Brief history of quality movement in US healthcare. *Current Reviews in Musculoskeletal Medicine*, *5*(4), 265–273. doi:10.100712178-012-9137-8 PMID:22961204

Markic, M. (2005). Innovation processes and quality development. *Int. J. Innovation and Learning*, *2*(3), 246–260. doi:10.1504/IJIL.2005.006368

Markus, L. (2001). Toward a theory of knowledge reuse: Types of knowledge reuse situations and factors in reuse success. *Journal of Management Information Systems*, *18*(1), 57–93. doi:10.1080/07421222.2001.11045671

Marshall, M. N., Hiscock, J., & Sibbald, B. (2002). Attitudes to the public release of comparative information on the quality of general practice care: Qualitative study. *BMJ (Clinical Research Ed.)*, *325*(7375), 1278. doi:10.1136/bmj.325.7375.1278 PMID:12458248

Marshall, M. N., Shekelle, P. G., Davies, H. T., & Smith, P. C. (2003). Public reporting on quality in the United States and the United Kingdom. *Health Affairs*, *22*(3), 134–148. doi:10.1377/hlthaff.22.3.134 PMID:12757278

Mata, R., Schooler, L. J., & Rieskamp, J. (2007). The aging decision maker: Cognitive aging and the adaptive selection of decision strategies. *Psychology and Aging*, *22*(4), 796–810. doi:10.1037/0882-7974.22.4.796 PMID:18179298

Mathieson, K. (1991). Predicting user intentions: Comparing the technology acceptance model with the theory of planned behavior. *Information Systems Research*, *2*(3), 173–191. doi:10.1287/isre.2.3.173

Matsumoto, J. S., Morris, J. M., Foley, T. A., & Williamson, E. E. (2015). Three-dimensional Physical Modeling: Applications and Experience at Mayo Clinic. *RadioGraphics*. Retrieved from https://pubs.rsna.org/doi/full/10.1148/rg.2015140260

Mauco, K. L., Scott, R. E., & Mars, M. (2018). Critical analysis of e-health readiness assessment frameworks: Suitability for application in developing countries. *Journal of Telemedicine and Telecare*, *24*(2), 110–117. doi:10.1177/1357633X16686548 PMID:28008790

Maurer, C., & Schaich, S. (2011). *Online customer reviews used as complaint management tool*. Enter. doi:10.1007/978-3-7091-0503-0_40

Maurer, M., Firminger, K., Dardess, P., Ikeler, K., Sofaer, S., & Carman, K. L. (2016). Understanding consumer perceptions and awareness of hospital-based maternity care quality measures. *Health Services Research*, *51*, 1188–1211. doi:10.1111/1475-6773.12472 PMID:26927831

Mazier, A., Xie, X., & Sarazin, M. (2010, August). Scheduling inpatient admission under high demand of emergency patients. In *Automation Science and Engineering (CASE), 2010 IEEE Conference on* (pp. 792-797). IEEE. 10.1109/COASE.2010.5584679

Mazman, S. G. (2011). Gender differences in using social networks. *The Turkish Online Journal of Educational Technology*, *10*(2), 133–139.

MBS Online. (2018). Available: http://www.mbsonline.gov.au/internet/mbsonline/publishing.nsf/Content/Home

McCormick, J. (1999). Wireless hospitals: New wave in healthcare technology. *Health Management Technology*, *20*, 12–13. PMID:10538649

McCreadie, M., & Rice, R. E. (1999). Trends in analyzing access to information. Part I: Cross-disciplinary conceptualizations of access. *Information Processing & Management*, *35*(1), 45–76. doi:10.1016/S0306-4573(98)00037-5

McCullough, J., Parente, S., & Town, R. (2016). Health information technology and patient outcomes: The role of information and labor coordination. *The Rand Journal of Economics*, *47*(1), 207–236. doi:10.1111/1756-2171.12124

McDaniel, L. (2017). 3D Printing in Medicine: Challenges Beyond Technology. *Design of Medical Devices Conference*.

McElligott, S., Pauly, M. V., Willke, R. J., Bergquist, H., Doshi, J., Fleisher, L. A., ... Glick, H. A. (2015). Comparative Effectiveness And Cost-Effectiveness Analyses Frequently Agree on Value. *Health Affairs*, 34. PMID:25941282

McLymont, R. (2018). *Digital Health: Revolutionizing Delivery Quality for African-Americans*. Retrieved from: https://tnj.com/digital-health-revolutionizing-delivery-quality-for-african-americans/

McQuail, D. (2010). *McQuail's mass communication theory*. London: Sage.

Medicare Hospital Readmissions Reduction Program. (2013, Nov. 12). *Health Affairs*. Retrieved from http://www.healthaffairs.org/healthpolicybriefs/brief.php?brief_id=102

Medjahed, H., Istrate, D., Boudy, J., Baldinger, J. L., & Dorizzi, B. (2011, June). A pervasive multi-sensor data fusion for smart home healthcare monitoring. In *IEEE International Conference on Fuzzy Systems (FUZZ)*, 2011 (pp. 1466–1473). 10.1109/FUZZY.2011.6007636

Mello, M., Merritt, M., & Halpern, S. (2015). Supporting those who go to fight Ebola. *PLOS Medicine*, *12*(1).

Mettler, T., Rohner, P., & Winter, R. (2010). Towards a classification of maturity models in information systems. In A. D'Atri, M. De Marco, A. M. Braccini, & F. Cabiddu (Eds.), *Management of the Interconnected World* (pp. 333–340). Physica-Verlag HD. doi:10.1007/978-3-7908-2404-9_39

Michard, F., Gan, T. J., & Kehlet, H. (2017a). Digital innovations and emerging technologies for enhanced recovery programmes. *British Journal of Anaesthesia*, *9*. doi:10.1093/bja/aex140 PMID:28605474

Michard, F., Mountford, W. K., Krukas, M. R., Ernst, F. R., & Fogel, S. L. (2015). Potential return on investment for implementation of perioperative goal directed fluid therapy in major surgery: A nationwide database study. *Perioperative Medicine (London, England)*, *4*(1), 11. doi:10.118613741-015-0021-0 PMID:26500766

Millard, R. W., & Fintak, P. A. (2002). Use of the Internet by patients with chronic illness. *Disease Management & Health Outcomes*, *10*(3), 187–194. doi:10.2165/00115677-200210030-00006

Mira, J.J., Susana, L., María, T.G., Jesús, A., & Carlos, A. (2015). Ebola's media outbreak: lessons for the future. *European Journal of Public Health*, *25*(2), 188-189.

Mitchell Peck, B. (2011). Age-related differences in doctor-patient interaction and patient satisfaction. *Current Gerontology and Geriatrics Research*, *2011*, 1–10. doi:10.1155/2011/137492 PMID:22007206

Moghimi, F., Wickramasinghe, N., & Zadeh, H. S. (2011). *An Intelligence Risk Detection Framework to Improve Decision Efficiency in Healthcare Contexts: The Example of Pediatric Congenital Heart Disease.* Paper presented at the System Sciences (HICSS), 2011 44th Hawaii International Conference on. 10.1109/HICSS.2011.58

Moghimi, H., Zadeh, H., Schaffer, J., & Wickramasinghe, N. (2012). Incorporating intelligent risk detection to enable superior decision support: The example of orthopaedic surgeries. *Health and Technology*, *2*(1), 33–41. doi:10.100712553-011-0014-z

Mohadisdudis, H. M., & Ali, N. M. (2014). A study of smartphone usage and barriers among the elderly. In *2014 3rd International Conference on User Science and Engineering (i-USEr)* (pp. 109–114). Piscataway, NJ: IEEE. 10.1109/IUSER.2014.7002686

Mohammad, S. M., Kiritchenko, S., & Zhu, X. (2013). NRC-Canada: Building the state-of-the-art in sentiment analysis of tweets. *Proceedings of the seventh international workshop on Semantic Evaluation Exercises*.

Mohammed, A., & Yunus, A. (2017). Technology Acceptance in Healthcare Service: A Case of Electronic Medical Records (ERM). *International Journal of Academic Research in Business and Social Sciences, 7*(11).

Moore, G. C., & Benbasat, I. (1991). Development of an instrument to measure the perceptions of adopting an information technology innovation. *Information Systems Research*, *2*(3), 192–222. doi:10.1287/isre.2.3.192

Mora, S., Cook, N., Buring, J. E., Ridker, P. M., & Lee, I. M. (2007). Physical activity and reduced risk of cardiovascular events: Potential mediating mechanisms. *Circulation*, *116*(19), 2110–2118. doi:10.1161/CIRCULATIONAHA.107.729939 PMID:17967770

More, D. (2014). *Sulfa drug allergy.* Retrieved June 29, 2015, from http://allergies.about.com/od/medicationallergies/a/sulfa.htm

Morris, K., & Zelmer, J. (2005). *Public reporting of performance measures in health care*. Ottawa: Canadian Policy Research Networks.

Morris, M. G., & Venkatesh, V. (2000). Age differences in technology adoption decisions: Implications for a changing workforce. *Personnel Psychology*, *3*(2), 375–403. doi:10.1111/j.1744-6570.2000.tb00206.x

Morrissey, J. (2000). 'Internet dominates providers' line of sight'. *Modern Healthcare, Chicago*, *30*, 72–92. PMID:11066427

Morrissey, J. (2001). Wanting more from information technology. *Modern Healthcare, Chicago*, *31*, 66–84. PMID:11216221

Morrissey, J. (2002). High on tech, low on budget. *Modern Healthcare*, *32*, 57–72. PMID:11859552

Moturu, S. T., Johnson, W. G., & Liu, H. (2007). *Predicting future high-cost patients: A real-world risk modeling application.* Paper presented at the 2007 IEEE International Conference on Bioinformatics and Biomedicine (BIBM 2007). 10.1109/BIBM.2007.54

Mudambi, S. M., & Schuff, D. (2010). What makes a helpful review? A study of customer reviews on Amazon. com. *Management Information Systems Quarterly*, *34*(1), 185–200. doi:10.2307/20721420

Muigg, D., Kastner, P., Modre-Osprian, R., Haluza, D., & Duftschmid, G. (2018). Is Austria ready for telemonitoring? A readiness assessment among doctors and patients in the field of diabetes. *Studies in Health Technology and Informatics*, *248*, 322–329. doi:10.3233/978-1-61499-858-7-322 PMID:29726454

Muntaner-Mas, A., Vidal-Conti, J., Borràs, P. A., Ortega, F. B., & Palou, P. (2017). Effects of a Whatsapp-delivered physical activity intervention to enhance health-related physical fitness components and cardiovascular disease risk factors in older adults. *The Journal of Sports Medicine and Physical Fitness*, *57*(1-2), 90–102. PMID:26364690

Murray, C. J., Lopez, A. D., & Organization, W. H. (1996). *The global burden of disease: a comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020: summary*. Academic Press.

Myers, M., & Venable, J. (2014). A set of ethical principles for design science research in information systems. *Information & Management, 51*(6), 801-809.

Myers, M.D., & Venable, J.R. (2014). A set of ethical principles for design science research in information systems. *Information & Management, 51*(6), 801-809.

Myers, M. D. (1997). Qualitative research in information systems. *Management Information Systems Quarterly*, *21*(2), 241–242. doi:10.2307/249422

Myers, M. D., & Avison, D. (Eds.). (2002). *Qualitative research in information systems: a reader*. Sage. doi:10.4135/9781849209687

Nagai, Y., Jones, C.I., & Sen, A. (2019). Galvanic Skin Response (GSR)/Electrodermal/Skin Conductance Biofeedback on Epilepsy: A Systematic Review and Meta-Analysis. *Frontier Neurology.* doi:10.3389/fneur.2019.00377

Nahhas, A., Awaldi, A., & Reggelin, T. (2017). Simulation and the Emergency Department Overcrowding Problem. *Procedia Engineering*, *178*, 368–376. doi:10.1016/j.proeng.2017.01.068

Narins, C. R., Dozier, A. M., Ling, F. S., & Zareba, W. (2005). The influence of public reporting of outcome data on medical decision making by physicians. *Archives of Internal Medicine*, *165*(1), 83–87. doi:10.1001/archinte.165.1.83 PMID:15642879

Nathan, D. M. (2002). Initial management of glycemia in type 2 diabetes mellitus. *The New England Journal of Medicine*, *347*(17), 1342–1349. doi:10.1056/NEJMcp021106 PMID:12397193

National Academy of Engineering of the National Academies. (2003). *The impact of academic research on industrial performance*. National Academy of Engineering of the National Academies Press.

National Coalition on Healthcare. (2004). *Building a Better Health: Specifications for Reform*. Author.

Nevis, E.C., DiBella, A.J., & Gould, J.M. (1997). *Understanding organizations as learning systems*. Cambridge, MA: MIT. Available at http://learning.mit.edu:80/res/wp/learning_sys.html

Newell, S., Robertson, M., Scarbrough, H., & Swan, J. (2002). *Managing Knowledge Work*. New York: Palgrave.

Nguyen, L., & Wickramasinghe, N. (2017). An examination of the mediating role for a nursing information system. *AJIS. Australasian Journal of Information Systems*, *21*. doi:10.3127/ajis.v21i0.1387

Nicholson, N. R. Jr. (2008). Social isolation in older adults: An evolutionary concept analysis. *Journal of Advanced Nursing*, *65*(6), 342–352. PMID:19291185

Nikmat, A. W., Hawthorne, G., & Al-Mashoor, S. H. (2015). The comparison of quality of life among people with mild dementia in nursing home and home care—A preliminary report. *Dementia (London)*, *14*(1), 114–125. doi:10.1177/1471301213494509 PMID:24339093

Nikou, S. (2015). Mobile technology and forgotten consumers: The young-elderly. *International Journal of Consumer Studies*, *39*(4), 294–304. doi:10.1111/ijcs.12187

No two breast cancer patients are the same and treatment should be tailored. (2018). Available: http://www.totalhealth.co.uk/blog/no-two-breast-cancer-patients-are-same-and-treatment-should-be-tailored

Nolan, C. J., Damm, P., & Prentki, M. (2011). Type 2 diabetes across generations: From pathophysiology to prevention and management. *Lancet*, *378*(9786), 169–181. doi:10.1016/S0140-6736(11)60614-4 PMID:21705072

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science*, *5*(1), 14–37. doi:10.1287/orsc.5.1.14

Nonaka, I., & Nishiguchi, T. (2001). *Knowledge Emergence*. Oxford, UK: Oxford University Press.

Nonnecke, B., & Preece, J. (1999). Shedding light on lurkers in online communities. Ethnographic Studies in Real and Virtual Environments: Inhabited Information Spaces and Connected Communities, 123-128.

Nordqvist, J. (2018, August 8). What is biofeedback therapy and who can benefit? *Medical News Today.* Retrieved from https://www.medicalnewstoday.com/articles/265802.php

Noreen, E., Smith, D., & Mackey, J. (1995). *The Theory of Constraints and Its Implications for Management Accounting* North River Press.

Norris, A. C., Stockdale, R. S., & Sharma, S. (2009). A strategic approach to m-health. *Health Informatics Journal*, *15*(3), 244–253. doi:10.1177/1460458209337445 PMID:19713398

Norris, S. L., Engelgau, M. M., & Narayan, K. V. (2001). Effectiveness of self-management training in type 2 diabetes: A systematic review of randomized controlled trials. *Diabetes Care*, *24*(3), 561–587. doi:10.2337/diacare.24.3.561 PMID:11289485

Novak, S. (2018, Dec.). The long history of America's anti-vaccination movement. *Discover*.

NSW Agency for Clinical Innovation. (2015). *Guidelines for the use of telehealth for clinical and non clinical settings in NSW*. Author.

Nugent, C., Mulvenna, M., Moelaert, F., Bergvall-Kåreborn, B., Meiland, F., Craig, D., & Bengtsson, J. E. (2007). Home based assistive technologies for people with mild dementia. In T. Okadome, T. Yamazaki, & M. Mokhtari (Eds.), *Pervasive computing for quality of life enhancement* (pp. 63–69). Heidelberg, Germany: Springer Berlin. doi:10.1007/978-3-540-73035-4_7

Nunnaly, J. (1978). *Psychometric theory* (2nd ed.). New York: McGraw-Hill.

Nutbeam, D. (2008). The evolving concept of health literacy. *Social Science & Medicine*, *67*(12), 2072–2078. doi:10.1016/j.socscimed.2008.09.050 PMID:18952344

Nygård, L., & Starkhammar, S. (2007). The use of everyday technology by people with dementia living alone: Mapping out the difficulties. *Aging & Mental Health*, *11*(2), 144–155. doi:10.1080/13607860600844168 PMID:17453547

Office of the National Coordinator for Health Information Technology. (n.d.). *Merit-based Incentive Payment System*. Retrieved from HealthIT: https://www.healthit.gov/topic/federal-incentive-programs/MACRA/merit-based-incentive-payment-system

Ohta, B., Mola, A., Rosenfeld, P., & Ford, S. (2016). Early Discharge Planning and Improved Care Transitions: Pre-Admission Assessment for Readmission Risk in an Elective Orthopedic and Cardiovascular Surgical Population. *International Journal of Integrated Care*, *16*(2), 10. doi:10.5334/ijic.2260 PMID:27616965

Oldenburg, B., Taylor, C. B., O'Neil, A., Cocker, F., & Cameron, L. D. (2015). Using new technologies to improve the prevention and management of chronic conditions in populations. *Annual Review of Public Health*, *36*(1), 483–505. doi:10.1146/annurev-publhealth-031914-122848 PMID:25581147

Or, C. K., & Karsh, B. T. (2009). A systematic review of patient acceptance of consumer health information technology. *Journal of the American Medical Informatics Association*, *16*(4), 550–560. doi:10.1197/jamia.M2888 PMID:19390112

Oster, N. V., Welch, V., Schild, L., Gazmararian, J. A., Rask, K., & Spettell, C. (2006). Differences in self-management behaviors and use of preventive services among diabetes management enrollees by race and ethnicity. *Disease Management*, *9*(3), 167–175. doi:10.1089/dis.2006.9.167 PMID:16764534

Otto, L., Whitehouse, D., & Schlieter, H. (2019). On the road to telemedicine maturity: A systematic review and classification of telemedicine maturity models. *BLED 2019 Proceedings*, 485–506. doi:10.18690/978-961-286-280-0.26

Oxford Dictionaries. (n.d.). *Mature | Definition of mature in English by Oxford Dictionaries*. Retrieved November 7, 2018, from Oxford Dictionaries | English website: https://en.oxforddictionaries.com/definition/mature

Pachur, T., Rieskamp, J., & Hertwig, R. (2005). The social circle heuristic: Fast and frugal decisions based on small samples. In *Proceedings of the 26th annual conference of the cognitive science society* (pp. 1077-1082). Mahwah, NJ: Erlbaum.

Paffenbarger, R. S., & Olsen, E. (1996). *Lifefit: An Effective exercise program for optimal health and a longer life*. Champaign, IL: Human Kinectics.

Pandian, P. S., Mohanavelu, K., Safeer, K. P., Kotresh, T. M., Shakunthala, D. T., Gopal, P., & Padaki, V. C. (2008). Smart vest: Wearable multi-parameter remote physiological monitoring system. *Medical Engineering & Physics*, *30*(4), 466–477. doi:10.1016/j.medengphy.2007.05.014 PMID:17869159

Pang, B., & Lilian, L. (2005). Seeing stars: Exploring class relationships for sentiment categorization with respect to rating scales. *Proceedings of the Association for Computational Lingustics*, *2005*, 417–424.

Paradiso, R., Alonso, A., Cianflone, D., Milsis, A., Vavouras, T., & Malliopoulos, C. (2008). Remote health monitoring with wearable non-invasive mobile system: The healthwear project. In *Engineering in Medicine and Biology Society, 2008. EMBS 2008., 30th Annual International Conference of the IEEE* (pp. 1699–1702). Piscataway, NJ: IEEE.

Parikh, R. B., Kakad, M., & Bates, D. W. (2016). Integrating predictive analytics into high-value care: The dawn of precision delivery. *Journal of the American Medical Association*, *315*(7), 651–652. doi:10.1001/jama.2015.19417 PMID:26881365

Parker, S. (2013). Kill or cure: The illustrated history of medicine. London, UK: DK.

Parker, P., Wasserman, I., Kram, K. E., & Hall, D. T. (2015). A relational communication approach to peer coaching. *The Journal of Applied Behavioral Science*, *51*(2), 231–252. doi:10.1177/0021886315573270

Park, N., Kee, K. F., & Valenzuela, S. (2009). Being immersed in social networking environment: Facebook groups, uses and gratifications, and social outcomes. *Cyberpsychology & Behavior*, *12*(6), 729–733. doi:10.1089/cpb.2009.0003 PMID:19619037

Patientslikeme.com. (2019). Retrieved September 6, 2019, from https://www.patientslikeme.com/

Patrick, K., Hekler, E.B., Estrin, D., Mohr, D.C., Riper, H., Crane, D., Godino, J., & Riley, W.T. (2016). *The pace of technologic change: implications for digital health behavior intervention research*. Academic Press.

Patton, M. Q. (2002). *Qualitative Research & Evalutation Methods* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Paul, C. L., Fradgley, E. A., Roach, D., & Baird, H. (2017). Impact of financial costs of cancer on patients-the Australian experience. In *Cancer Forum, 2017*. The Cancer Council Australia.

Paul, C. L., Boyes, A., Searles, A., Carey, M., & Turon, H. (2016). The impact of loss of income and medicine costs on the financial burden for cancer patients in Australia. *The Journal of Community and Supportive Oncology*, *14*(7), 307–313. doi:10.12788/jcso.0273

Peck, B., & Conner, S. (2011). Talking with me or talking at me? The impact of status characteristics on doctor–patient interaction. *Sociological Perspectives*, *54*(4), 547–567. doi:10.1525op.2011.54.4.547

Peck, J., & Kim, S. (2008). 147: Improving emergency department patient flow through optimal fast track usage. *Annals of Emergency Medicine*, *52*(4), S88. doi:10.1016/j.annemergmed.2008.06.061

Peek, M. E., Wilkes, A. E., Roberson, T. S., Goddu, A. P., Nocon, R. S., Tang, H., ... Chin, M. H. (2012). Early lessons from an initiative on Chicago's South Side to reduce disparities in diabetes care and outcomes. *Health Affairs*, *31*(1), 177–186. doi:10.1377/hlthaff.2011.1058 PMID:22232108

Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A design science research methodology for information systems research. *Journal of Management Information Systems, 24*(3), 45-77.

Peffers, K., Tuunanen, T., Rothenberger, M.A., & Chatterjee, S. (2007). A design science research methodology for information systems research. *Journal of Management Information Systems*, *24*(3), 45-77.

Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A design science research methodology for information systems research. *Journal of Management Information Systems*, *24*(3), 45–77. doi:10.2753/MIS0742-1222240302

Peisl, T., Selen, W., Raeside, R., & Alber, T. (2014). Predictive crowding as a concept to support the assessment of disruptive ideas: A conceptual framework. *Journal of New Business Ideas and Trends*, *12*(2), 1–13.

Perednia, D. A., & Allen, A. (1995). Telemedicine technology and clinical applications. *Journal of the American Medical Association*, *273*(6), 483–488. doi:10.1001/jama.1995.03520300057037 PMID:7837367

Pesec, M., & Sherertz, T. (2015). Global health from a cancer care perspective. *Future Oncology (London, England)*, *11*(15), 2235–2245. doi:10.2217/fon.15.142 PMID:26235185

Peteromode, V. F., & Peretomode, O. (2005). *Human Resource Management*. Lagos: Onoosomegbwho Ogbinaka Publishers.

Peters, E., Dieckmann, N., Dixon, A., Hibbard, J. H., & Mertz, C. K. (2007). Less is more in presenting quality information to consumers. *Medical Care Research and Review: MCRR*, *64*(2), 169–190. doi:10.1177/1077558707064002030 1 PMID:17406019

Peterson, A. T. (2015). Good and bad news about Ebola. *PLoS Neglected Tropical Diseases*, *9*(3), e0003509. doi:10.1371/journal.pntd.0003509 PMID:25764305

Peter, T. (Ed.). (1988). *Inequalities in Health: The Black Report*. London: Penguin.

Petty, R. E., & Wegener, D. T. (1999). The elaboration likelihood model: Current status and controversies. In S. Chaiken & Y. Trope (Eds.), Dual process theories in social psychology, (pp. 41-72). New York: Guilford Press.

Petty, R. E., & Cacioppo, J. T. (1979). Issue involvement can increase of decrease persuasion by enhancing message-Relevant cognitive responses. *Journal of Personality and Social Psychology*, *37*(10), 1915–1926. doi:10.1037/0022-3514.37.10.1915

Petty, R. E., & Cacioppo, J. T. (1981). *Attitudes and persuasion: Classic and contemporary approaches*. Dubuque, IA: Wm. C. Brown.

Petty, R. E., & Cacioppo, J. T. (1984). Source factors and the elaboration likelihood model of persuasion. *Advances in Consumer Research. Association for Consumer Research (U. S.)*, *11*, 668–672.

Petty, R. E., & Cacioppo, J. T. (1986). *Communication and persuasion: Central and peripheral routes to attitude change*. New York: Springer-Verlag. doi:10.1007/978-1-4612-4964-1

Pham, H. H., O'Malley, A. S., Bach, P. B., Saiontz-Martinez, C., & Schrag, D. (2009). Primary Care Physicians' Links to Other Physicians through Medicare Patients: The Scope of Care Coordination. *Annals of Internal Medicine*, *150*(4), 236–242. doi:10.7326/0003-4819-150-4-200902170-00004 PMID:19221375

Pheeraphuttharangkoon, S., Choudrie, J., Zamani, E., & Giaglis, G. (2014). *Investigating the adoption and use of smartphones in the UK: A silver-surfers perspective* (Working paper). Hertfordshire Business School, UK.

Philippon, M., Briggs, K., Yen, Y.-M., & Kuppersmith, D. (2009). Outcomes following hip arthroscopy for femoroacetabular impingement with associated chondrolabral dysfunction MINIMUM TWO-YEAR FOLLOW-UP. *The Journal of Bone and Joint Surgery. British Volume*, *91*(1), 16–23. doi:10.1302/0301-620X.91B1.21329 PMID:19091999

Pinsky, M. R., Clermont, G., & Hravnak, M. (2016). Predicting cardiorespiratory instability. *Critical Care (London, England)*, *20*(1), 70. doi:10.118613054-016-1223-7 PMID:26984263

Pinsonneault, A., & Kraemer, K. L. (1993). Survey research methodology in a management information systems: An assessment. *Journal of Management Information Systems*, *10*(2), 75–105. doi:10.1080/07421222.1993.11518001

Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *The Journal of Applied Psychology*, *88*(5), 879–903. doi:10.1037/0021-9010.88.5.879 PMID:14516251

Poeppelbuss, J., & Roeglinger, M. (2011). What makes a useful maturity model? A framework of general design principles for maturity models and its demonstration in business process management. *Proceedings of the ECIS 2011*. Retrieved from http://aisel.aisnet.org/ecis2011/28

Polanyi, M. (1966). *The Tacit dimension*. Chicago: University of Chicago Press.

Popper, M., & Lipshitz, R. (2000). Organizational learning: Mechanisms, culture, and feasibility. *Management Learning*, *31*(2), 181–196. doi:10.1177/1350507600312003

Porter, M., & Teisberg, E. (2014, June). Redefining Competition in Health Care. *Harvard Business Review*, 64-78.

Porter, M. (2010). What Is Value in Health Care? *The New England Journal of Medicine*, *364*(13). doi:10.1056/NEJMc1101108 PMID:21142528

Porter, M. E., & Kaplan, R. S. (2016). How to Pay for Health Care. *Economics & Society*. PMID:27526565

Porter, M. E., & Lee, T. H. (2013). The strategy that will fix health care. *Harvard Business Review*, *91*(10), 1–19.

Portugal, D., Santos, L., Alvito, P., Dias, J., Samaras, G., & Christodoulou, E. (2015). SocialRobot: An interactive mobile robot for elderly home care. In *2015 IEEE/SICE International Symposium on System Integration (SII)* (pp. 811–816). Piscataway, NJ: IEEE. 10.1109/SII.2015.7405084

Powers, M. A., Bardsley, J., Cypress, M., Duker, P., Funnell, M. M., Fischl, A. H., ... Vivian, E. (2017). Diabetes self-management education and support in type 2 diabetes: A joint position statement of the American Diabetes Association, the American Association of Diabetes Educators, and the Academy of Nutrition and Dietetics. *The Diabetes Educator*, *43*(1), 40–53. doi:10.1177/0145721716689694 PMID:28118121

Prochaska, J. O., & Velicer, W. F. (1997). The transtheoretical model of health behavior change. *American Journal of Health Promotion*, *12*(1), 38–48. doi:10.4278/0890-1171-12.1.38 PMID:10170434

Prostate cancer in Australia. (2013). Australian Institute of Health and Welfare.

Protti, D., Johansen, I., & Perez-Torres, F. (2009). Comparing the application of Health Information Technology in primary care in Denmark and Andalucía, Spain. *International Journal of Medical Informatics, 78*(4), 270-283.

Pulakkazhy, S., & Balan, R. (2013). Data Mining in Banking and Its Applications-A Review. *Journal of Computational Science*, *9*(10), 1252–1259. doi:10.3844/jcssp.2013.1252.1259

Purdie, N., & Boulton-Lewis, G. (2003). The learning needs of older adults. *Educational Gerontology*, *29*(2), 129–149. doi:10.1080/713844281

Quality Assurance Project TASC 2, Eritrea. (2003). *Quality Assurance Core Course*. Associate Student Nurses State of Eritrea, Ministry of Health.

Quan, H., Sundararajan, V., Halfon, P., Fong, A., Burnand, B., Luthi, J.-C., ... Ghali, W. A. (2005). Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. *Medical Care*, *43*(11), 1130–1139. doi:10.1097/01.mlr.0000182534.19832.83 PMID:16224307

Quinlan, J. R. (1996). *Bagging, boosting, and C4.S*. AAAI Press.

Raad, M. W., & Yang, L. T. (2009). A ubiquitous smart home for elderly. *Information Systems Frontiers*, *11*(5), 529–536. doi:10.100710796-008-9119-y

Rahm, E., & Do, H. H. (2000). Data Cleaning: Problems and Current Approaches. In Zinc Industry. Woodhead Pub. doi:10.1016/B978-1-85573-345-9.50005-4

Rai, A. (2017). Editor's comments: Diversity of Design Science Research. *Management Information Systems Quarterly*, *41*, 1.

Rashid, S. F., Hadin, A., Afsana, K., & Begum, S. A. (2001). Acute respiratory infections in rural Bangladesh: Cultural understanding, practices and the role of mothers and community health volunteers. *Tropical Medicine & International Health*, *6*(4), 249–255. doi:10.1046/j.1365-3156.2001.00702.x PMID:11348514

Rastogi, R., Chaturvedi, D.K., Satya, S., Arora, N., Yadav, V., Chauhan, S., & Sharma, P. (2018c). SF-36 Scores Analysis for EMG and GSR Therapy on Audio, Visual and Audio Visual Modes for Chronic TTH. *Proceedings of the ICCIDA-2018 on 27 and 28th October 2018, CCIS Series, Springer, Gandhi Institute for Technology*.

Rastogi, R., Chaturvedi, D. K., Arora, N., Trivedi, P., & Mishra, V. (2017b). Swarm Intelligent Optimized Method of Development of Noble Life in the perspective of Indian Scientific Philosophy and Psychology. *Proceedings of NSC-2017(National system conference)*.

Raz, O., & Ert, E. (2008). Size counts: The effect of queue length on choice between similar restaurants. *NA - Advances in Consumer Research. Association for Consumer Research (U. S.)*, *35*, 803–804.

Rechel, B., McKee, M., Haas, M., Marchildon, G. P., Bousquet, F., Blümel, M., ... Anell, A. (2016). Public reporting on quality, waiting times and patient experience in 11 high-income countries. *Health Policy (Amsterdam)*, *120*(4), 377–383. doi:10.1016/j.healthpol.2016.02.008 PMID:26964783

Regmi, K., Kassim, N., Ahmad, N., & Tuah, N. A. A. (2017). Effectiveness of mobile apps for smoking cessation: A review. *Tob. Prevent. Cessat.*, *3*, 1–11.

Reiss, S. (2004). Multifaceted nature of intrinsic motivation: The theory of 16 basic desires. *Review of General Psychology*, *8*(3), 179–193. doi:10.1037/1089-2680.8.3.179

Ricciardi, F., Rossignoli, C., & De Marco, M. (2013). Participatory networks for place safety and livability: organisational success factors. *International Journal of Networking and Virtual Organisations 4, 13*(1), 42-65.

Riloff, E., Wiebe, J., & Wilson, T. (2003). Learning Subjective Nouns Using Extraction Pattern Bootstrapping. in *Proceedings of the seventh conference on Natural language learning at HLTNAACL 2003.* Association for Computational Linguistics. 10.3115/1119176.1119180

Ring, M., Eriksson, M. J., Fritz, T., Nyberg, G., Östenson, C. G., Krook, A., ... Caidahl, K. (2015). Influence of physical activity and gender on arterial function in type 2 diabetes, normal and impaired glucose tolerance. *Diabetes & Vascular Disease Research; Official Journal of the International Society of Diabetes and Vascular Disease*, *12*(5), 315–324. doi:10.1177/1479164115588548 PMID:26092821

Ripley, B. D. (2009). *Pattern recognition and neural networks*. Cambridge, UK: Cambridge University Press.

Rivard, S., & Huff, S. (1988). Factors of success for end user computing. *Communications of the ACM*, *31*(5), 552–561. doi:10.1145/42411.42418

Robbins, R., Krebs, P., Jagannathan, R., Jean-Louis, G., & Duncan, D. T. (2017). Health app use among US mobile phone users: Analysis of trends by chronic disease status. *JMIR mHealth and uHealth*, *5*(12), e197. doi:10.2196/mhealth.7832 PMID:29258981

Rodrigues, D. F., Horta, E. T., Silva, B., Guedes, F. D., & Rodrigues, J. J. (2014). A mobile healthcare solution for ambient assisted living environments. In *2014 IEEE 16th International Conference on e-Health Networking, Applications and Services (Healthcom)* (pp. 170–175). Piscataway, NJ: IEEE. 10.1109/HealthCom.2014.7001836

Rodriguez, S., Munevar, D., Delaney, C., Yang, L., & Tumlinson, A. (2014). *Effective management of high-risk medicare populations*. Washington, DC: Avalere Health LLC.

Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). New York: Free Press.

Rogoff, R. (1985). *U.S. Patent No. 4,538,616*. Washington, DC: U.S. Patent and Trademark Office.

Rose, A. J. (2017). Targeted approaches to improve outcomes for highest-cost patients. *Israel Journal of Health Policy Research*, *6*(1), 25. doi:10.118613584-017-0151-6 PMID:28593037

Rosenberg, N., Gelijns, A. C., & Dawkins, H. (Eds.). (1995). *Sources of medical technology: universities and industry*. National Academies Press.

Rouzbehani, K. (2019). (in press). Let's Collaborate but How: A Dynamic Model for Discussing Barriers and Opportunities in the Digital Era. *Canadian Journal of Public Administration.*

Rouzbehani, K. (2019). Emotional Intelligence and Online Healthcare: The case study of Canada. *International Journal of Applied Research on Public Health Management*, *4*(2), 1–14. doi:10.4018/IJARPHM.2019070101

Roy, C. B., & Brunton, S. (2008). Managing multiple cardiovascular risk factors. *The Journal of Family Practice, 57*(3), 13-20.

Rubin, A. (1992). Biofeedback and binocular vision. *Journal of Behavioral Optometry*, *3*(4), 9598.

Rumsfeld, D. (2002). *DOD News Briefing*. Retrieved June 29, 2015, from http://www.defense.gov/transcripts/transcript.aspx?transcriptid=2636

Russello, G., Dong, C., & Dulay, N. (2008, June). Consent-based workflows for healthcare management. In *IEEE Workshop on Policies for Distributed Systems and Networks, 2008. POLICY 2008* (pp. 153–161). DOI: 10.1109/POLICY.2008.22

Sahoo, B. M., Gupta, A. D., & Shivahare, B. D. (2018). Audio Visual EMG & GSR Biofeedback Analysis and Spiritual Methods for Understanding Human Behaviour and Psychosomatic Disorders. *Amity Journal of Computational Sciences, 2*(1). Retrieved from www.amity.edu/ajcs

Saini, H., Rastogi, R., Chaturvedi, D. K., Satya, S., Arora, N., Gupta, M., & Verma, H. (2019c). An Optimized Biofeedback EMG and GSR Biofeedback Therapy for Chronic TTH on SF-36 Scores of Different MMBD Modes on Various Medical Symptoms. Studies Comp. Intelligence, 841. doi:10.1007/978-981-13-8930-6_8

Saini, H., Rastogi, R., Chaturvedi, D. K., Satya, S., Arora, N., Verma, H., & Mehlyan, K. (2018j). Comparative Efficacy Analysis of Electromyography and Galvanic Skin Resistance Biofeedback on Audio Mode for Chronic TTH on Various Indicators. In *Proceedings of ICCIIoT- 2018*. Elsevier.

Sakurada, N., & Miyake, D. I. (2009). Aplicação de simuladores de eventos discretos no processo de modelagem de sistemas de operações de serviços. *Gestão & Produção*, *16*(1), 25–43. doi:10.1590/S0104-530X2009000100004

Saletti, P., Sanna, P., Gabutti, L., & Ghielmini, M. (2018). Choosing wisely in oncology: Necessity and obstacles. *ESMO Open*, *3*(5), e000382. doi:10.1136/esmoopen-2018-000382 PMID:30018817

Sanders, G. L., & Courtney, J. F. (1985). A field study of organizational factors influencing DSS success. *Management Information Systems Quarterly*, *9*(1), 77–91. doi:10.2307/249275

Sandhu, K., & Corbitt, B. (2008). A framework for electronic services system. *International Journal of Electronic Customer Relationship Management, 2*(1). Retrieved from https://www.inderscienceonline.com/doi/abs/10.1504/IJECRM.2008.019568

Sandmeyer, B., & Fraser, I. (2016). New evidence on what works in effective public reporting. *Health Services Research*, *51*, 1159–1166. doi:10.1111/1475-6773.12502 PMID:27120996

Sanger, P. C., Hartzler, A., Han, S. M., Armstrong, C. A., Stewart, M. R., Lordon, R. J., ... Evans, H. L. (2014). Patient perspectives on post-discharge surgical site infections: Towards a patient-centered mobile health solution. *PLoS One*, *9*(12), e114016. doi:10.1371/journal.pone.0114016 PMID:25436912

Sanghavi Goel, M., Brown, T., Williams, A., Cooper, A., Hasnain-Wynia, R., & Baker, D. (2011). Patient reported barriers to enrolling in a patient portal. *Journal of the American Medical Informatics Association*, *18*(1Supplement 1), I8–I12. doi:10.1136/amiajnl-2011-000473 PMID:22071530

Sarkar, U., Karter, A. J., Liu, J. Y., Adler, N. E., Nguyen, R., López, A., & Schillinger, D. (2010). Social disparities in Internet patient portal use in diabetes: Evidence that the digital divide extends beyond access. *Journal of the American Medical Informatics Association*, *18*(3), 318–321. doi:10.1136/jamia.2010.006015 PMID:21262921

Scanaill, C. N., Ahearne, B., & Lyons, G. M. (2006). Long-term telemonitoring of mobility trends of elderly people using SMS messaging. *Transactions on Information Technology in Biomedicine*, *10*(2), 412–413. doi:10.1109/TITB.2005.859890 PMID:16617630

Schapire, R. E. (1990). The strength of weak learnability. *Machine Learning*, *5*(2), 197–227. doi:10.1007/BF00116037

Schenk, L., Meyer, R., Behr, A., Kuhlmey, A., & Holzhausen, M. (2013). Quality of life in nursing homes: Results of a qualitative resident survey. *Quality of Life Research: An International Journal of Quality of Life Aspects of Treatment, Care and Rehabilitation*, *22*(10), 2929–2938. doi:10.100711136-013-0400-2 PMID:23595411

Schriesheim, C. A. (1979). The similarity of individual directed and group directed leader behavior descriptions. *Academy of Management Journal*, *22*(2), 345–355.

Schrotenboer, B. (2015). *How Soviet Union science helped American sports heroes.* Retrieved July 7, 2015, from http://www.usatoday.com/story/sports/2015/05/18/goride-howe-stem-cells-john-brodie-stemedica-soviet-union-fetal/27504019/

Schultze, U., & Leidner, D. (2002). Studying knowledge management in information systems research: Discourses and theoretical assumptions. *Management Information Systems Quarterly*, *26*(3), 212–242. doi:10.2307/4132331

Schulz, J. (2014). Technology solutions in chronic disease management: The role of 'Social Media'. *International Journal of Biomedical Engineering and Technology*, *15*(4), 291–304. doi:10.1504/IJBET.2014.064819

Schwarzer, R., Richert, J., Kreausukon, P., Remme, L., Wiedemann, A. U., & Reuter, T. (2010). Translating intentions into nutrition behaviors via planning requires self-efficacy: Evidence from Thailand and Germany. *International Journal of Psychology*, *45*(4), 260–268. doi:10.1080/00207591003674479 PMID:22044011

Schwarz, F., Ward, J., & Willcock, S. (2014). E-Health readiness in outback communities: An exploratory study. *Rural and Remote Health*, *14*(3), 2871. PMID:25190566

Scott, I. A. (2010). Preventing the rebound: Improving care transition in hospital discharge processes. *Australian Health Review: a Publication of the Australian Hospital Association*, *34*(4), 445–451. doi:10.1071/AH09777 PMID:21108906

Scott, W. R. (2001). *Institutions and organizations* (2nd ed.). Thousand Oaks, CA: Sage.

Secretary, M. H. (2012). *Unidades de saúde: urgência e emergência*. Rio de Janeiro, RJ: Prefeitura do Rio de Janeiro. Retrieved from http://www.rio.rj.gov.br/web/sms/urgencia-e-emergencia

Seligman, M. E. P. (2012). *Flourish: A visionary new understanding of happiness and well-being*. New York: Simon and Schuster.

Selvin, E., Marinopoulos, S., Berkenblit, G., Rami, T., Brancati, F. L., Powe, N. R., & Golden, S. H. (2004). Meta-analysis: Glycosylated hemoglobin and cardiovascular disease in diabetes mellitus. *Annals of Internal Medicine*, *141*(6), 421–431. doi:10.7326/0003-4819-141-6-200409210-00007 PMID:15381515

Senge, P. M. (1990). The leader's new work: Building learning organizations. *Sloan Management Review*, 7–23.

Senge, P. M. (1994). *The Fifth Discipline: the Art and Practice of the Learning Organization*. New York: Currency, Doubleday.

Senneville, E., Joulie, D., Legout, L., Valette, M., Dezèque, H., Beltrand, E., ... Caillaux, M. (2011). Outcome and predictors of treatment failure in total hip/knee prosthetic joint infections due to Staphylococcus aureus. *Clinical Infectious Diseases*, *53*(4), 334–340. doi:10.1093/cid/cir402 PMID:21810745

Serb, C. (2002). Health care at your fingertips? *Hospitals & Health Networks*, *76*, 44–46. PMID:12035573

SERMO.com. (2019). Retrieved September 6, 2019, from https://www.sermo.com/

Shadmi, E., Flaks-Manov, N., Hoshen, M., Goldman, O., Bitterman, H., & Balicer, R. D. (2015). Predicting 30-day readmissions with preadmission electronic health record data. *Medical Care*, *53*(3), 283–289. doi:10.1097/MLR.0000000000000315 PMID:25634089

Shah, A. M., Whitman, S., & Silva, A. (2006). Variations in the health conditions of 6 Chicago community areas: A case for local-level data. *American Journal of Public Health*, *96*(8), 1485–1491. doi:10.2105/AJPH.2004.052076 PMID:16809605

Shahmoradi, L., Safadari, R., & Jimma, W. (2017). Knowledge management implementation and the tools utilized in healthcare for evidence-based decision making: A systematic review. *Ethiopian Journal of Health Sciences*, *27*(5), 541–558. doi:10.4314/ejhs.v27i5.13 PMID:29217960

Shannon, R. E. (1975). *Systems Simulation: The Art and Science*. Upper Saddle River, NJ: Prentice-Hall.

Sharma, A., Rastogi, R., Chaturvedi, D. K., Satya, S., Arora, N., Trivedi, P., ... Singh, A. (2019a). *Intelligent Analysis for Personality Detection on Various Indicators by Clinical Reliable Psychological TTH and Stress Surveys. In Proceedings of CIPR 2019 at Indian Institute of Engineering Science and Technology*. Springer-AISC Series.

Sharma, P., Rastogi, R., Chaturvedi, D. K., Satya, S., Arora, N., Yadav, V., & Chauhan, S. (2018d). *Analytical Comparison of Efficacy for Electromyography and Galvanic Skin Resistance Biofeedback on Audio-Visual Mode for Chronic TTH on Various Attributes. In Proceedings of the ICCIDA-2018. Springer*.

Sharma, S., Gupta, J., & Wickramasinghe, N. (2005). A framework for building a learning organization in the 21st century. *Int. J. Innovation and Learning*, *2*(3), 261–273. doi:10.1504/IJIL.2005.006369

Sharma, S., Xu, B., Ahmed, N., & Wickramasinghe, N. (2006). Electronic healthcare: Issues and challenges. *International Journal of Electronic Healthcare*, *2*(1), 50–65. doi:10.1504/IJEH.2006.008693 PMID:18048234

Shaw, J., & Tanamas, S. (2012). *Diabetes: the silent pandemic and its impact on Australia.* Melbourne: Baker IDI Heart and Diabetes Institute. Available from https://static.diabetesaustralia.com.au/s/fileassets/diabetes-australia/e7282521-472b-4313-b18e-be84c3d5d907.pdf

Sherman, H. D. (1984). Hospital efficiency measurement and evaluation: Empirical test of a new technique. *Medical Care*, *22*(10), 922–938. doi:10.1097/00005650-198410000-00005 PMID:6436590

Shigaki, C., Kruse, R. L., Mehr, D., Sheldon, K. M., Ge, B., Moore, C., & Lemaster, J. (2010). Motivation and diabetes self-management. *Chronic Illness*, *6*(3), 202–214. doi:10.1177/1742395310375630 PMID:20675362

Shmueli, G., & Koppius, O. (2011). Predictive Analytics in Information Systems Research. *Management Information Systems Quarterly*, *35*(3), 553–572. doi:10.2307/23042796

Sickweather.com. (2019). Retrieved September 7, 2019, from http://www.sickweather.com/index.php

Silva, S. B., Caulliraux, H. M., & Spiegel, T. (2015). Modelo de simulação para auxílio em planejamento e gestão de serviços de saúde. *Sistemas & Gestão*, *10*(4), 608–616. doi:10.20985/1980-5160.2015.v10n4.616

Simmons, R., Fajans, P., & Ghiron, L. (2007). *Scaling up health service delivery: From pilot innovations to policies and programmes*. Geneva: World Health Organization.

Simon, L. (2016). *The relationship between knowledge management tools and interprofessional healthcare team decision making*. Academic Press.

Simon, N. J. (1999). The learning organization. *Competitive Intelligence Magazine*, *2*, 40–42.

Simons, L. P. A., & Hampe, J. F. (2010). Exploring e/mHealth Potential for Health Improvement; A Design Analysis for Future e/mHealth Impact. Paper presented at the 23rd Bled eConference. Bled, Slovenia, from www.bledconference.org. Accessed 20-6-2018.

Simons, L. P. A., & Hampe, J. F. (2010b). Service Experience Design for Healthy Living Support; Comparing an In-House with an eHealth Solution. Paper presented at the 23rd Bled eConference. Bled, Slovenia, from www.bledconference.org. Accessed 20-6-2018.

Simons, L. P. A., Hampe, J. F., & Guldemond, N. A. (2012). Designing Healthy Consumption Support: Mobile application use added to (e)Coach Solution. Paper presented at the 25th Bled eConference. Bled, Slovenia, from www.bledconference.org. Accessed 20-6-2018.

Simons, L. P. A., Pijl, M., Verhoef, J., Lamb, H. J., van Ommen, B., Gerritsen, B., . . . Jonker, C. M. (2016). Intensive Lifestyle (e)Support to Reverse Diabetes-2. Paper *presented at the 29th Bled eConference*. Bled, Slovenia, from http://aisel.aisnet.org/cgi/viewcontent.cgi?article=1023&context=bled2016 & www.bledconference.org. Accessed 20-6-2018.

Simons, L. P. A., Pijl, M., Verhoef, J., Lamb, H. J., van Ommen, B., Gerritsen, B., . . . Jonker, C. M. (2017). Diabetes Lifestyle (e)Coaching 50 Weeks Follow Up; Technology Acceptance & e-Relationships, pp. 545-560, *presented at the 30th Bled eConference*. Bled, Slovenia, Proceedings retrieval from www.bledconference.org. Accessed 20-6-2018. ISBN 978-961-286-043-1, DOI: https://doi.org/ doi:10.18690/978-961-286-043-1

Simons, L. P. A., van den Heuvel, A. C., & Jonker, C. M. (2018). eHealth WhatsApp Group for Social Support; Preliminary Results, pp. 225-237, *presented at the 31st Bled eConference*. Bled, Slovenia, Proceedings retrieval from www.bledconference.org. Accessed 20-6-2018. ISBN-13: 978-961-286-170-4, DOI: https://doi.org/ doi:10.18690/978-961-286-170-4

Simons, L. P. A., Foerster, F., Bruck, P. A., Motiwalla, L., & Jonker, C. M. (2015). Microlearning mApp Raises Health Competence: Hybrid Service Design. *Health and Technology*, *5*, 35–43. doi:10.100712553-015-0095-1

Simons, L. P. A., Hafkamp, M. P. J., Bodegom, D., Dumaij, A., & Jonker, C. M. (2017b). Improving Employee Health; Lessons from an RCT. *Int. J. Networking and Virtual Organisations*, *17*(4), 341–353.

Simons, L. P. A., Hampe, J. F., & Guldemond, N. A. (2013). Designing Healthy Living Support: Mobile applications added to hybrid (e)Coach Solution. *Health and Technology*, *3*(1), 1–11.

Simons, L. P. A., Hampe, J. F., & Guldemond, N. A. (2014). ICT supported healthy lifestyle interventions: Design Lessons. *Electronic Markets*, *24*, 179–192. doi:10.100712525-014-0157-7

Simons, L. P. A., Pijl, M., Verhoef, J., Lamb, H. J., van Ommen, B., Gerritsen, B., ... Jonker, C. M. (2019b). (Accepted). e-Health Diabetes; 50 Weeks Evaluation. [DOI will follow]. *International Journal of Biomedical Engineering and Technology*.

Simons, L. P. A., van den Heuvel, A. C., & Jonker, C. M. (2019). (Accepted). eHealth WhatsApp for social support: Design lessons. [DOI will follow]. *Int. J. Networking and Virtual Organisations*.

Sinai Community Health Survey. (2017). *Community Health Counts*. Retrieved from: https://news.wttw.com/sites/default/files/article/file-attachments/Community%20Health%20Counts_Sinai%20Community%20Health%20Survey%202017.pdf

Singh, P., Rastogi, R., Chaturvedi, D. K., Arora, N., Trivedi, P., & Vyas, P. (2018h). Study on Efficacy of Electromyography and Electroencephalography Biofeedback with Mindful Meditation on Mental health of Youths. *Proceedings of the 12th INDIACom*, 84-89.

Singh, V., Rastogi, R., Chaturvedi, D. K., Satya, S., Arora, N., Sirohi, H., . . . Verma, P. (2018i). Which One is Best: Electromyography Biofeedback Efficacy Analysis on Audio, Visual and Audio-Visual Modes for Chronic TTH on Different Characteristics. In *Proceedings of ICCIIoT- 2018.* Elsevier.

Singh, A., Rastogi, R., Chaturvedi, D. K., Satya, S., Arora, N., Sharma, A., & Singh, A. (2019d). Intelligent Personality Analysis on Indicators in IoT-MMBD Enabled Environment. *Nature in Singapore*, 185–215. doi:10.1007/978-981-13-8759-3_7

Singhal, P., Rastogi, R., Chaturvedi, D. K., Satya, S., Arora, N., Gupta, M., . . . Gulati, M. (2019b). Statistical Analysis of Exponential and Polynomial Models of EMG & GSR Biofeedback for Correlation between Subjects Medications Movement & Medication Scores. *IJITEE, 8*(6S), 625-635. Retrieved from https://www.ijitee.org/download/volume-8-issue-6S/

Smith, M., Higgs, J., & Ellis, E. (2008). Factors influencing clinical decision making. *Clinical Reasoning in the Health Professions, 3*, 89-100.

Smith, C. A., Barry, R., & Brubaker, C. E. (2007). *Going lean: busting barriers to patient flow.* Chicago, IL: Health Administration Press.

Smith, G., Watson, K. J., Baker, W. H., & Pokorski, J. A. II. (2007). A critical balance: Collaboration and security in the IT-enabled supply chain. *International Journal of Production Research*, *45*(11), 2595–2613. doi:10.1080/00207540601020544

Smith, S. G., O'Conor, R., Aitken, W., Curtis, L. M., Wolf, M. S., & Goel, M. S. (2015). Disparities in registration and use of an online patient portal among older adults: Findings from the LitCog cohort. *Journal of the American Medical Informatics Association*, *22*(4), 888–895. doi:10.1093/jamia/ocv025 PMID:25914099

Smith, T. O., Blake, V., & Hing, C. B. (2011). Minimally invasive versus conventional exposure for total hip arthroplasty: A systematic review and meta-analysis of clinical and radiological outcomes. *International Orthopaedics*, *35*(2), 173–184. doi:10.100700264-010-1075-8 PMID:20559827

Snider, J. T., Bognar, K., Globe, D., Ng-Mak, D., Sullivan, J., Summers, N., & Goldman, D. (2014). Identifying patients at risk for high medical costs and good candidates for obesity intervention. *American Journal of Health Promotion*, *28*(4), 218–227. doi:10.4278/ajhp.121116-QUAN-561 PMID:24359175

Sofaer, S., & Hibbard, J. (2010). *Best practices in public reporting no. 2: Maximizing consumer understanding of public comparative quality reports: Effective use of explanatory information*. Rockville, MD: Agency for Healthcare Research and Quality.

Sokolovich, N., & Fera, B. (2015). *UPMC Telehealth Adoption Model—A HIMSS Case Study*. Retrieved from https://exhibitionfloor.himss.org/mhealth2015/Custom/Handout/Speaker0_Session529_2.pdf

Sonesh, S. C., Coultas, C. W., Marlow, S. L., Lacerenza, C. N., Reyes, D., & Salas, E. (2015). Coaching in the wild: Identifying factors that lead to success. *Consulting Psychology Journal: Practice and Research*, *67*(3), 189–217. doi:10.1037/cpb0000042

Song, X., Chi, Y., Hino, K., & Tseng, B. (2007, November). Identifying opinion leaders in the blogosphere. In *Proceedings of the sixteenth ACM conference on Conference on information and knowledge management* (pp. 971-974). ACM.

Song, Y., Klevak, A., Manson, J. E., Buring, J. E., & Liu, S. (2010). Asthma, chronic obstructive pulmonary disease, and type 2 diabetes in the Women's Health Study. *Diabetes Research and Clinical Practice*, *90*(3), 365–371. doi:10.1016/j.diabres.2010.09.010 PMID:20926152

Sonnenberg, C., & vom Brocke, J. (2012). Evaluations in the Science of the Artificial – Reconsidering the Build-Evaluate Pattern in Design Science Research. In K. Peffers, M. Rothenberger, & B. Kuechler (Eds.), *DESRIST 2012, LNCS 7286* (pp. 381–397). doi:10.1007/978-3-642-29863-9_28

Sood, S., Mbarika, V., Jugoo, S., Dookhy, R., Doarn, C. R., Prakash, N., & Merrell, R. C. (2007). What is telemedicine? A collection of 104 peer-reviewed perspectives and theoretical underpinnings. *Telemedicine Journal and e-Health*, *13*(5), 573–590. doi:10.1089/tmj.2006.0073 PMID:17999619

Southwick, S. M., & Charney, D. S. (2012). *Resilience: The science of mastering life's greatest challenges*. Cambridge University Press. doi:10.1017/CBO9781139013857

Spiegel, T., & Assad, D. B. (2018). Operations model for trauma centers: Multiple case study. *International Journal of Public Health Management and Ethics*, *3*(1), 1–13. doi:10.4018/IJPHME.2018010101

Spiegel, T., & Assad, D. B. N. (2016). Operations project and management in trauma centers: the case of brazilian units. In *Handbook of Research on Healthcare Administration and Management* (pp. 104–119). Hershey, PA: IGI Global.

Spiegel, T., & Cameira, R. F. (2016). The processing chain of sterilized material from the health units of Rio de Janeiro county: analysis and proposition of scenarios. In *Supply chain management: applications for manufacturing and service industries* (pp. 245–263). New York, NY: Nova Science Publishers.

Spiegel, T., Caulliraux, H. M., Treistman, F. E., Guimaraes, G. E., Vaccaro, G. L. R., Amorim, L. G., ... Azzam, S. M. (2016). Projeto e Gestão de Operações em Saúde. In V. Cavenaghi & V. F. Oliveira (Eds.), *Tópicos emergentes e desafio metodológicos em engenharia de produção: casos, experiências e proposições* (pp. 15–72). Rio de Janeiro, RJ: Associação Brasileira de Engenharia de Produção.

Spijkerman, A. M. W., Dekker, J. M., Nijpels, G., Jager, A., Kostense, P. J., Van Hinsbergh, V. W. M., ... Stehouwer, C. D. A. (2002). Impact of diabetes duration and cardiovascular risk factors on mortality in type 2 diabetes: The Hoorn Study. *European Journal of Clinical Investigation*, *32*(12), 924–930. doi:10.1046/j.1365-2362.2002.01090.x PMID:12534452

Štambuk, S., Šundov, D., Kuret, S., Beljan, R., & Anđelinović, Š. (2010). Future perspectives of personalized oncology. *Collegium Antropologicum*, *34*, 763–769. PMID:20698168

Starr, P. (1982). The Social Transformation of American Medicine Basic Books. Boston: Academic Press.

Stephanie, W. Y., Hill, C., Ricks, M. L., Bennet, J., & Oriol, N. E. (2017). The scope and impact of mobile health clinics in the United States: A literature review. *International Journal for Equity in Health*, *16*(1), 178. doi:10.118612939-017-0671-2 PMID:28982362

Stevens, M., Reininga, I. H., Bulstra, S. K., Wagenmakers, R., & van den Akker-Scheek, I. (2012). Physical Activity Participation Among Patients After Total Hip and Knee Arthroplasty. *Clinics in Geriatric Medicine*, *28*(3), 509–520. doi:10.1016/j.cger.2012.05.003 PMID:22840311

Stinson, K. J. (2017). Benner's framework and clinical decision-making in the critical care environment. *Nursing Science Quarterly*, *30*(1), 52–57. doi:10.1177/0894318416680536 PMID:28899295

Straub, D., Boudreau, M. C., & Gefen, D. (2004). Validation guidelines for IS positivist research? *Communications of the Association for Information Systems*, *13*(24), 380–427.

Strauss, R. W. (Ed.). (2014). Strauss and Mayer's emergency department management. New York, NY: McGraw-Hill Education Medical.

Subbarayappa, B. V. (2001). The roots of ancient medicine. *Journal of Biosciences*, *26*(2), 135–144. doi:10.1007/BF02703637 PMID:11426049

Subbe, C. P., Duller, B., & Bellomo, R. (2017). Effect of an automated notification system for deteriorating ward patients on clinical outcomes. *Critical Care (London, England)*, *21*(1), 52. doi:10.118613054-017-1635-z PMID:28288655

Sulaiman, H., & Wickramasinghe, N. (2014). Assimilating Healthcare Information Systems in a Malaysian Hospital. CAIS, 34, 77.

Sullivan, P. W., Morrato, E. H., Ghushchyan, V., Wyatt, H. R., & Hill, J. O. (2005). Obesity, inactivity, and the prevalence of diabetes and diabetes-related cardiovascular comorbidities in the US, 2000–2002. *Diabetes Care*, *28*(7), 1599–1603. doi:10.2337/diacare.28.7.1599 PMID:15983307

Sundbo, J. (1994). Modulization of service production and a thesis of convergence between service and manufacturing organizations. *Scandinavian Journal of Management, 10*(3), 245-266.

Sun, N., Rau, P. P. L., & Ma, L. (2014). Understanding lurkers in online communities: A literature review. *Computers in Human Behavior*, *38*, 110–117. doi:10.1016/j.chb.2014.05.022

Sun, Y., Wong, A., & Kamel, M. (2009). Classification of imbalanced data: A review. *International Journal of Pattern Recognition and Artificial Intelligence*, *23*(04), 687–719. doi:10.1142/S0218001409007326

Suryadevara, N. K., & Mukhopadhyay, S. C. (2012). Wireless sensor network based home monitoring system for wellness determination of elderly. *Sensors Journal*, *12*(6), 1965–1972. doi:10.1109/JSEN.2011.2182341

Swarbrick, M., Gill, K. J., & Pratt, C. W. (2016). Impact of peer delivered wellness coaching. *Psychiatric Rehabilitation Journal*, *39*(3), 234–238. doi:10.1037/prj0000187 PMID:27054901

Szczepura, A. (2005). Access to health care for ethnic minority populations. *Postgraduate Medical Journal*, *81*(953), 141–147. doi:10.1136/pgmj.2004.026237 PMID:15749788

Taber, J.M., Leyva, B., & Persoskie, A. (2015). Why do people avoid medical care? A qualitative study using national data. *J Gen Intern Med., 30*(3), 290–7.

Tahrani, A. A., Bailey, C. J., Del Prato, S., & Barnett, A. H. (2011). Management of type 2 diabetes: New and future developments in treatment. *Lancet*, *378*(9786), 182–197. doi:10.1016/S0140-6736(11)60207-9 PMID:21705062

Tam, K. Y., & Ho, S. Y. (2005). Web personalization as a persuasion strategy: An elaboration likelihood model perspective. *Information Systems Research*, *16*(3), 271–293. doi:10.1287/isre.1050.0058

Tang, P. C., Overhage, J. M., Chan, A. S., Brown, N. L., Aghighi, B., Entwistle, M. P., ... Young, C. Y. (2013). Online disease management of diabetes: Engaging and motivating patients online with enhanced resources-diabetes (EMPOWER-D), a randomized controlled trial. *Journal of the American Medical Informatics Association*, *20*(3), 526–534. doi:10.1136/amiajnl-2012-001263 PMID:23171659

Tanniru, M. (2019). Engagement Leading to Empowerment—Digital Innovation Strategies for Patient Care Continuity. *Journal of Hospital Management and Health Policy.* (forthcoming)

Taylor, S., & Todd, P. A. (1995). Assessing IT usage: The role of prior experience. *Management Information Systems Quarterly*, *19*(4), 561–570. doi:10.2307/249633

Te Morenga, L., Mallard, S., & Mann, J. (2013). Dietary sugars and body weight: Systematic review and meta-analyses of randomised controlled trials and cohort studies. *BMJ (Clinical Research Ed.)*, *346*(jan15 3), e7492. doi:10.1136/bmj.e7492 PMID:23321486

Teli, M. (2019). Family Empowerment Model for Type 2 DM Management: Integration of Self care Model by Orem and Family Centered Nursing by Friedman in Sikumana Health Center-Kupang. *Jurnal Info Kesehatan*, *17*(1), 75–87. doi:10.31965/infokes.Vol17.Iss1.261

Teo, H. H., Wei, K. K., & Benbasat, I. (2003). Predicting intention to adopt interorganizational linkages: An institutional perspective. *Management Information Systems Quarterly*, *27*(1), 19–49. doi:10.2307/30036518

Thacker, K., Moutford, W. K., & Ernst, F. R. (2016). Perioperative fluid utilization variability and association with outcomes: Considerations for enhanced recovery efforts in sample US surgical patients. *Annals of Surgery*, *263*(3), 502–510. doi:10.1097/SLA.0000000000001402 PMID:26565138

Thaker, D. A., Monypenny, R., Olver, I., & Sabesan, S. (2013). Cost savings from a telemedicine model of care in northern Queensland, Australia. *The Medical Journal of Australia*, *199*(6), 414–417. doi:10.5694/mja12.11781 PMID:24033216

The Alliance for Building Capacity. (2002). Framework for rural and remote readiness in telehealth: Project report for CANARIE. Calgary, Canada: Author.

The medium and the message of Ebola. (2014). *Lancet*, *2014*, 384–9955.

Thom, D. H., Ghorob, A., Hessler, D., De Vore, D., Chen, E., & Bodenheimer, T. A. (2013). Impact of peer health coaching on glycemic control in low-income patients with diabetes: A randomized controlled trial. *Annals of Family Medicine*, *11*(2), 137–144. doi:10.1370/afm.1443 PMID:23508600

Thometz, K. (2017). *Survey Reveals 'Alarming' Health Disparities in Chicago Neighborhoods*. Retrieved from: https://news.wttw.com/2017/03/23/survey-reveals-alarming-health-disparities-chicago-neighborhoods

Thompson, D., Baranowski, T., Buday, R., Baranowski, J., Thompson, V., Jago, R., & Griffith, M. J. (2010). Serious video games for health: How behavioral science guided the development of a serious video game. *Simulation & Gaming*, *41*(4), 587–606. doi:10.1177/1046878108328087 PMID:20711522

Thorne, K., & Smith, M. (2000). Competitive advantage in world class organizations. *Management Accounting*, *78*, 22–26.

Thornton, R. L., Glover, C. M., Cené, C. W., Glik, D. C., Henderson, J. A., & Williams, D. R. (2016). Evaluating strategies for reducing health disparities by addressing the social determinants of health. *Health Affairs*, *35*(8), 1416–1423. doi:10.1377/hlthaff.2015.1357 PMID:27503966

Thorpe, K. E. (2005). *The Rise in Health Care Spending and What to Do About It Health Affairs*. Academic Press.

Thorpe, K. E., Ogden, L. L., & Galactionova, K. (2010, April). Chronic Conditions Accout For Rise In Medicare Spending From 1987 To 2006. *Health Affairs*, 29.

Tieghi, A. L. (2013, November). A saúde brasileira tem cura? *Revista Espaço Aberto, 155*. São Paulo, SP: Universidade de São Paulo.

Tillett, S., & Newbold, E. (2006). Grey literature at The British Library: Revealing a hidden resource. *Interlending & Document Supply*, *34*(2), 70–73. doi:10.1108/02641610610669769

Timen, A., Sprenger, M., Edelstein, M., Martin-Moreno, J., & McKee, M. (2015). The Ebola crisis: Perspectives from European Public Health. *European Journal of Public Health*, *25*(2), 187–188. doi:10.1093/eurpub/cku236 PMID:25583039

Torre, L. A., Bray, F., Siegel, R. L., Ferlay, J., Lortet-Tieulent, J., & Jemal, A. (2015). Global cancer statistics, 2012. *CA: a Cancer Journal for Clinicians*, *65*(2), 87–108. doi:10.3322/caac.21262 PMID:25651787

Torre, L. A., Siegel, R. L., Ward, E. M., & Jemal, A. (2016). Global cancer incidence and mortality rates and trends—An update. *Cancer Epidemiology and Prevention Biomarkers*, *25*(1), 16–27. doi:10.1158/1055-9965.EPI-15-0578 PMID:26667886

Trudel, M.-C. (2008). *Challenges to personal information sharing in interorganizational settings: Learning from the Quebec Health Smart Card project*. School of Graduate and Postdoctoral Studies, University of Western Ontario.

Trzeciak, S., Gaughan, J. P., Bosire, J., & Mazzarelli, A. J. (2016). Association Between Medicare Summary Star Ratings for Patient Experience and Clinical Outcomes in US Hospitals. *Journal of Patient Experience*, *3*(1), 2374373516636681. doi:10.1177/2374373516636681 PMID:28725825

Tully, J. (2002). Political philosophy as a critical activity. *Political Theory*, *30*(4), 533–555. doi:10.1177/0090591702304005

Tung, E. L., Boyd, K., Lindau, S. T., & Peek, M. E. (2018). Neighborhood crime and access to health-enabling resources in Chicago. *Preventive Medicine Reports*, *9*, 153–156. doi:10.1016/j.pmedr.2018.01.017 PMID:29527469

Tuominen, L., Leino-Kilpi, H., & Suhonen, R. (2016). Older people's experiences of their free will in nursing homes. *Nursing Ethics*, *23*(1), 22–35. doi:10.1177/0969733014557119 PMID:25488758

Tversky, A., & Kahneman, D. (1975). Judgment under uncertainty: Heuristics and biases. *Science*, *185*(4157), 1124–1131. doi:10.1126cience.185.4157.1124 PMID:17835457

Twa, M. D. (2018). Deep Learning and Clinical Decision Support. *Optometry and Vision Science*, *95*(4), 275–276. doi:10.1097/OPX.0000000000001210 PMID:29608543

Twitter graphic cancer in Aust 2017. (n.d.). Available: https://www.aihw.gov.au/getmedia/96aa3854-ceb0-40c5-8d25-27d4b1098490/twitter-graphic-cancer-in-aust-2017.pdf.aspx

U.S. Department of Health and Human Services. (2010). *Multiple Chronic Conditions—A Strategic Framework: Optimum Health and Quality of Life for Individuals with Multiple Chronic Conditions*. U.S. Department of Health and Human Services.

Understanding Cancer. (2018). Available: https://www.mesotheliomagroup.com/our-mission/resources/understanding-cancer/

Urquhart, D. M., Hanna, F. S., Brennan, S. L., Wluka, A. E., Leder, K., Cameron, P. A., . . . Cicuttini, F. M. (2010). Incidence and risk factors for deep surgical site infection after primary total hip arthroplasty: a systematic review. *The Journal of Arthroplasty, 25*(8), 1216-1222.

Uvin, P. (1995). Fighting hunger at the grassroots: Paths to scaling up. *World Development*, *23*(6), 927–939. doi:10.1016/0305-750X(95)00028-B

Vähätalo, M., & Kallio, T. J. (2015). Organising health services through modularity. *International Journal of Operations & Production Management*, *35*(6), 925–945. doi:10.1108/IJOPM-12-2013-0523

Vaishnavi, V., & Kuechler, W. (2004). *Design Research in Information Systems*. Retrieved from http://desrist.org/design-research-in-information-systems

Valchanov, P. (2017). 3D Printing In Medicine – Principles, Applications And Challenges. Department of Anatomy and Cell Biology, Faculty of Medicine, Medical University of Varna, Bulgaria, 1(1), 18-22.

Van Acker, K., Bouhassira, D., De Bacquer, D., Weiss, S., Matthys, K., Raemen, H., ... Colin, I. M. (2009). Prevalence and impact on quality of life of peripheral neuropathy with or without neuropathic pain in type 1 and type 2 diabetic patients attending hospital outpatients clinics. *Diabetes & Metabolism*, *35*(3), 206–213. doi:10.1016/j.diabet.2008.11.004 PMID:19297223

Van den Bulte, C., & Lilien, G. L. (2001). Medical innovation revisited: Social contagion versus marketing effort. *American Journal of Sociology*, *106*(5), 1409–1435. doi:10.1086/320819

van Dyk, L., & Schutte, C. S. L. (2012). Development of a maturity model for telemedicine. *South African Journal of Industrial Engineering, 23*(2), 61–72.

van Dyk, L. (2014). A Review of Telehealth Service Implementation Frameworks. *International Journal of Environmental Research and Public Health*, *11*(2), 1279–1298. doi:10.3390/ijerph110201279 PMID:24464237

van Dyk, L., & Schutte, C. S. L. (2013). The Telemedicine Service Maturity Model: A framework for the measurement and improvement of telemedicine services. In R. Madhavan (Ed.), *Telemedicine* (pp. 217–238). InTech.

Van Galen, L. S., Brabrand, M., Cooksley, T., van de Ven, P. M., Merten, H., So, R. K., ... Nanayakkara, P. W. (2017). Patients' and providers' perceptions of the preventability of hospital readmission: A prospective, observational study in four European countries. *BMJ Quality & Safety*, *26*(12), 958–969; Advance online publication. doi:10.1136/bmjqs-2017-006645 PMID:28642333

Van Langenhove, L., & Hertleer, C. (2004). Smart clothing: A new life. *International Journal of Clothing Science and Technology*, *16*(1/2), 63–72. doi:10.1108/09556220410520360

Van Sambeek, J. R. C., Cornelissen, F. A., Bakker, P. J. M., & Krabbendam, J. J. (2010). Models as instruments for optimizing hospital processes: A systematic review. *International Journal of Health Care Quality Assurance*, *23*(4), 356–377. doi:10.1108/09526861011037434 PMID:20535906

Van Someren, M. W., Barnard, Y. F., & Sandberg, J. A. C. (1994). *The think aloud method: A practical approach to modelling cognitive processes*. London: Academic Press.

Van Walraven, C., Bennett, C., Jennings, A., Austin, P. C., & Forster, A. J. (2011). Proportion of hospital readmissions deemed avoidable: a systematic review. CMAJ: Canadian Medical Association Journal = Journal De L'Association Medicale Canadienne, 183(7), E391-402. doi:10.1503/cmaj.101860

Van Walraven, C., Dhalla, I. A., Bell, C., Etchells, E., Stiell, I. G., Zarnke, K., . . . Forster, A. J. (2010). Derivation and validation of an index to predict early death or unplanned readmission after discharge from hospital to the community. CMAJ: Canadian Medical Association Journal = Journal De L'Association Medicale Canadienne, 182(6), 551–557. doi:10.1503/cmaj.091117

Van Walraven, C., Wong, J., & Forster, A. J. (2012). Derivation and validation of a diagnostic score based on case-mix groups to predict 30-day death or urgent readmission. *Open Medicine: a Peer-Reviewed, Independent, Open-Access Journal*, *6*(3), e90–e100. PMID:23687525

Vandaveer, V. V., Lowman, R. L., Pearlman, K., & Brannick, J. P. (2016). A practice analysis of coaching psychology: Toward a foundational competency model. *Consulting Psychology Journal: Practice and Research*, *68*(2), 118–142. doi:10.1037/cpb0000057

Vander S. J., & Stocksman. (2017). *Building Evidence for 3D Printing Applications in Medicine*. . doi:10.13140/RG.2.2.14182.11846

Varanasi, O. M. T. (2015). Seeking Intelligence from Patient Experience using Text Mining - Analysis of Emergency Department Data. *Journal of Systems Management*, *32*, 1–9.

Vargo, S. L., & Lusch, R. F. (2008). Service-Dominant Logic: Continuing the Evolution. *Journal of the Academy of Marketing Science*, *36*(1), 1–10. doi:10.100711747-007-0069-6

Vargo, S. L., Wieland, H., & Akaka, M. A. (2016). Innovation in Service Ecosystems. *J. Serviceol*, *1*, 1–5.

Varshney, U. (2005). Pervasive healthcare: Applications, challenges and wireless solutions. *Communications of the Association for Information Systems*, *16*, 3. doi:10.17705/1CAIS.01603

Vazirani, A. A., O'Donoghue, O., Brindley, D., & Meinert, E. (2019). Implementing Blockchains for Efficient Health Care: Systematic Review. *Journal of Medical Internet Research*, *21*(2), e12439. doi:10.2196/12439 PMID:30747714

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science*, *46*(2), 186–204. doi:10.1287/mnsc.46.2.186.11926

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *Management Information Systems Quarterly*, *27*(3), 425–478. doi:10.2307/30036540

Venkatesh, V., Thong, J. Y. L., & Xu, X. (2012). Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology. *Management Information Systems Quarterly*, *36*(1), 157–178. doi:10.2307/41410412

Vogeli, C., Shields, A. E., Lee, T. A., Gibson, T. B., Marder, W. D., Weiss, K. B., & Blumenthal, D. (2007, November). Multiple Chronic Conditions: Prevalence, Health Consequences, an Implications for Quality, Care Management, and Costs. *Journal of General Internal Medicine*, *22*(S3), 391–395. doi:10.100711606-007-0322-1 PMID:18026807

Von Lubitz, D., & Wickramasinghe, N. (2006). Creating germane knowledge in dynamic environments. *International Journal of Innovation and Learning*, *3*(3), 326–347. doi:10.1504/IJIL.2006.009226

Voogdt-Pruis, H. R., Beusmans, G. H. M. I., Gorgels, A. P. M., & van Ree, J. W. (2011). Experiences of doctors and nurses implementing nurse-delivered cardiovascular prevention in primary care: A qualitative study. *Journal of Advanced Nursing*, *67*(8), 1758–1766. doi:10.1111/j.1365-2648.2011.05627.x PMID:21545701

Vyas, P., Rastogi, R., Chaturvedi, D. K., Satya, S., Arora, N., & Singh, P. (2018e). Statistical Analysis for Effect of Positive Thinking on Stress Management and Creative Problem Solving for Adolescents. *Proceedings of the 12th INDIACom,* 245-251.

Wagenmakers, R., Stevens, M., Groothoff, J. W., Zijlstra, W., Bulstra, S. K., van Beveren, J., ... van den Akker-Scheek, I. (2011). Physical activity behavior of patients 1 year after primary total hip arthroplasty: A prospective multicenter cohort study. *Physical Therapy*, *91*(3), 373–380. doi:10.2522/ptj.20100148 PMID:21233307

Walls, J. G., Widmeyer, G. R., & El Sawy, O. A. (1992). Building an information system design theory for vigilant EIS. *Information Systems Research, 3*(1), 36-59.

Walls, J.G., Widmeyer, G.R., & El Sawy, O.A. (1992). Building an information system design theory for vigilant EIS. *Information Systems Research*, *3*(1), 36-59.

Walters, L. E. M., Mars, M., & Scott, R. E. (2016). A review and critique of teledermatology in the South African public health sector. *Studies in Health Technology and Informatics*, *231*, 143–151. PMID:27782026

Wang, K. (2019). Clinical 3D Printing: Status, Challenges and Opportunities. *RSCNA*. Retrieved from https://www.rsna.org/en/news/2019/January/Clinical-3D-Printing-Status-Challenges-and-Opportunities

Wang, C. Y., & Fenske, M. M. (1996). Self-care of adults with non-insulin-dependent diabetes mellitus: Influence of family and friends. *The Diabetes Educator*, *22*(5), 465–470. doi:10.1177/014572179602200506 PMID:8936125

Wang, Y., Kung, L., & Byrd, T. A. (2018). Big data analytics: Understanding its capabilities and potential benefits for healthcare organizations. *Technological Forecasting and Social Change*, *126*, 3–13. doi:10.1016/j.techfore.2015.12.019

Ware, J. E. Jr, & Gandek, B. (1998). Overview of the SF-36 health survey and the international quality of life assessment (IQOLA) project. *Journal of Clinical Epidemiology*, *51*(11), 903–912. doi:10.1016/S0895-4356(98)00081-X PMID:9817107

Weber, M. (1962). *Basic concepts in sociology. Philosophical Library*. New York, NY: Philosophical Library, Inc.

Weber, R. H. (2010). Internet of Things – New security and privacy challenges. *Computer Law & Security Review*, *26*(1), 23–30. doi:10.1016/j.clsr.2009.11.008

Weeks, W. B., & Wwinstein, J. (2015). Caveats to Consider When Calculating Healthcare Value. *The American Journal of Medicine*, *128*(8), 802–803. doi:10.1016/j.amjmed.2014.11.012 PMID:25433299

Weimer, D. L., & Vining, A. (2011). Policy analysis (5th ed.). Academic Press.

Weiner, B. J. (2019). Enhancing the Impact of Implementation Strategies in Healthcare: A Research Agenda. *Frontiers in Public Health*, *7*, 3. doi:10.3389/fpubh.2019.00003 PMID:30723713

Welch, S., & Savitz, L. (2012). Exploring strategies to improve emergency department intake. *The Journal of Emergency Medicine*, *43*(1), 149–158. doi:10.1016/j.jemermed.2011.03.007 PMID:21621363

Wen, P., & Korakianitis, T. (2018). Medical Applications for 3D Printing: Recent Developments. *Science of Medicine, 115*(1).

Wendt, D., & Vlek, C. (1975). Utility, probability, and human decision making. *Theory and Decision Library*, *11*, 141–162.

Weppner, W. G., Ralston, J. D., Koepsell, T. D., Grothaus, L. C., Reid, R. J., Jordan, L., & Larson, E. B. (2010). Use of a shared medical record with secure messaging by older patients with diabetes. *Diabetes Care*, *33*(11), 2314–2319. doi:10.2337/dc10-1124 PMID:20739686

Werner, R. M., & Asch, D. A. (2005). The unintended consequences of publicly reporting quality information. *Journal of the American Medical Association*, *293*(10), 1239–1244. doi:10.1001/jama.293.10.1239 PMID:15755946

Werner, R. M., & Bradlow, E. T. (2010). Public reporting on hospital process improvements is linked to better patient outcomes. *Health Affairs*, *29*(7), 1319–1324. doi:10.1377/hlthaff.2008.0770 PMID:20606180

Werner, R. M., Konetzka, R. T., Stuart, E. A., Norton, E. C., Polsky, D., & Park, J. (2009). Impact of public reporting on quality of postacute care. *Health Services Research*, *44*(4), 1169–1187. doi:10.1111/j.1475-6773.2009.00967.x PMID:19490160

Wessler, B. S., Lai, Y. H. L., Kramer, W., Cangelosi, M., Raman, G., Lutz, J. S., & Kent, D. M. (2015). Clinical prediction models for cardiovascular disease: Tufts predictive analytics and comparative effectiveness clinical prediction model database. *Circulation: Cardiovascular Quality and Outcomes*, *8*(4), 368–375. doi:10.1161/CIRCOUTCOMES.115.001693 PMID:26152680

Westby, M. D., & Backman, C. L. (2010). Patient and health professional views on rehabilitation practices and outcomes following total hip and knee arthroplasty for osteoarthritis: A focus group study. *BMC Health Services Research*, *10*(1), 119. doi:10.1186/1472-6963-10-119 PMID:20459834

Wetters, N. G., Murray, T. G., Moric, M., Sporer, S. M., Paprosky, W. G., & Della Valle, C. J. (2013). Risk factors for dislocation after revision total hip arthroplasty. *Clinical Orthopaedics and Related Research*, *471*(2), 410–416. doi:10.100711999-012-2561-7 PMID:22956236

Whiteford & Szelag. (2000). Access and Utility as reflections of culture construction of pregnancv. *Primary Care Update, 7*, 98-104.

WHO. (2009). *Practical guidance for scaling up health service innovations*. Geneva: World Health Organization.

WHO. (2014). *Statement on the meeting of the international health regulations emergency committee regarding the 2014 Ebola outbreak in West Africa*. Geneva: World Health Organization. Retrieved from http://www.who.int/mediacentre/news/statements/2014/ebola-20140808/en/

WHO. (2016b). *Ebola data and statistics – 11 May 2016*. Retrieved from http://apps.who.int/gho/data/node.ebola-sitrep.quick-downloads?lang=en

WHO. (2019). *Ebola situation report - 24 April 2019*. Retrieved from https://www.who.int/ebola/situation-reports/drc-2018/en/

WHO/FAO Expert Consultation, WHO Technical Report Series 916 Diet, Nutrition, and the Prevention of Chronic Diseases. (2003). Geneva: WHO. Available from http://health.euroafrica.org/books/dietnutritionwho.pdf

Wickramasinghe, C. S., Kliman, L., Vogel, D., & Goldberg, S. (2014). *Exploring the Possibility for a Pervasive Technology Solution to Facilitate Effective Diabetes Selfcare for Patients with GDM*. Paper presented at 2014 ECIS, Tel Aviv, Israel.

Wickramasinghe, N., & Schaffer, J. (2010). *Realizing value driven e-health solutions.* Washington, DC: Report for IBM.

Wickramasinghe, N., & von Lubitz, D. (2007). Knowledge-based Enterprise: Theories and Fundamentals. IDEA Group.

Wickramasinghe, N., Bali, R. K., Choi, C. J. H. J., & Schaffer, J. L. (2009). *A Systematic Approach Optimization of Healthcare Operations with Knowledge Management*. Paper presented at the HIMSS.

Wickramasinghe, N., Haddad, P., Vaughan, S., Han-Lin, C., & Moghimi, H. (2015). Identifying key success factors for the adoption and implementation of a chemotherapy ordering system: A case study from the Australian private healthcare sector. In *21st Americas Conference on Information Systems, AMCIS 2015*. Americas Conference on Information Systems.

Wickramasinghe, N. (2003). Do we practise what we preach: Are knowledge management systems in practice truly reflective of knowledge management systems in theory? *Business Process Management Journal*, *9*(3), 295–316. doi:10.1108/14637150310477902

Wickramasinghe, N. (2006). Fostering knowledge assets in healthcare with the KMI model. *International Journal of Management and Enterprise Development*, *4*(1), 52–65. doi:10.1504/IJMED.2007.011455

Wickramasinghe, N. (2006). Knowledge creation: A meta-framework. *International Journal of Innovation and Learning*, *3*(5), 558–573. doi:10.1504/IJIL.2006.010489

Wickramasinghe, N., Bali, R., Gibbons, M., Choi, J., & Schaffer, J. (2008). A systematic approach: Optimization of healthcare operations with knowledge management. *Journal of healthcare information management*. *Journal of Healthcare Information Management*, *23*(3), 44–50. PMID:19663164

Wickramasinghe, N., Bloomendal, H., de Bruin, A., & Krabbendam, K. (2004). Enabling innovative healthcare delivery through the use of the focused factory model: The case of the spine clinic of the future. *Int. J. Innovation and Learning*, *2*(1), 90–110. doi:10.1504/IJIL.2005.006086

Wickramasinghe, N., Davey, B., & Tatnall, A. (2013). Web 2.0 panacea or placebo for superior healthcare delivery? In R. Bali, I. Troshani, S. Goldberg, & N. Wickramasinghe (Eds.), *Pervasive health knowledge management* (pp. 317–330). New York: Springer. doi:10.1007/978-1-4614-4514-2_23

Wickramasinghe, N., & Davison, G. (2004). Making explicit the implicit knowledge assets in healthcare. *Health Care Management Science*, *7*(3), 185–196. doi:10.1023/B:HCMS.0000039381.02400.49 PMID:15648561

Wickramasinghe, N., Fadlalla, A., Geisler, E., & Schaffer, J. (2005). A framework for assessing e-health preparedness. *International Journal of Electronic Healthcare*, *1*(3), 316–334. doi:10.1504/IJEH.2005.006478 PMID:18048213

Wickramasinghe, N., & Goldberg, S. (2004). How M=EC2 in Healthcare. *International Journal of Mobile Communications*, *2*(2), 140–156. doi:10.1504/IJMC.2004.004664

Wickramasinghe, N., John, B., George, J., & Vogel, D. (2019). *Achieving Value-Based Care in Chronic Disease Management: The DiaMonD (diabetes monitoring device)*. Solution JMIR Diabetes.

Wickramasinghe, N., & Lichtenstein, S. (2006). Supporting knowledge creation with e-mail. *International Journal of Innovation and Learning*, *3*(4), 416–426. doi:10.1504/IJIL.2006.009565

Wickramasinghe, N., & Mills, G. (2001). MARS: The electronic medical record system the core of the Kaiser galaxy. *Health Information Systems and Informatics*, *1*, 68–81. doi:10.4018/jhisi.2006100106

Wickramasinghe, N., & Schaffer, J. (2006). Creating Knowledge Driven Healthcare Processes With The Intelligence Continuum. *International Journal of Electronic Healthcare*, *2*(2), 164–174. doi:10.1504/IJEH.2006.008830 PMID:18048242

Wiedemann, A. U., Lippke, S., Reuter, T., Ziegelmann, J. P., & Schwarzer, R. (2011). How planning facilitates behaviour change: Additive and interactive effects of a randomized controlled trial. *European Journal of Social Psychology*, *41*(1), 42–51. doi:10.1002/ejsp.724

Williams, I., & Brown, H. (2014). Factors influencing decisions of value in health care: a review of the literature. Health Service Management Center: University of Birmingham.

Williams, C. (1999). Gender, adolescence and the management of diabetes. *Journal of Advanced Nursing*, *30*(5), 1160–1166. doi:10.1046/j.1365-2648.1999.01168.x PMID:10564415

Wold, H. (1985). Partial least squares. In S. Kotz & N. L. Johnson (Eds.), *Encyclopedia of statistical sciences* (pp. 581–591). New York: Wiley.

Wong, J. K. W., Leung, J., Skitmore, M., & Buys, L. (2017). Technical requirements of age-friendly smart home technologies in high-rise residential buildings: A system intelligence analytical approach. *Automation in Construction*, *73*, 12–19. doi:10.1016/j.autcon.2016.10.007

Wootton, R. (1998). Telemedicine in the national health service. *Journal of the Royal Society of Medicine*, *91*(12), 614–621. doi:10.1177/014107689809101202 PMID:10730107

World Health Organisation. (2019). Retrieved from https://www.who.int/behealthy/digital-health

World Health Organization (WHO). (2016). *Global report on diabetes: executive summary* (No. WHO/NMH/NVI/16.3). World Health Organization. Available from https://apps.who.int/iris/bitstream/handle/10665/204871/9789241565257_eng.pdf?sequence=1

World Health Organization. (2008). *Health information systems*. Retrieved July 5, 2019 from <http://www.who.int/healthinfo/statisticstoolkit_hss/EN_PDF_Toolkit_HSS_InformationSystems.pdf> <https://publicreporting.sts.org/sites/default/files/files/Consumer%20Reports%20and%20STS%20Public%20Reporting.pdf>

Wright, W. F. (2013). Prosthetic joint Infections. *Essentials of Clinical Infectious Diseases*, 241.

Wu, M., Yang, J., Liu, L., & Ye, B. (2016). An Investigation of Factors Influencing Nurses' Clinical Decision-Making Skills. *Western Journal of Nursing Research*, *38*(8), 974–991. doi:10.1177/0193945916633458 PMID:26906246

Xie, L. J., & Cheng, M. H. (2012). Body adipose distribution among patients with type 2 diabetes mellitus. *Obesity Research & Clinical Practice*, *6*(4), e270–e279. doi:10.1016/j.orcp.2012.09.003 PMID:24331587

Yadav, V., Rastogi, R., Chaturvedi, D. K., Satya, S., Arora, N., & Bansal, I. (2018k). Intelligent Analysis for Detection of Complex Human Personality by Clinical Reliable Psychological Surveys on Various Indicators. *National Conference on 3rd MDNCPDR-2018*.

Yadav, V., Rastogi, R., Chaturvedi, D. K., Satya, S., Arora, N., Gupta, M., . . . Sharma, P. (2019b). Book chapter titled as Chronic TTH Analysis by EMG & GSR Biofeedback on Various Modes and Various Medical Symptoms Using IoT. Advances in ubiquitous sensing applications for healthcare, Book-Big Data Analytics for Intelligent Healthcare Management.

Yadav, V., Rastogi, R., Chaturvedi, D. K., Satya, S., Arora, N., Yadav, V., ... Chauhan, S. (2018j). Statistical Analysis of EMG & GSR Biofeedback Efficacy on Different Modes for Chronic TTH on Various Indicators. *Int. J. Advanced Intelligence Paradigms*, *13*(1), 251–275. doi:10.1504/IJAIP.2019.10021825

Ye, X., Li, S., Yang, X., Lee, J., & Wu, L. (2018). The fear of Ebola: A tale of two cities in China. In *Big data support of urban planning and management* (pp. 113–132). Cham: Springer. doi:10.1007/978-3-319-51929-6_7

Yin, R. K. (2005). *Case study research: design and methods*. New York, NY: Sage Publications.

Yoon, P. (2003). *Emergency department fast-track system. Alberta Heritage Foundation for Medical Research*. Edmonton, Canada: AHFMR.

Yoo, Y., Henfridsson, O., & Lyytinen, K. (2010). Research commentary—the new organizing logic of digital innovation: An agenda for information systems research. *Information Systems Research*, *21*(4), 724–735. doi:10.1287/isre.1100.0322

Yu, L., & Liu, H. (2003). Feature Selection for High-Dimensional Data: A Fast Correlation-Based Filter Solution. Academic Press.

Yuan, B., & Herbert, J. (2011). Web-based real-time remote monitoring for pervasive healthcare. In *2011 IEEE International Conference on Pervasive Computing and Communications Workshops (PERCOM Workshops)* (pp. 625–629). Piscataway, NJ: IEEE. 10.1109/PERCOMW.2011.5766964

Yu, H., & Hatzivassiloglou, V. (2003). Towards answering opinion questions: Separating facts from opinions and identifying the polarity of opinion sentences. In *Proceedings of the 2003 conference on Empirical methods in natural language processing*. Association for Computational Linguistics. 10.3115/1119355.1119372

Yusif, S., Hafeez-Baig, A., & Soar, J. (2017). e-Health readiness assessment factors and measuring tools: A systematic review. *International Journal of Medical Informatics*, *107*, 56–64. doi:10.1016/j.ijmedinf.2017.08.006 PMID:29029692

Zanaboni, P., & Wootton, R. (2012). Adoption of telemedicine: From pilot stage to routine delivery. *BMC Medical Informatics and Decision Making*, *12*(1), 1. doi:10.1186/1472-6947-12-1 PMID:22217121

Zapka, J., Simpson, K., Hiott, L., Langston, L., Fakhry, S., & Ford, D. (2013). A mixed methods descriptive investigation of readiness to change in rural hospitals participating in a tele-critical care intervention. *BMC Health Services Research*, *13*(1), 1–11. doi:10.1186/1472-6963-13-33 PMID:23360332

Zhou, H., Della, P. R., Roberts, P., Goh, L., & Dhaliwal, S. S. (2016). Utility of models to predict 28-day or 30-day unplanned hospital readmissions: An updated systematic review. *BMJ Open*, *6*(6), e011060. doi:10.1136/bmjopen-2016-011060 PMID:27354072

Zwart, R. C., Wubbels, T., Bergen, T., & Bolhuis, S. (2009). Which characteristics of a reciprocal peer coaching context affect teacher learning as perceived by teachers and their students? *Journal of Teacher Education*, *60*(3), 243–257. doi:10.1177/0022487109336968

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