TECHNOLOGY ACCEPTANCE ISSUES FOR A MOBILE APPLICATION TO SUPPORT DIABETES PATIENTS IN SAUDI ARABIA

By

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Abstract

Saudi Arabia is a developing country faced with numerous economic, political and societal challenges. The country's healthcare sector is in serious need of improvement due tofactors like a dilapidated transport network, suppression of women's rights, the existence of many foreign nationals and health centers which are clustered around population centers and thus unequal to the task of providing convenient, prompt healthcare to some sections of the population. The introduction of a mobile application to manage a chronic disease such as diabetes could make it easier for patients to manage their illness and communicate with their healthcare specialists remotely; thus reducing the expense and time involved in attending appointments; as well as receiving vital information on areas such as diet, exercise and blood glucose monitoring alerts.

Extensive applications in mHealth are being used globally with some success. However, Saudi Arabia has its own limitationsand is a very specific social and cultural context,and this study aims to fill the knowledge gap in the literature about how such mHealth technology would be accepted by Saudi diabetics, doctors and diabetes specialists; and a specially adapted theoretical model of technology acceptance was used. Male and female specialist doctors were interviewed and patients and doctors surveyedby means of an online questionnaire. All participants were asked to watch a short video,especially designed by the researcher to fit the Saudi context, about the functions of a diabetes management application.This primary data is a vital contribution to the understanding of the problems faced at present by Saudi diabetics in receiving adequate care and self-managing their illness, as well as

providing an insight into the current state of technology acceptance for mHealth applications in Saudi Arabia.

Findings reveal that both doctors and patients are generally positive about using a diabetes mHealth application but some wouldneed training, and there were concerns about privacy issues and whether its use would make more work for doctors.Culture, gender, age, education levels, income and locationwere found to impact adoption of technology in the Saudi context. The study seeks to make practical recommendations for Saudi healthcare providers and recommends starting with an IVR system based on the COSMOS Model, which addresses many of the challenges in self-management of diabetes. Furthermore, the diabetes management application ‘Glucose Buddy’ was evaluated and findings suggest that with incentives and training, this could be successfully implemented.

Face-to-face communication is a major limitation in mHealth but at least patients receive care between appointments, and female patients unwilling to see male specialists can receive information and contact their hospital. The study concludes that mHealth is workable in Saudi Arabia and the model is scalable; as literacy and educational level rises, more sophisticated applications could be used. Finally, the study notes its limitations and uses them to make recommendations for further research.

CHAPTER I: INTRODUCTION

1.1 Background

The Kingdom of Saudi Arabia (KSA), a country whose total population was 30.8 million in 2014 (Central Department of Statistics and Information, 2015), is experiencing an alarming growth in the incidence of chronic diseases along with a continued burden of communicable diseases. According to statistics by the International Diabetes Federation (IDF) in 2015, Saudi Arabia's population indicated the highest prevalence of diabetes compared to average prevalence of the disease in the world and countries of the Middle East and North Africa (MENA). IDF statistics on Saudi Arabia indicated over 3.4 million cases of diabetes in the year 2015 alone (International Diabetes Federation, 2015). Based on the data, the adult prevalence between the ages 20-79 for the disease was 17.6 % much higher than the universal prevalence. The older population also indicated the highest prevalence i.e. 47 % for the age group of 65-69 years old. Saudi Arabia is between the middle and low-income countries, and has a higher percentage of the population below 60 years; and the diabetes mortality rate for this group is higher than that of developed countries. In addition to the national increase in mortality rate, statistics by the IDF also indicated a significant economic burden on the financial stratum of the healthcare system with the government spending $1,145 per diabetic patient (International Diabetes Federation, 2015). Saudi Arabian statistics on the prevalence, economical burden and healthcare limitations are likely to worsen in the near future since surveys indicate that there are over 1.25 million cases of diabetes that have not been officially reported (International Diabetes Federation, 2015). It is hence apparent that diabetes presents a national challenge that is rapidly progressing to other spheres of the economy.

The growth of this chronic disease condition can be traced in part to lifestyle issues such as poor diet and lack of exercise, although cumulative research indicates inadequate access to healthcare resources as the primary factor (World Health Organization, 2013). Approximately 83% of Saudi residents live within a metropolitan area and can conceivably access some level of institutional healthcare. For these residents, quality, facility-based care is the norm (World Bank, 2016). Due to their social and cultural backgrounds, many sections of the population, including women, expatriates, people who live far from central hospitals and those on poorer incomes are largely detached from available and efficient healthcare support (Marsh, 2006; Twaddle, 2002). Furthermore, according to reports in Arab News (2014), Saudi Arabia' s Ministry of Labour disclosed that the country was hosting over 7.5 million foreign workers who had obtained legal documentation to reside in the state. The workforce largely lives in worker compounds that are remotely located and suffers from unavailability of healthcare and emergency first aid support (Mufti, 2000).

In addition to less favourable healthcare facilities in the country, Baranowski (2009) further identified numerous challenges facing healthcare professionals in Saudi Arabia, and suggested that these medically challenged areas present promising grounds for the development of mobile health solutions. Baranowski (2009) noted that internal communication in Saudi hospitals was a crucial problem, resulting from a 'silo-based' mentality amongst workers in different hospital departments. Thus, 'conventional' information systems, augmented by mobile/ubiquitous computing applications would be instrumental in mitigating communication barriers in the healthcare systems. Specifically, that direct contact between the patient and the specialist department by means of the mobile application would improve communications and lessen the chances of important information getting lost or delayed.

Shortcomings in the health sector, especially in developing nations, have motivated the growth of initiatives with the label of ‘mHealth’. The World Health Organization (WHO) defined the term ‘mobile health’ (mHealth) as a subset of electronic health (eHealth) that facilitates the provision of health services and information using mobile technology such as mobile cells, laptops, iPads and PDAs (WHO, 2012). It is the limitations of existing healthcare systems that have emerged as some of the key drivers of mHealth prevalence. These limitations include: high population growth curves, a high disease quotient, few health practitioners and a lack of finances for infrastructure and health systems (WHO, 2012). Information and communications technology have been used extensively in many Western countries to improve multiple aspects of healthcare, such as expert diagnostic systems, online patient records and digital medical information systems to name only a few (Open Clinical, 2013)**.** Many of these technologies are very costly and involve specialist hardware and services, making them the domain of the developed world. The advent of almost universal ownership of a much less expensive, generally available tool, the mobile phone, has provoked the emergence of new thinking about the potential for technologies in the context of developing countries. Their healthcare systems face cost challenges if their governments are to implement radical reforms in the sector.

For a period of over 30 years, Saudi Arabia has been offering comprehensive and universal access to health services to its citizens. Efforts aimed at transforming Saudi Arabia’s healthcare system began in 1978 when the government introduced a three-tiered health system into the country and successfully integrated together a network of hospitals, which had been isolated from the national healthcare system (Longwoods, 2014). In recent years, faced with unprecedented economic and technological progress, the government has embarked on a second wave to reform Saudi Arabia's healthcare market system by introducing private health insurance, fees for service medicine in governmental hospitals, and the privatization of hospitals in order to mitigate medical challenges relating to spiraling costs and perceptions of low quality that have characterized the country's healthcare system in the 21st century (Walston et al, 2008).

The area of mobile healthcare in Saudi Arabia offers an outstanding potential due to the fact that mobile communication services, in addition to 3G data coverage, is regarded as having the best infrastructure in the whole Middle East and to be of international standards (Deloitte, 2013). Although there already exists a limited number of mobile health applications in the market, their impact on the healthcare sector has not been adequately documented for official study and derivation of information for use by the Saudi Arabian government, due to their informal nature. This study intends to contribute to the knowledge that would fill this gap by exploring the factors that affect the acceptance and use of a diabetes management application by both patients and medical professionals. However, the fundamental role of the mHealth application in Saudi Arabia's health care system is likely to increase as statistics indicating 186% mobile penetration in the country and the latest implementation of the 4G mobile infrastructural platforms is bound to encourage investment and the development of more advanced mHealth applications for the Saudi Arabian healthcare markets (Fahad et al., 2014). Furthermore, the global healthcare fraternity will increasingly focus their mobile-related healthcare technology in the Kingdom of Saudi Arabia due to the latest projections that the country will be the leading 4G market in the Middle East by 2016; hence creating a perfect market for mHealth applications (Fahad et al., 2014). According to the medical website MobiHealth News, “the Middle East is quickly becoming a hotbed of activity for mobile health” (Dolan, 2011)**.** Although the impact of the mHealth apps have not been adequately appreciated by the national healthcare system, statistics indicated a rapid development, proliferation and adoption of these applications in the Saudi Arabian healthcare market due to their versatility and accessibility. In addition, there already exists a partnership between information technology companies and the Saudi Arabian government since 2011, as was indicated by the MobiHealth (2011) report that Qualcomm was working with regional governments in both Egypt and Saudi Arabia to launch mobile health networks across the countries. The report further mentioned another tie between the Saudi Arabian operator Mobily, Ericsson and another unnamed healthcare provider (Dolan, B. 2010). The ‘proof of concept’ service coming from this trio uses sensors to monitor vital signs remotely and provide healthcare providers with relevant data and alerts. These commercial activities show the potential of mobile health services in Saudi Arabia, but the majority of the applications have focused on the key detrimental chronic diseases such as diabetes on a nationwide scale that would benefit lower income members of the society and reinforce the country’s health care system.

1.2 Risk Factors of Diabetes Mellitus

According to Murad et al. (2014), there has never been a comprehensive epidemiologic study and follow up on the trends and patterns of chronic diseases in Saudi Arabia. However, as a result of their studies, Murad et al. (2014) noted that the overall crude prevalence of diabetes mellitus type 2 was 23.7% in the KSA. In 2013, the prevalence of diabetes was 14.8% and 11.7% for men and women respectively.

However, the study correlated the continued prevalence of the DMT2 (diabetes mellitus type 2) with the unprecedented prevalence of obesity, which stood at 40%. Based on the measurement of body mass index (BMI), the prevalence of obesity in the country stood at 28.7%. Saudi women were more susceptible to obesity than men with the respective prevalence at 33.5% and 24.1% for women and men respectively (Murad et al., 2014). These findings showed that age and gender correlated with the prevalence of obesity and DMT2; and that the prevalence was higher for those aged between 55- 65. The study also indicated that measures aimed at addressing the prevalence of the DMT2 should first mitigate the detrimental effects of the obesity problem in the Kingdom of Saudi Arabia. In retrospect, the findings of the studies on obesity and lifestyle diseases in the KSA demonstrate that it is paramount that measures aimed at mitigating the challenge of chronic diseases in the country implement a multidimensional and comprehensive approach that will address the entire continuum of the diseases and precursors to the onset of the epidemic such as inappropriate lifestyles.

Al-Nuaim et al. (2012) note that the lifestyle pattern of Saudi citizens has changed considerably over the last thirty years. The gradual adoption of sedentary lifestyles among Saudis has given rise to the onset of non-communicable diseases ranging from heart-related conditions to obesity. The newly adopted lifestyles have intensified the presence of chronic disease risk factors and have been characterized by physical inactivity and eating habits that are deemed unhealthy. The authors suggest that a sedentary lifestyle is responsible for the rapid onset of an epidemic of non-communicable diseases, such as diabetes, in the country; and lamented that the health care system of Saudi Arabia lacked a comprehensive physical activity surveillance system. Based on the gender, physical location and age of Saudis, statistics by Al-

Hazzaa (2004) indicated that the extent of physical inactivity ranged between 43% and 99%. Further studies on the prevalence of physical inactivity and unhealthy eating habits showed that adults led in physical inactivity followed by adolescents and children with rates of 80%, 70 % and 60 % respectively. In relation to the prevalence of chronic illness in the KSA, studies by Al-Nuaim et al (2012) showed that inactivity not only resulted adding to the financial and public health burden, but also heightened the risk factors associated with non-communicable diseases in the Kingdom. Studies by Al-Hazzaa (2004) showed that physical inactivity was the prime reason for 10%-16% of cases of diabetes mellitus and breast, colon and rectal cancer globally. Physical inactivity is highest among Saudi women in congruence with the extent of obesity among the same gender. The epidemic level of obesity and the prevalence of physical inactivity in KSA have contributed to the development of a chronic burden to the state. The inactivity of the state institutions in addressing the risks factors associated with a sedentary lifestyle only contributes to an escalation of this chronic burden.

The successful management of chronic diseases, and in particular diabetes, needs to be addressed through comprehensive public education on the risks factors related to the non-communicable diseases. It also highlights the need for diabetics to receive information about diet and exercise and to have a simple way to monitor these aspects of their lifestyle, which can be done through the use of a diabetes management application.

1.3 Government Policies

The KSA is further faced with an inadequate policy framework for overseeing the formulation and execution of healthcare preventive policies. The public healthcare system of KSA lacks comprehensive disease control programmes dedicated to promoting a healthy lifestyle and behaviours among the Saudis (Almalki, M et al. 2011). The primary solution to curbing the rapid growth of non-communicable diseases lies in the provision of access to primary care services. However, such a system should be coupled with healthcare social accountability of the higher education institutions, which is currently lacking in the healthcare system of the KSA. Flinders University (2014) defined this 'social accountability' as the obligation of education centres to adequately direct their research programmes and resources towards the pertinent and current healthcare concerns of the immediate society. This calls for the interlinking of the government agencies, healthcare institutions, medical professionals and the public. The presence of such a continuum of stakeholders should enhance the robustness of the healthcare system, hence facilitating the delivery of healthcare services to chronic patients in KSA. However, at the present, the campaign against the prevalence of chronic disease and risk factors is being executed on diverse fronts. While the government has realized the imminence of a chronic diseases epidemic, non-government organizations are slowly initiating campaigns on lifestyle and behaviour changes (WHO, 2013). Nevertheless, such a piecemeal approach may well fail in offering immediate solutions to the national challenge of a chronic disease burden. The Helen Ziegler Associates (2014) noted that an effective healthcare infrastructure should incorporate the following: the introduction of information technology and communication systems, chronic disease surveillance, public health promotion campaigns and the introduction of standards of care at both national and local levels. It would seem then, that mHealth applications have an important part to play in any government initiative to introduce an effective policy in curbing chronic disease such as diabetes in the KSA. Indeed, Dr Alymeni, the Deputy Minister for Planning and Health Economics was reported in 2014 as revealing plans for Saudi Arabia to have a national eHealth network up and running by 2020. He believes that there will be challenges connected to interoperability of all the regional health centres and being able to successfully unify all electronic patient records securely and in a way that ensures confidentiality. However, he identified that ‘the biggest hurdle’ faced by the Saudi Ministry of Health was user adoption and that the key barriers were ‘resistance to change, limited training and lack of communication’ (Nuviun Digital Technology 2016). If this is indeed the case than gaining a deeper understanding of the factors which affect technology adoption are a crucial part of successful government implementation.

The Unified Theory of Acceptance and Use of Technology (UTAUT) is a theoretical model that was formulated by Venkatesh et al. to explain technology acceptance. It has been chosen as the theoretical framework for this study and will be explained in detail later. The model’s main function is to explain the intentions of the user to utilize a certain piece of technology and the subsequent use behaviour. The main advantage of using the UTAUT is because it includes experience and demographics as explanatory factors. This advantage highly improves its application in service or product-oriented research; as the traditional models of technology acceptance were mainly used in the adoption of technologies (largely computer based) where use was not voluntary. The four main constructs of the model are how the user expects the technology to perform, their expectations about how easy it is to use, how significant people around them influence their acceptance of the technology and what infrastructure exists to support this use.

There are certain assumptions that pertain to the UTAUT constructs as applied to the particular context of this study: Firstly, that mHealth can be largely adopted if the facilitating conditions like Smart phones and computers are made available. Secondly, that mHealth can be largely adopted if it is made easy to use and perceived as such by the intended users. Thirdly, mHealth can be largely adopted if the significant groups around the diabetic patient, such as their medical practitioners encourage and support the use of mHealth and reassure them about issues such as privacy and security. Finally, that mHealth can be adopted if it is seen to perform well. The UTAUT model informed the design of the research tools used to gather information about the perceptions of Saudi specialists, doctors and diabetic patients the mHealth application relating to the four constructs of the model and regarding the performance expected of the application and how easy to use it would be; information also had to be obtained about how Saudi diabetics are influenced by relevant others, and focusing on the doctor-patient relationship. Finally, there was also a need to gather information about the factors that would facilitate the use of the technology. When looking to develop mHealth technology, such as diabetes management application, it is essential to consider factors that relate to its acceptance and adoption so that the choice of application and its implementation are successful.

1.4 Diabetes and Related Diseases

The prevalence of diabetes has been related to increased incidences of heart disease and stroke; therefore, new cases of diabetes in the KSA could eventually result in cases of heart diseases. Diabetic patients are twice as likely to suffer from strokes or heart conditions compared to those who have never been diagnosed with diabetes. Similarly, studies by Larsen & Lubkin (2009) further identified significant correlation between chronic diseases and symptoms of depression. Therefore, an increase in cases of chronic illness could result in a rise in diagnoses of depression in the Saudi population. In the long run, psychologically unstable patients lower the national productivity of the state in addition to suffering deterioration in their living conditions. It could hence be deduced that pre–emptive prevention and management of chronic disease could translate to the mitigation of psychological distress among chronically ill patients. The challenge of chronic diseases in the KSA is evidently a multivariate issue whose implications run deeper than those currently anticipated by both the public and government agencies. Effective management of chronic illness and specifically diabetes in the KSA promises far-reaching consequences that may include the reduction of public health burden, financial saving by the healthcare sectors and advancement of the KSA's public health (WHO, 2013)**.**

1.5 Statement of the Problem

There are many reasons why Saudi diabetics do not always receive the care they need. Factors such as the lack of female specialists to care for those women whose cultural attitudes preclude them from seeing a male specialist, inability to take time off work for appointments, lack of income to pay for care, mistrust of doctors and distance from the appropriate clinic all play a part**.** For some Saudi diabetics, seeing a specialist involves travelling long distances (often requiring more than a single day) to clinics for consultations and tests. For cultural reasons, these patients are often accompanied by family members, thus adding to the expense and lifestyle disruption associated with even basic medical care. Geography, cost and a strained healthcare infrastructure has yielded a healthcare industry whose moving parts are disorganised, clustered around populated centers and unequal to the task of providing convenient, prompt healthcare to the whole population. According to a report by the Saudi Arabia Demographic Profile and IndexMundi (2015), there is less than 1 doctor for every 1,000 SA residents (compared to a 1 to 350 ratio in the UK). Therefore, there is a clear need for the development of a remote consultation facility that will connect patients with centralized medical staff, field based and centralized medical staff or a combination of both. Establishing a traditional bricks and mortar solution to the problem of remote access to care in SA is both costly and time-consuming.

The following scenarios illustrate the kind of situations that under-served groups of diabetics in Saudi Arabia may face and in which access to a mHealth diabetes mobile application may be of use.

SCENARIOS

REMOTE AREA SCENARIOS

Scenario One

Many people in Saudi Arabia live in areas that are far away from the nearest health facility. Travelling to such a facility can be very difficult as the amount of time needed to make the journey can be long. A patient may not be able to take the time for many reasons, for example family responsibilities and work responsibilities, as well as having their health problems exacerbated by a long journey. Elderly and disabled patients may have particular difficulties with this. The mobile phone application saves a considerable amount of time.

Scenario Two

A patient in a remote area may be able to spare the time involved in making a long journey to a hospital but find that the cost of it is prohibitive. Apart from obvious costs such as petrol and possibly finding somewhere to stay near the hospital where they are having a consultation, there may be hidden costs. For example, if the patient is a woman she will need to be accompanied by a male relative who may need to take time away from work in order to make the journey. The mobile phone application saves money.

Scenario Three

Patients with mental health problems such as agoraphobia may find it very difficult, even impossible, to make a long journey into an area that they do not know in order to have an appointment at a hospital. This can of course apply to patients who only have to make a short journey, as in severe cases of agoraphobia the patient has difficulty leaving their home. In addition, a physically disabled patient might have difficulties in travelling. The mobile phone application would allow such patients to obtain the information and advice they need without leaving their home.

SCENARIOS INVOLVING IMMIGRANT WORKERS IN SAUDI ARABIA

Scenario One

There is no free health care for immigrant workers in Saudi Arabia and hospital treatment and follow-up appointments would have to be paid for. Many immigrant workers could ill-afford this and may elect to neglect their condition. It is possible that, in the future, the Saudi government would issue an mHealth application free of charge to everyone, including immigrant workers.

Scenario Two

An immigrant worker may speak little Arabic and would find it hard to understand what a doctor was telling him. A mobile phone application could easily be made to operate entirely in the immigrant's native language allowing him to fully understand all instructions and advice.

SCENARIOS INVOLVING FEMALE PATIENTS IN SAUDI ARABIA

Scenario One

A Saudi woman with a diabetic condition may feel very ill and require advice on whether her medication needs altering. This woman may not be in a position to go to hospital as, even if the family has a car, she is not allowed to drive herself to hospital. She is also not able to order a taxi to take her, as it would be against Saudi norms for a woman to be driven by a male stranger. Although there are plans to possibly allow women to drive in the future, to date this legislation has not been passed. In such a case, the woman could use the mobile phone application to send her reading to the hospital. The nurse or doctor who receives the reading can then send advice about her medication directly to her, via the application on her mobile phone. If the reading indicates that there is an emergency, the hospital can arrange for an ambulance to be sent.

Scenario Two

A Saudi woman has no problems with transportation but would require monitoring by a male doctor, as no female doctors are available at her hospital. Many Saudi women would not find it acceptable for a male, even a doctor, to touch them, so would not want to go to a hospital for this reason. Using the mobile phone application would remove any need for a face-to- face consultation.

Scenario Three

A Saudi woman feels unwell or wants a check-up, but has childcare responsibilities or is pregnant and worried about making a long trip to a hospital. Having to make a long journey, can also make managing diabetes more difficult and could exacerbate her health problems. Using the mobile phone application avoids her having to leave home.

1.6 Purpose of the Study

The purpose of this study is to explore the experiences of a representative sample of Saudi diabetes specialists, Saudi doctors, and Saudi diabetes patients about the extent to which a mobile phone diabetes management application would be an acceptable solution to diabetes management within the Saudi context. The study seeks to determine the suitability of mHealth applications in the management of diabetes based on the geopolitical, social and economic factors characterizing Saudi Arabia's healthcare system. The results may be useful in creating a timely and efficient solution, using a mobile/ Internet application to provide healthcare services for specific groups who are not easily able to access specialist care.

The globalization of information technology has led to a rapid spread and acceptance of mHealth technology by both medical practitioners and patients. Findings from a survey by Price Waterhouse Cooper Network indicated that 68% of clinicians of the sampled population recommended the use of mHealth while 59 % of the patients surveyed were already using varied forms of mHealth services (Wasden, 2012). The study reported here will be an exploration of a mHealth solution to diabetes management in Saudi Arabia to determine whether this solution is acceptable to both doctors and patients. The intended effort is also to explore ways in which this solution would alleviate the current problems that Saudi diabetics have in accessing specialist care especially women, immigrants, and people who cannot attend appointments with diabetes specialists. Data collection and subsequent results will be focused on arriving at a recommendation to the Saudi healthcare community to adopt and implement the mobile health services solution.

1.6.1 Reasons for Choosing the Thesis Topic

The incidence of diabetes in Saudi Arabia's has now reached epidemic proportions. Furthermore, diabetes is a disease that requires a very high level of self-management on the part of patients. For this reason, a case study of Saudi Arabia as a potential user of mHealth as a partial solution to the problem of diabetes has been chosen. The diabetes management application has been the tool of choice for this, as it contains unique features for illness management that are not found elsewhere. These include provision for patients to log data related to diabetes, allowing patients to customize the app by finding their preferred recipes, synchronization of the logged data with databases of health institutions, access to nutritional databases with thousands of nutritional options and efficient patient feedback through the production of patient charts and graphs indicating glucose levels and trends on a weekly basis (Tran et al., 2012).

1.7 Research Questions and Hypotheses

I approached this study with a number of over-arching research questions, set out below.

1.7.1 Research Questions

RQ1: Is there a significant relationship between application of mobile health services and improvement in the management of chronic diseases such as diabetes?

RQ2: To what extent does Saudi Arabia offer an infrastructure for an mHealth system for the management of chronic diseases such as diabetes?

RQ3: How will socio-cultural factors affect acceptance of an mHealth solution among Saudi diabetics?

RQ4: What are the likely challenges to successful adoption of a diabetes management application by Saudi diabetic patients and their doctors?

RQ5: What theoretical model best describes issues of technology acceptance of a diabetes management application among Saudi diabetics and their doctors?

RQ6: What diabetes mHealth solution would best suit both Saudi diabetics and the doctors who treat them?

RQ7: What security, privacy and confidentiality issues relate to implementation of mHealth in Saudi Arabia?

Some of these research questions will be addressed by an analysis of the literature. However, this study particularly seeks to discover the perceptions, attitudes and life experiences of Saudi diabetes specialists, Saudi doctors, and Saudi diabetes patients and research questions on these aspects will be addressed by the field studies.

The research questions will be re-addressed in the subsequent chapters, particularly Chapter V Discussion and Implications.

1.7.2 Research Hypotheses

The research questions suggest a number of (pairs of) hypotheses, which are again revisited in subsequent chapters.

Ho1: There is **no** significant relationship between application of mobile health services and improvement in the management of chronic diseases.

Ha1: There **is** a significant relationship between application of mobile health services and improvement in the management of chronic diseases.

Ho2: Saudi Arabia does **not** offer a sufficient design and infrastructure for an mHealth system for the management of chronic diseases.

Ha2: Saudi Arabia **does** offer a sufficient design and infrastructure for an mHealth system for the management of chronic diseases.

Ho3: Doctors **will not** perceive that a mobile health solution would benefit diabetes patients in Saudi Arabia.

Ha3: Doctors **will** perceive that a mobile health solution would benefit diabetes patients in Saudi Arabia.

Ho4: Diabetes patients **will not** have a favourable response to using a mobile phone application to help manage diabetes.

Ha4: Diabetes patients **will** have a favourable response to using a mobile phone application to help manage diabetes.

Ho5: Diabetes patients **will not** accept the use of mobile phone application to help manage diabetes in Saudi Arabia.

Ha5: Diabetes patients **will** accept the use of mobile phone application to help manage diabetes in Saudi Arabia.

Ho6: Diabetes specialists **will not** accept the use of mobile phone application to help manage diabetes in Saudi Arabia.

Ha6: Diabetes specialists **will** accept the use of mobile phone application to help manage diabetes in Saudi Arabia.

The hypotheses relating to application of mobile services and improvement in the management of chronic disease and whether Saudi Arabia offers optimum design and infrastructure for an mHealth system for the management of chronic disease will be addressed at the end of the Literature Review. The other hypotheses will be considered in the chapter on the results of the study.

1.8 Aims and Objectives of this Study

The general aim of the study is to investigate the concrete benefits and challenges of implementing the use of an mHealth application for diabetes management in the KSA. This will be established via a number of more concrete objectives:

1. To investigate mobile technological solutions to health issues.

2. To investigate the current infrastructure for the medical monitoring and communication processes in Saudi Arabia.

3. To explore the requirements of diabetes patients living in Saudi Arabia.

4. To find out the suitability and applicability of an mHealth diabetes management app for the Saudi Arabian healthcare system.

5. To explore what Saudi medical professionals require from an mHealth solution to diabetes management.

6. To examine the feasibility of the proposed solution in terms of a technology acceptance framework that takes in account of the cultural and religious context of Saudi Arabia.

7. To propose recommendations both for the successful adoption of a mobile solution to diabetes management by the Saudi healthcare system and for future research in the field.

1.9 Significance of the Research

A remotely based or mobile health solution presents distinct advantages:

(a) Cost-efficient development and deployment,

(b) Efficient equipment maintenance,

(c) Customized user adoption,

(d) Scalability

(e) The ability to introduce collaborative, accountable healthcare to regions where little or none exists.

It has been shown in other emerging markets that mobile or mHealth solutions can impact dramatically on population health characteristics (PwC, 2014). That shift towards mHealth is currently underway. Diabetes has already reached epidemic levels in the country and is evidently becoming a national problem in Saudi Arabia and the difficulties of adequately treating all groups within the population are well known. Although there have been studies on the use of mobile solutions to manage chronic diseases (which are outlined in the Literature Review), there have not been any specific study that primarily focused on researching the potential mHealth solution that addresses Saudi Arabia's healthcare challenges. The Saudi healthcare service needs to know if an mHealth solution is likely to be accepted as a way of managing diabetes by its own professionals and, above all by diabetes patients. Saudi Arabia is currently in an interesting position in terms of mHealth, in that its healthcare system is less developed than in the West where the acceptance and acquisition of mobile phone technology has advanced rapidly. However, a positive outcome could be facilitated by the fact that Saudi Arabia is the leading mobile user in the Middle East. These facts suggest that the diabetes management application might be an excellent solution. If this solution were acceptable to both healthcare professionals and to patients themselves, then it could provide a good solution to diabetes management in Saudi Arabia. Such intervention would optimally favour groups that have problems accessing face-to-face healthcare such as women, immigrants, and people in rural communities. Thus, due to cultural and religious reasons, some residents of SA (mainly women and immigrant workers) face problems in accessing traditional healthcare in hospitals – this research will provide a clear and comprehensive view of the ways in which the use of mobile apps will help overcome those problems and provide the needed healthcare to those citizens.

1.10 Nature of the Study

This research aims to discover the extent to which Saudi diabetes patients and their doctors believe that a mobile solution would fit the needs of diabetics in self-managing their illness and the factors that affect their perceptions, acceptance and use of this technology. A quantitative design that would result in exact numerical measurements (Cooper & Schindler, 2006) was deemed appropriate for a study that aimed to form a picture of the current experience of patients and doctors and to explore the relevant factors relating to technology acceptance. Questions that result in precise numerical data that could be processed statistically to offer numerical explanations were chosen because the problem outlined in the study is a phenomenon where the variables and patterns are known (Creswell, 2009), a quantitative approach would meet the needs of data collection and analysis.In order to more fully explore diabetes management issues and possible barriers to technology acceptance, Saudi diabetes specialists were interviewed about the challenges that faced their patients in accessing adequate care and managing their illness, and their professional opinions were sought about the efficacy of a mobile solution. Details of the procedure will be found in Chapter 3. In summary, a survey questionnaire was distributed to a purposive sample of participants, medical professionals and patients, complemented by an interview study of medical professionals.

1.11 Scope of the Research

I intend to review literature which relates to the Saudi context in terms of what specific problems there are in the management of chronic illness as well as what infrastructure is already available which would support a mobile phone solution to diabetes management. I will explore mHealth within the wider context of eHealth and look in particular at studies that examine the use of mobile phone applications as solutions to managing chronic illness. I will identify a mobile phone diabetes management application that could be used in the Saudi context and carry out primary research in the form of semi-structured interviews with Saudi diabetes specialists and online surveys with Saudi doctors and Saudi diabetes patients to determine to what extent this would be an acceptable solution. For the purpose of this study, a single mobile application will be identified based on its suitability to the Saudi Arabian's rural healthcare system.

1.12 Assumptions and Limitations

Leedy and Ormrod (2005) defined research assumptions as self-evident truths. It will be assumed that the Saudi diabetes specialists, Saudi healthcare workers, and Saudi diabetes patients to be sent a survey questionnaire or interviewed will have the appropriate licenses or will be legitimate diabetes patients. The patient survey will specifically ask participants not to continue if they have not been diagnosed with diabetes. The validity of the study will be predicated on the assumption that the participants will answer truthfully and accurately to the survey questionnaire and interview questions based on their personal experience (Bruyn, 1966). It was assumed that the lived experiences of the participants in this study could positively contribute to decisions about incorporating mHealth system in Saudi Arabia (Thornton et al, 2007). It will be assumed that the lived experiences of the participants could contribute new knowledge to the issue of mHealth system in Saudi Arabia.

1.13 Summary

Diabetes is an already massive and growing problem in Saudi Arabia and the difficulties of adequately treating all groups within the population are well known. Although there have been studies on the application of mobile solutions to the management of chronic diseases (which are outlined in the Literature Review), there have not been any specific study aimed at looking at such a solution for Saudi Arabia. Given the current state of Saudi Arabia, both in terms of its healthcare limitations and the relatively advanced state of the relevant technology, the study aims to explore the extent to which an mHealth diabetes management application will be a solution as well as the issues that surround acceptance and adoption of this technology.

1.14 Organization of the thesis

Chapter I provides the foundations for the need to study the experiences of Saudi diabetes specialists, Saudi healthcare doctors, and Saudi diabetes patients about the extent to which a mobile phone diabetes management application would be an acceptable solution to diabetes management within the Saudi context. The importance of establishing a mHealth system is summarized. The possible problems and purpose for the proposed mixed methods study are briefly given; and the fundamental needs for a study of mHealth application feasibility within Saudi Arabia's healthcare system are stated. The research questions and hypotheses for both the quantitative and qualitative portions of the study are cited. The theoretical foundation is outlined, as is the nature of the study and the assumptions and limitations. An initial definition of terms is given and the chapter ends by illustrating the use of an mHealth diabetes management application in specific scenarios with underserved diabetes patients.

Chapter II provides the literature review that supports the importance of establishing a mHealth system in Saudi Arabia. It begins by delineating the effects of chronic disease on healthcare systems and moves on to consider the inequalities of access to healthcare in developing countries and Saudi Arabia in particular. The chapter then moves on to examine mobile health applications and the role of mobile technology in healthcare, specifically in developing countries. The healthcare system of Saudi Arabia is reviewed, the current challenges it faces are explained and the growing problem of diabetes is outlined. There is a review of what literature reveals about Saudi Arabia's underserved populations, specifically Bedouin nomads, immigrant workers and women. The chapter goes on to explore eHealth in Saudi Arabia and what devices are currently available on the market before reviewing mHealth, its benefits present and future and the challenges it faces. The use of a diabetes management application in Saudi Arabia is considered in terms of the technical capabilities and technology acceptance models. The chapter ends by identifying a research gap that this study intends to fill i.e. the acceptability of mHealth application to manage diabetes in the Kingdom of Saudi Arabia

Chapter III outlines the methodology of the study. It starts by describing the research design and its aims and objectives. There is a description of the quantitative study, consisting of online surveys with Saudi diabetics and Saudi doctors (Phase One), the method of sampling and the hypotheses to be tested, before moving on to consider the ethical issues. A discussion of how the questionnaires were developed in order to assess the impact of the constructs of the chosen technology acceptance model is included; as well as an overview of how the results will be used to confirm or question the relationship between these constructs and the acceptance of mHealth technology by Saudi patients and doctors. Data collection and analysis are discussed, along with issues of validity, reliability and credibility. The chapter then goes on to outline the qualitative study, consisting of semi-structured interviews with Saudi diabetic specialists (Phase Two) and discusses how the research instruments for both phases were piloted.

Chapter IV presents an analysis of the results of both phases of the study and highlights the important insights gained into the needs, experiences and attitudes of Saudi diabetic patients in managing their illness as well as their reactions to a diabetes management application. The online survey allows them to see a short video on how such an application could work. The views of Saudi diabetes specialists are collected and analysed in both phases of the study. The results of the qualitative study are shown using thematic analysis and the results of the online surveys are given in chart form. This is followed by a bivariate analysis of both surveys and a comparison between the views of Saudi diabetics and Saudi doctors. The results of the study are then related to the technology acceptance model; and this model is then adapted to become more relevant to the Saudi context.

Finally, **Chapter V** draws together the main conclusions from the study, before going on to consider what might be involved and gained from testing the a diabetes management application in the field. The chapter then outlines other related areas of study that would lead on from the investigations conducted by this researcher, including those in related fields.

CHAPTER II: REVIEW OF THE LITERATURE

The purpose of the study reported here was to explore the potential acceptance factors for a mobile health application in the context of Saudi Arabia. This chapter explores some of the literature that forms the background for the research. Firstly, in Section 2.1, an overview of chronic disease and its treatment in developing countries including Saudi Arabia is provided. There is a review of healthcare in Saudi Arabia,discussing the challenges that might be overcome by mHealth applications. Section 2.2 introduces the area of e-health and provides an overview of work on e-health and mobile health as a response to chronic disease. In Section 2.3 state-of-the-art mHealth technologies for managing chronic disease are examined, while Section 2.4 introduces technology acceptance, the field that provides the theoretical underpinnings for the study.

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2.1 Managing Chronic Disease in Developing Countries

2.1.1 Chronic Diseases in developing Countries

Holtz (2008) reported that the global prevalence of chronic diseases is on the rise with renewed focus on developing countries where communicable diseases are already a major medical challenge. Increased cases of chronic diseases in both developed and developing countries have not only resulted in deaths, but have also led to an increased burden on individuals and state authorities. The increased global prevalence of chronic diseases has been directly associated with increased mortality rate, especially in developed nations. Based on a report by Harris (2013) chronic diseases are currently the leading causes of deaths globally with the exception of Africa, where infectious diseases are still the leading cause. However, the report indicated that, based on current projections, non-communicable diseases would be the leading cause of deaths in Africa in the next two decades. Apart from deaths, chronic diseases are also the major cause of disabilities among the population.

Chronic diseases have further resulted in increasing the economic burden on the state. In addition to non-communicable diseases, developing countries struggle with the management of infectious diseases such as HIV/AIDS and malaria epidemics. Jeffreys (2011) argued that the prevalence of chronic diseases in these states does not displace the effects of the infectious diseases but enhances further the deteriorative effects of both types of disease. This has led to overburdening of the medical budget, which directly affects medical healthcare services. Increased cases of chronic diseases have been closely linked with poorer healthcare services due to inadequacy of funds and strained medical staff that are often overworked and underpaid. In the end, the continued prevalence of non-communicable diseases is likely to deter the economic growth of developing countries. This is due to diversion of funds to health care systems as opposed to allocation of the funds to income-generating projects.

There also exists the burden of managing risk factors associated with chronic diseases. According to Defronzo (2004), chronic diseases can be easily controlled by the minimization of associated risk factors. The main risk factors associated with non-communicable diseases include the following: tobacco use in any form, intake of high cholesterol, low fruit and vegetable diet, overweight and obesity, alcohol consumption and a sedentary lifestyle. Studies by Centre for Disease Control (2014) indicated that 80% of heart diseases, strokes and Type 2 diabetes could be prevented and controlled by avoiding chronic risk factors. The prevalence of risk factors among members of a society is likely to indicate the imminent onset of chronic disease. This can be best demonstrated by Saudi Arabia (KSA), which is characterized by increased cases of obesity. As a result, the diabetes prevalence rate in the KSA is among the highest in the Middle East. Consequently, research indicated that many cases of chronic conditions could not be prevented but their effects and complications could be successfully slowed down by elimination of the shared risk factors.

2.1.2 Diabetes as a Chronic Disease

Studies indicate that diabetes has the highest rate of prevalence in comparison to other non-communicable diseases globally. According to a report by Oxford Business Group (2007), the global prevalence of diabetes has risen over six times within a period 20 years. The report further indicated that diabetes currently affects over 246 million people globally and the figures are expected to reach 380 million by 2025. The research also attributed 3.8 million deaths annually to diabetes that is equivalent of 6% of the global deaths. According to the World Health Organisation (2014), diabetes refers to a medical condition in which the pancreas does not produce sufficient insulin or when the body is unable to metabolize effectively the produced insulin. Insulin is the primary hormone responsible for regulation of sugar levels in our bodies. Consequently, diabetes may occur as either Type 1 or Type 2. Type 1 diabetes is characterized by deficiency in insulin production by the body and hence patients require daily administration of insulin for regulation of sugar levels. A Type 2 diabetes patient suffers from ineffective use of insulin and this is the most common form of diabetes globally. Currently, the principal cause of Type 1 diabetes is unknown and, unlike Type 2 diabetes, it cannot be prevented by the elimination of existing risk factors.

Medical scholars argue that the global prevalence of diabetes has already transformed into an epidemic. According to International Diabetes Federation Annual Report (2012), in 1985 the number of people suffering from diabetes globally was 30 million. By 1995, the figure had risen to 135 million and currently it is estimated that 177 million people suffer from diabetes. The number is expected to reach 300 million by 2025. Consequently, the prevalence of diabetes has resulted in an economic burden on individuals, existing healthcare systems and state economies. Developing countries are the most affected due to additional prevalence of infectious diseases such HIV/AIDS and malaria. Globally it is estimated that the total expenditure on management of diabetes by 2035 will amount to $627 billion. Based on statistics by International Diabetes Federation, countries with the leading number of diabetes patients include China, India Unites States, Russia and Brazil. However, Saudi Arabia, Nauru and Mauritius have been noted as the leading countries with the highest prevalence rate.

The current health crisis facing Saudi Arabia could be attributed to urbanization, suppressive customary laws and ineffective legislation. The prevalence of chronic disease in the Kingdom been closely linked to the rise in obesity cases among members of the society. Female Saudi citizens were more likely to suffer from obesity than their male counterparts. This is because Saudi Arabia laws restrict the participation of women in physical activities, hence encouraging a sedentary lifestyle. Al-Mohamed (2008) also noted that the existing healthcare system did not offer specialized medical packages to women but rather discriminated against them because of their gender. The findings also showed that chronic patients from rural areas faced healthcare inequality due to lack of comprehensive health system and were likely to incur huge costs travelling to the cities for treatment. Measures to control and prevent prevalence of chronic diseases in the Kingdom of Saudi Arabia were negatively impacted by limited resources and funding by the state government. Public hospitals lacked sufficient medical staff and appropriate technology necessary to manage the epidemic of chronic diseases. The studies thus projected that developing countries are most likely to face the aforementioned challenges in regards to prevalence of chronic diseases.

2.1.3 Inequalities in Health Access in Developing Countries

The general difficulties of providing treatment for chronic diseases, including diabetes, in developing countries may be exacerbated by inequalities of various kinds, which may reduce health options for particular sections of society. Here location and gender inequalities are considered.

2.1.3.1 Rural Health

Developing countries predominantly comprise rural areas with a few cities and urban centres. The majority of rural residents in many developing countries have difficulty in accessing quality health care services. This could be attributed to a number of specific causes.

One such cause is the lack of medical professionals in these rural areas. A case study conducted by ITC's international business division in India indicated that out of 78 health practitioners interviewed only 16 % qualified to practice medicine in the rural areas (Chaval & Anupindi, 2012). The findings of the study further noted the number of medical practitioners declined drastically beyond 11 kilometers from the urban centres. Similarly, according to the World Health Organisation (2014), Bangladesh has been reported as having a shortage of human health resources and higher disparity in the geographical distribution of health workers. Health workers are concentrated in the country's secondary and tertiary hospitals in the urban centres while over 70 % of the total population resides in rural areas. Rural areas are characterized by economic hardships and offer limited incentives to medical practitioners. Consequently, most nurses and doctors seek employment in urban centres. This has worsened the management of chronic diseases that normally require highly trained medical practitioners.

Rural areas also present the challenge of geographic barriers. Rural areas lack elaborate transport systems that could facilitate the transportation of chronic patients to existing health care facilities. According to Harris (2013), studies indicated that lack of access to continuing development on research and lack of peer support (owing to low peer group numbers) contributed to the limited supply of health services in rural Australia.

Rural residents are further subjected to dilapidated health care facilities that are understaffed. Existing medical centres lack ambulances and modern equipment that are the prerequisite for effective management of chronic diseases. Residents suffering from non-communicable diseases are thus forced to seek medical services from the urban centres that are often costly.

The Saudi Arabian rural health care sector is also faced with the challenges of transport barriers, regional variations and rural-urban inequalities (WHO, 2014). Health care access and the challenge of transportation difficulties have been further worsened by cultural practices that require male members to facilitate the transportation process. Like Bangladesh, Saudi Arabia is also facing a shortage of health workers and around 60% of medical professionals working in the KSA's health sector are expatriates.

However, the impact of culture as a barrier to healthcare access in the rural areas, particularly the social position of women, may be more detrimental in Saudi Arabia when compared to rural areas in other developing countries like India and Bangladesh.

2.1.3.2 Women and Healthcare

Women in developing countries are often not comprehensively covered by the existing healthcare systems. Although campaigns aimed at empowering women have ensured provision of equal opportunities for employment and education, there still exist inequalities in the provision of health care services. Research by the Centre for Disease Control (2014) estimated that over 63.2 million unintended pregnancies occurred in 2012 due to lack of access to modern contraceptives. Rampant health inequalities could be associated with gender inequity issues such as cultural beliefs, limited education and the failure of legal systems to safeguard women's rights. According to the World Health Organisation (WHO, 2014), the existence of varied gender norms and values in the society has given rise to gender-related inequalities. As a result of this gender inequality, certain practices and beliefs have been observed to empower males while discriminating against women.

One of the key factors that have been identified as leading to women's health inequality is their sexual vulnerability. Women in the developing countries have limited rights over their sexual and reproductive health. In addition to limited sexual health, women in developing countries are further subjected to physical abuse, rape and domestic sexual abuse. All these factors contribute to the continued deterioration of women's health in developing countries. Furthermore, developing countries often lack comprehensive women-oriented health care systems that specifically cater for women and girls. This has resulted in ineffective primary care for women, which includes immunization, access to safe drinking water, sanitation and maternity health care.

According to Acog, there is another important factor that lies at the root of gender-related health inequality; this is the low ratio of female-to-male employees in the healthcare system, particularly in the upper echelons and the related gender-biases in the policies that these healthcare systems espouse. Developing countries often suffer from a shortage of specialists, such as gynecologists and obstetricians, who are so essential if women are to be given effective comprehensive healthcare. The domination of men in government and key healthcare positions arguably mean that it is less likely that women's rights and healthcare requirements are to be adequately served (2014).

Women's rights in Saudi Arabia have been significantly undermined by the country's cultural attitudes, which are reflected in the state laws. Most importantly, in Saudi Arabia, the law provides that women can only be admitted to a public hospital when accompanied by a male guardian. Some cultural beliefs further prohibit women from being examined by male gynecologists or obstetricians. In addition, most hospitals do not recognize medical consent signed by a female in the case of an emergency operation. The existence of such gender and healthcare inequalities impede the successful control and prevention ofchronic disease in developing countries, including Saudi Arabia and will be discussed in greater depth in the next section (particularly 2.1.4.6 women's access to healthcare), where perspectives on the geographic, economic and social context of the study with an overview of the Saudi health system and its current challenges are discussed.

2.1.4 Healthcare in Saudi Arabia

2.1.4.1 Background

Saudi Arabia, although a young country, avoids some of the problems that other developing countries experience in healthcare, essentially because of the generous funding of the Saudi royal family for healthcare of Saudi citizens. The healthcare system in Saudi Arabia can be classified as a national health care system in which the government provides health care services through a number of government agencies. However, there is a growing role and increased participation from the private sector in the provision of health care services. The Ministry of Health (MOH) is the major government agency entrusted with the provision of preventive, curative and rehabilitative health care for the Kingdom's population. The Ministry provides primary health care (PHC) services through a network of healthcare centres throughout the Kingdom. There were an estimated 4,594 centres according to an MOH report (2010). It also adopts a referral system which provides curative care for all members of society from the level of general practitioners at health centres to advanced technology specialist curative services through a broad base of 415 general and specialist hospitals (MOH, 2010). The MOH is considered the lead Government agency responsible for the management, planning, financing and regulating of the healthcare sector. The MOH also undertakes the overall supervision and follow-up of healthcare-related activities carried out by the private sector. Therefore, the MOH can be viewed as a national health service (NHS) for the entire population.

There are also three other mini-NHSs that finance and deliver primary, secondary and tertiary care to specific enrolled security and armed forces populations: the Ministry of Defence and Aviation (MODA), the Ministry of the Interior (MOI) and the Saudi

Arabian National Guard (SANG). In addition to these agencies, there are several autonomous government agencies that are responsible for the delivery and financing of healthcare services in the KSA. The Ministry of Education provides immediate primary healthcare to students; and the Ministry of Labour and Social Affairs operates institutions for patients with special needs and custodial homes for orphans. These facilities provide their residents a certain amount of medical care. The General Organization for Social Insurance and General Presidency of Youth Welfare provides health services for certain categories of the population in connection with its management of sport facilities. The Royal Commission for Jubail and Yanbu provides health facilities for employees and residents in these two industrial cities. The Saudi Arabian Airlines operates its own healthcare facilities with the aim of providing healthcare services to its employees. The Kingdom's universities provide, through their medical colleges or hospitals, specialist curative services and medical education and training programmes, while they also conduct health research in collaboration with other research centres.

The Government also finances and provides care on a referral basis in its major specialized national tertiary care referral hospitals, i.e. King Faisal Specialist Hospital and Research Centre and King Khalid Eye Specialist Hospital. The King Faisal Specialist Hospital and Research Centre uses highly advanced technologies and acts as a reference hospital for cases that require advanced and specialist treatment, while it also conducts research on health issues in general and those related to the Kingdom in particular. The King Khalid Eye Specialist Hospital is designed to be a large health facility offering high quality specialized services for ophthalmology and eye surgery and medicine as well as being a regional research centre in the area of ophthalmology. The hospital also has a cornea bank in which imported corneas are stored. Moreover, the private sector provides health services through its health facilities including hospitals, dispensaries, laboratories, pharmacies and physiotherapy centres throughout the kingdom. According to the MOH (2014), the following are the major indicators provided by the private sector by the end of the year 2000:

1. 127 hospitals with 12,817 beds, accounting for about 19% of the total number of hospitals beds in the Kingdom.
2. 622 dispensaries, 785 clinics, 45 medical laboratories and 11 physiotherapy centres.
3. 273 pharmaceutical stores and 3,208 pharmacies.
4. Increased investments in manufacturing of drugs and medical supplies of medical appliances, and pharmaceuticals, in addition to the operation of some governmental hospitals and maintenance and cleaning in all health facilities.

There is an increasing contribution of the private sector in the provision of health care services, where out-patient visits to its facilities increased from 12.1% of total out-patient visits in 1994 to % in 2010. In addition, in-patients in the Kingdom's private hospitals as average of total in-patients rose by 16 % from 1994 to 2010 (Ministry of Health, Department of Statistics, 2010).

According to the World Health Organization (2013), the KSA is on track to achieve its millennium development goals. The country had a per capita GDP of US $22713.4 in 2004 with an impressive human development index of 56 in 2011. The healthcare system is under the supervision of the Ministry of Health that regulates both the public and private sectors. The healthcare system consists of two tiers, the primary care system and the specialized treatment tier. The primary care system comprises the clinics and healthcare centres offering preventive, prenatal and emergency health services while the second tier is characterized by the provision of specialized treatment in the hospitals. In accordance with the country's 5-year development plan, the numbers of the primary healthcare facilities grew by 8.9 % from the year 2004. The national healthcare systems have been overwhelmingly characterized by the improvement of maternal care, immunization, reduction of preventable diseases and the enhancement of child health.

The government of the Saudi Arabia has successfully attained the significant improvements stipulated in the country’s ninth national development plan for 2010-2014. The Ministry of Health has successively managed to establish multiple sources of funding for the state’s healthcare system. The government had also successfully facilitated the availability of healthcare information at the local and national levels through the incorporation of modern information technologies. The collaboration of the Ministries of Education, Labour and Health further created employment opportunities in the healthcare sector (World Health Organization, 2013). The Ministry of Health further introduced strategic management practices in the healthcare system by adopting decentralized management, sufficient budget allocation for the health sector, the institution of referral hospitals and the employment of specialized medical professionals. There have also been improved governance and policy frameworks for the healthcare agencies. The Ministry of Health has been in the forefront, providing guidelines on preventive and curative campaigns. From having a total of 74 hospitals in 1970, statistics from the Ministry of Health indicated that there were 415 hospitals in 2009. Similarly, there has been rapid development of the medical colleges, evidenced by 16 government-sponsored universities and five private medical colleges. Additionally, there are 17 colleges of dentistry, with 12 being government-sponsored and seven privately managed. Helen Ziegler Associates (2014) noted that 62 % of the hospital and 53 % of the primary healthcare centres fall under the jurisdiction of the Ministry of Health. Healthcare facilities in the KSA could further be categorized into the following: Ministry of Health facilities, military hospitals, Ministry of the Interior hospitals, referral hospitals and private healthcare facilities. Additionally, the government has adopted the patient –centred approach in the delivery of public services based on the national strategy for primary healthcare. Through the institution of standard operating procedures and the accreditation of health facilities, the Ministry of Health guarantees the delivery of quality healthcare services (Helen Ziegler Associates 2014).

2.1.4.2 Challenges Facing the Healthcare System in Saudi Arabia: distance

Saudi Arabia is the largest country in the Middle East, occupying approximately 80% of the Arabian Peninsula (see below for map). Specialist facilities tend to be concentrated in large cities such as Riyadh and Jeddah.

Patients need to travel long distances to clinics for consultations and tests. Patients are often accompanied by family members, for cultural reasons, thus adding to expense and disruption. A clear need exists for a distance consultation facility, both involving patients and centralized medical staff, local and centralized medical staff or a combination. Mobile services could be developed, initially for specific groups such as expectant mothers, children and the elderly.

Figure 2.1: Map of Saudi Arabia (Lonely Planet.com)

2.1.4.3. Challenges Facing the Healthcare System in Saudi Arabia: *Diabetes*

Diabetes Mellitus (DM), which is predominantly associated with the developed countries, is increasingly becoming a major healthcare problem in SA, due to drastic changes in Saudi lifestyles (Baranowski, 2009). Khan et al. stated that approximately 25% of the population in the Kingdom of Saudi Arabia has been diagnosed with diabetes. Furthermore, that in the last ten years, there has been an 8% increase in the prevalence of DM in Saudi Arabia (2010).

The Kingdom of Saudi Arabia (KSA) has been observed to be developing at a rapid rate, hence an accelerating urbanization of the population. Urbanization in the KSA has been associated with adoption of new lifestyles, which has resulted in the emergence of chronic diseases among the urban population. Numerous studies have indicated an epidemic occurrence of diabetes cases in the Kingdom with the latest prevalence at 23.9% hence placing the KSA as the seventh leading state in diabetes prevalence. The Oxford Business Group (2007) reported that over 19% of the urban population is suffering diabetes in KSA and the figures are expected to rise. Projections from the survey further indicated that the number Saudi citizens suffering from the disease could reach 5.5 million from the current 2.8 million patients by 2030. Consequently, over 2.1 million Saudi citizens continue to live with diabetes without diagnosis. As a result, the introduction of mobile health application in Saudi Arabia presents an opportunity to offer medical services to the vast population suffering from diabetes.

2.1.4.4 Challenges Facing the Healthcare System in Saudi Arabia: *the Bedouin*

In Saudi Arabia there are specific groups that are of concern in terms of access to effective healthcare. One such is the Bedouin nomads; these are Arab-speaking nomads mainly found in the Arabic desert of the Middle East. Although Bedouins have migrated to other parts of the region, they first settled in Saudi Arabia where there still exists over 700,000 Bedouin Saudis to date (Mundy, 2000). The Bedouin nomads fall into two main social classes, the fellahin and the true Bedouins. Unlike the true Bedouins, the fellahin have adopted farming besides their pastoral cultures. Bedouin nomads are susceptible to healthcare challenges due to myriad factors associated with their lifestyles. As nomads, they lack permanent houses, living in makeshift black tents made from the woven goat hair. Their main means of transport is the camel and the majority of the community members are not educated, due to their nomadic lifestyle. Bedouin nomads move into the deserts during the rainy seasons but live on desert boundaries during the summer, hence the difficulty of maintaining school sessions.

According to Chatty (2006), Bedouin nomads have below par score on school enrolment, school attendance, classroom performance, transition to higher education and gender-related bias. It has been noted that the paradigms of formal education seem to conflict with principles and beliefs of the Bedouin culture. Furthermore, the challenge of illiteracy among the Bedouin communities has been attributed to both social and economic factors. The majority of the Bedouin communities live in highly remote areas that are characterised with poor infrastructure and further lack social amenities such as clean water and electricity. As a result of these, Bedouin students are thus forced to travel over long distances in order to access public schools that are located intermediately to the cities and towns. The Islam and Arabic culture also contributes to the disparity of education levels between boys and girls among the Bedouin communities. Women are highly susceptible to harsh desert conditions, such as walking long distance to access schools. The limited number of intellectuals from the Bedouin communities has resulted to reduced opportunities for the clan members. These communities lack local healthcare professionals who could aid in the provision of healthcare services. As illiterate nomads, Bedouins rarely comprehend the healthcare benefits derived from services such as vaccinations, maternity care and birth control mechanisms. Chatty (2006) further noted that the limited number of Bedouin members in state organisations further contributes to weak government policies on the improvement of Nomadic education levels. As a result of low education levels, these communities are prone to increased mortality rate due to chronic diseases. Bedouin nomads are likely to lack pertinent information on how to prevent and manage of diseases such as diabetes.

In terms of the financial domain of the Kingdom of Saudi Arabia, the Bedouins have been vastly marginalized from the economy of the country since the discovery of oil.

Bedouins are traditionally nomads who exist by subsistence herding of livestock. As a result of the emergent economic system, the nomadic Bedouins have been subjected to economic constraints. Bedouins have become accustomed to a sedentary form of lifestyle without consideration to financial saving and venturing into productive trade. The result of the traditional economical system of the Bedouins has been low capita income of the nomads in comparison to the national average, overreliance on livestock as the main source of income, the deterioration of the rangelands and under-exposure to education systems and modern trade. The extremity of the living conditions in the rural areas has further forced many members to migrate to urban areas leading to unprecedented decrease of the nomadic population. Subsequently, Bedouin members who migrate to the cities only end up undertaking manual jobs in constructions and oil industries to due to their lack of trained skills and career qualifications. The financial difficulties facing the Bedouin communities adversely affect their healthcare status (Galaty, & Salzman, 1981). They lack funds to facilitate routine appointments and visits to healthcare centres that are sparsely located in the rural areas. Furthermore, the majority of the nomads may be forced to avoid seeking conventional forms of treatment due to medical charges that are beyond their social class. The financial disparity between the Bedouin men and women is even far worse. This could be due to the subjective cultural traditions and beliefs that hinder women from actively participating in commercial activities such as the selling of livestock without the consent of male members of the family. In turn, women and children's healthcare has been neglected by the society.

The nomadic nature of the Bedouin communities has further resulted in the hindrance of access opportunities to healthcare centres (Galaty & Salzman, 1981). Bedouin nomads constantly move from one location to another seeking greener pastures and water for their livestock. Consequently, the majority of the nomadic communities dwell in highly remote and rural areas where most healthcare professionals are unwilling to work. Therefore, Bedouins are forced to travel vast distances in search of medical services. This hampers access to essential medical care such as maternity care and the management of chronic diseases. Another challenge is presented by the absence of transportation networks and means. Bedouins principally depended on camels for transportation, which are ineffective in cases of medical emergencies. Therefore, nomadic members may be able to access medical centres for the first time but perform poorly on the subsequent keeping of medical appointments with doctors.

2.1.4.5 Challenges Facing the Healthcare System in Saudi Arabia: Immigrant Labour

Another underserved group is the immigrant workforce on whom many sectors of the KSA economy heavily depend, as immigrant workers make a third of the population of Saudi Arabia and half of the country's workforce. According to statistics from the United Nations in 2007, the constitution of the migrants in Saudi Arabia was as follows, 1.3 million Indians, 900,000 Pakistanis, 900, 000 Egyptians, 800,000 Yemeni, 500,000 Bangladesh and the least group being of westerners who totalled 100,000. Foreign domestic workers accounted for over 500,000 of the immigrants in 2013 (Roth & Watch, 2014).

This group might benefit greatly from mHealth service, as they do not currently have the same rights to healthcare as Saudi citizens. Schwenken (2011) points out that these immigrant workers come into the KSA through a system of sponsorship, whereby they are invited into the country by prospective employers. Under the provisions of articles 5, 11 and 44 of the Saudi Residency Law (1952), the *kafeel*(local company) or local citizen of Saudi Arabia must be responsible for the sponsorship of foreign worker for the purposes of validating their work permit and residency permit in the country (Ramady, 2010). As a result of this system, a foreign worker's right to remain in the country is subject to the approval of their employer. By being liable to their local employers, immigrant workers in Saudi Arabia have been subjected to extreme violation of human rights ranging from violation of movement rights, physical and emotional abuse, discrimination and racism. Schwenken (2011) noted that immigrant workers are subjected to working over 15-20 hours a day without off days. Subsequently, some employers withhold their employee's salaries for months.

This system has, however, resulted in many instances of discrimination and violation of human rights for these workers, including a lack of duty of care for their health, and this has been the subject of campaigning by Amnesty International. Schwenken (2011) goes on to note that the sponsorship system allows the employer to restrict the freedom of movement of their immigrant workers and many actually confiscate their employees' passports. This can result in immigrant workers not being able to have the time or the permission to travel in order to access the healthcare they may require. This is especially true of women workers, who are also particularly vulnerable to abuse of a physical or emotional nature. This situation for many immigrant workers constitutes a nationwide challenge to ensure that all residents of Saudi Arabia have rights, and in particular the right to have access to healthcare. However, it should be noted that the sponsorship system does not indicate permission to local employers to abuse immigrant workers. For instance, in 2000 King Fahd bin Abdul issued Decree 166 that abolished the employment related sponsorship system while maintaining the system only for immigration and residency cases (Ramady, 2010). The law also categorically illegalized the confiscation of immigrants' passports by employers.

Ramady (2010) noted that migrant workers are more likely to face higher health risks than local members of the host countries due to factors which include the language barrier, lack of access to local health centres, risky working environment, and transfer of communicable diseases from developing countries with poor healthcare systems. For these reasons, migrant workers in Saudi Arabia are at a higher risk of developing health complications. Language barriers also present a primary concern about the provision and access to healthcare information in Saudi Arabia. Statistics indicated that the majority of the immigrants come from non-Arab speaking countries. These immigrants have difficulties communicating with Saudi doctors and medical staff in Arabic. Therefore, foreign workers in Saudi Arabia are subjected to substandard healthcare services due to the prevalence of Arabia language among members of healthcare system. In some cases, differences in language may lead to miscommunication of directional and guidance information on the management of illness among immigrants. The majority of immigrant workers are English speakers while Saudis predominantly speak Arabic (Roth & Watch, 2014). Most migrants are thus forced to teach themselves Arabic in order to communicate and interact with other Saudis; however, a language barrier often contributes to the deterioration of the health status of immigrant workers in Saudi Arabia. Domestic foreign workers are at higher risk of suffering from a language barrier due to the diversity of local dialects within Saudi families. Therefore, domestic workers may be forced to learn a local dialect in addition to national language.

According to Roth and Watch (2014,) highly skilled and skilled foreign workers accounted for 13 % of the total demand for work permits in the year 2013. These ranged from foreign clerical workers to managers in the corporate sector who are highly literate and educated. Ramady (2010) noted that majority of foreign workers in Saudi Arabia are literate with average education levels. The dominance of literate foreign immigrants has been due to requirements instituted by immigration agencies in other states to limit the number of the applicants for work permits in Saudi Arabia.

Although the literature on migrants' access to Smart phones is highly limited, Saudi Arabia has the leading penetration of mobile phones in the world. It hence follows that migrant workers in Saudi Arabia could readily access Smart phones. However, according to Roth and Watch (2014) numerous cases have been witnessed where foreign domestic workers have been physically abused by their employers because of accessing mobile phones. The prohibition of access to mobile phones by employers is illegal; nevertheless the country lacks a dedicated policy framework and supervisory bodies that protect foreign workers against such injustices. Furthermore, foreign workers who are Christians and women tend to experience extreme discrimination and abuse from the Saudi employers. Immigrant women in some cases have reported being denied access to medical services despite suffering severe sexual and physical abuse from their male employers.

2.1.4.6 Challenges Facing the Healthcare System in Saudi Arabia: Women's access to healthcare

It is not just immigrant women who suffer discrimination in terms of access to adequate healthcare; this also applies to the female population of Saudi Arabia in general. Abiad (2008) noted that discrimination against women and the victimization of minority groups have often been enshrined in laws and regulations, for instance, Saudi women are not allowed to drive cars. However, Abiad added that there does not exist a documented ban on women drivers, and that the prohibition of female drivers stems from the generalization of the teachings of Wahhabism, a conservative form of Islam which is practised in Saudi Arabia. This interpretation of Islam requires women to seek permission from male guardians when undertaking key activities such as joining a school, working, travelling and getting married. Despite the non-existence of any documented prohibition of women from driving, Saudi Arabia's Ministry of the Interior has declined to issue Saudi women with driving licenses. When caught driving, women are forced to pledge and sign that they will not drive again. If caught violating the first pledge, one is forced to pledge again, and a male representative is mandated also to pledge and pick up the woman caught driving (Byrnes, 2014). The prohibition of women from driving has led to the worsening of medical emergencies in cases where Saudi women could not drive themselves to medical centres. The ban on women from driving has been noted as a predominant hindrance to the right of access to healthcare services especially among the middle-class members of the Saudi Arabia population. However, according to Inter Nations, there is hope that the situation will change in the next few years. In 2011, a Saudi activist group, Women2Drive, began a campaign demanding that women be allowed to drive. As of April 2013 women can now ride bicycles and motorbikes. However, this new rule stipulates that women can only do so as a 'recreational activity' as opposed to a 'mode of transportation', so women would presumably not be allowed to ride bikes to the hospital. These initiatives are, however, a sign that the situation for women may be changing, such that access to healthcare for women may no longer be subject to restrictions on transport; until then, using an application may, in part, provide a solution (Inter Nations, 2014).

Similarly, Saudi women are expected to have male company while leaving the house. The male companion is usually a family member and referred to as a *mahram*. It thus follows that women should always be accompanied by a *mahram* while visiting medical centres. Saudi women, therefore, are forced to forfeit their medical appointments with physicians in situations when their *mahrams* are too busy to accompany them to the hospitals. Furthermore, the consistent presence of male guardians during medical appointments may constitute a violation of women's health privacy, as this limits the confidentiality of patient-doctor relationships.

The Ministry of Health has further been wrongfully depicted as insisting on the mandate that male guardians and husbands of Saudi women must give consent for their treatment in hospitals. According to Toebes (2014), the healthcare sector and medical professional in the industry erroneously deny women their right to sign consent forms for medical purposes. There exists an ill-founded misconception among doctors and Saudi women that female Saudis cannot independently fill medical consent forms. An assessment of the medical resolution highlighted on the decree of 1988 on the practice of medicine and dentistry that placed equivalent rights to both consents from male and female patients (Nazir & Tomppert, 2004). The decree in part stated that prior to the undertaking of medical treatment or medical operative procedure; a legal medical consent must be obtained from the male or female patients. It is hence alarming to note that women in Saudi Arabia experience health care prejudice as a result of this ignorance on the part of some male Saudi doctors. Efforts by the government of Saudi Arabia to sensitize the public and the medical fraternity on the illegality of the requirement for male consent have been unsatisfactory. In 2012, the Ministry of Health issued an official circulation 11/26/84484 to all healthcare providers reiterating that female patients should be allowed to sign consent forms for their treatment and surgical operations (Nazir & Tomppert, 2004). The guardianship system, although not officially recorded, contributes to the violation of the fundamental health rights of women in Saudi Arabia. For instance, a male doctor may refuse to examine a female patient without the consent of the husband for the fear of religious condemnation from other Islamic believers. Saudi Arabia's healthcare system has also strictly adhered to the stringent doctrines of Wahhabism. Numerous cases of emergencies where female patients have not been immediately offered medical due to the absence of a male guardian are rampant. According to Harbi (2014), a female Master's student at King Saud University died from a heart attack after the male paramedic waited for the arrival of the male guardian for over two hours to get permission to access the campus. Thus, the guardian system has led to treatment of Saudi women as minors and subsequently promoted violation of fundamental health rights of women in the country. Sometimes it is the women themselves who hinder access to healthcare. A significant number of Saudi women have declined to be medically examined by male doctors. These Saudi women view it as a taboo and against *Shari'ah* law to be touched by a male other that their husbands (Toebes, 2014).

Due to the restriction of movement accorded to Saudi women, many of them have bought of mobile phones to facilitate communication with friends and the relatives. Members of the middle class and the upper class have a higher preference for Smart phones. The heightened level of mobile phone penetration has further been driven by the younger female members of the colleges and universities. Saudi women have also embraced the Internet, hence the unprecedented growth of Smart phone ownership in the country. Although male members of the society account for a larger portion of mobile phone subscribers, women are also slowly gaining interest in social platforms such as Facebook and Twitter. According to a survey by Ghouth (2014), 95 % of Saudi women own a Smart phone, 4% own camera phones and 1% own a secondary non- camera phone. Therefore, Saudi women have positively embraced mobile technology and the services associated with it. Although the government has also infringed Saudi women's right to own cell phones by banning camera phones at weddings and graduation ceremonies; nevertheless, mobile phones have been welcomed as providing Saudi women suitably with their right of expression and interaction with other female members while at the same time maintaining their personal privacy. The high ownership of Smart phones means that women have access to the technology required to use a diabetes management application.

2.1.4.7 Challenges Facing the Healthcare System in Saudi Arabia: professionalism

Synonymous with the trend in the traditional commercial sector, professionalism has gained heightened prominence among the expectations of patients. However, appropriate professionalism has always been underscored by the attitude and behaviours of a professional that extend beyond the provision of medical services. The Health and Care Professions Council (2012) noted that professionalism in the healthcare sectors entails the medical professional's adherence to the stipulated ethical practices, harmonious interaction with the patients, productive interaction with co-workers and commitment to effective service delivery. On the other hand, lack of professionalism among medical practitioners contributes to the victimization of patients. Based on the study by Brockopp & Eich (2008), the rehabilitation and societal integration of Saudis with disabilities have been hampered by the negative attitude of professionals towards the disabled. There further exist vast evidence of victimization and prejudice against women and foreigners when visiting healthcare centres in Saudi Arabia. Findings by Brockopp & Eich (2008) and Binsalih (2013) identified cultural values, Islamic religion, traditional beliefs and educational level as the prime cause of the victimization. However, in his studies, Binsalih (2013) emphasised that the concept of professionalism was highly complex and multivariate and that professionalism encompassed numerous contextual factors that ranged from the health institutions, workplace, and the nature of every clinical interaction. Nevertheless, the attitudes and behaviour of medical practitioners were identified as playing a significant role in patients' recovery in hospital. These aspects of professionalism further determined the nature of patient – doctor relationship and their interactions.

Despite the tremendous effort by the government of the KSA to upgrade the healthcare system of the country, nursing care in the kingdom has been plagued by claims of inefficiency and unprofessionalism. An overview of the structure and composition of the nursing professionals should be a prerequisite in order to frame the current situation. Al-Homayan (2013) noted that in 2010 Saudi nurses totalled 129,792. As mentioned earlier, this pool of nurses was spread unevenly within the three segments of the healthcare segment, the Ministry of Health, Ministry of Defence and the private sector. Alarmingly, statistics indicated that 68.21 % of the nurses comprised of foreigners while Saudi nurses barely exceeded 5.81 % of private-sector nurses. It is thus transparent that the health sector of the KSA is predominantly founded on the expertise of non–Saudis. A profound challenge for the health service lies in relying on an extensive foreign workforce that is unstable, since expatriates are primarily driven by financial incentives.

According to Al-Homayan (2013), an examination of patient safety management in the KSA indicated that the nursing community was still at the development stage in adopting an effective management of patients. The findings highlighted that the leadership of the nursing team, workload, working hours and poor remuneration were the leading causes of poor service delivery. Although the medical institutions have successfully trained Saudi nurses, the majority of nurses end up working in managerial positions discouraged by the less lucrative profession of nursing in the country. In comparison to the salary scale of nurses from other countries, the KSA's healthcare system offers limited remuneration to nurses. Nurses' salaries are further graded on the basis of the origin of expatriates, be they Western nurses, Malaysian nurses or nurses from developing countries. Fundamentally, the reported cases of inefficiency and ethical violations in the KSA principally stem from substandard working conditions, poor remuneration and flawed leadership for nurses.

In this section we have given an overview of health provision in KSA and suggested that mHealth applications might be of particular value to a number of social groups: the rural population, Bedouin residents, immigrants and women in general.

In the next section we briefly introduce the topic of eHealth in general, before introducing the topic of mobile health, first in general and then as it relates to the management of chronic disease.

2.2 EHealth and MHealth

2.2.1. EHealth

2.2.1.1 EHealth history and scope

E-health is a term dating back to at least 1999 that describes healthcare supported by electronic processes and communication. It encompasses a range of services or systems that are at the leading edge of healthcare and information technology. E-health includes:

1. Electronic health records: facilitating the communication of patient information between diverse health care specialists.

2. Telemedicine: psychological and physical treatment at a distance.

3. Health knowledge management.

4. Virtual health teams: comprised of healthcare specialists who coordinate care and share information about patients through digital apparatus.

5. mHealth, entailing the use of gadgets in collecting comprehensive and patient level health information, supplying healthcare information to researchers, patients, and practitioners, the real time checking of patient vital signs, and delivery of care through mobile telemedicine.

6. Medical research using grids: great computing and data administration abilities to handle huge amounts of assorted data.

7. Health information systems: patient data administration, work schedule administration and other organizational responsibilities surrounding health (Varshney, 2007).

New technologies have been used for health in many ways, e.g. telephone, radio and TV. The history of E-health, like health informatics, goes back to the development of the first mechanized pathology reporting appliances that were fitted in the very initial DOS-based non-mainframe computers. E-Health developed out of the laboratories into sanatoriums at large, being applied as hospital management systems or information systems that facilitated patient scheduling, staff rostering and very partial patient result coverage and, largely importantly for their ‘bottom line’, patient invoicing. Over their lifetime, these early applications have matured, with newer applications added.

However, this study concentrates on developments since the Internet. Health technology is any tool that may be applied to manage, document, diagnose or treat illness or for prevention, psychoanalysis or extended care (Satyanarayanan, 2001). These solutions include the pharmaceuticals, appliances, procedures and managerial systems applied in healthcare. Medical technology improves the quality of life and can lessen the severity and duration of pain, handicap and injury; thus, its role in healthcare is crucial. Constant medical technology modernization improves the quality and efficiency of care.

Until the Internet era, things had not moved too much more than that, as the charge of satellite transmission was expensive, and the simple, old telephone system did not offer the bandwidth required to enable involvements that would regularly change clinical results. With the introduction of personal computers, email and the Internet, the potential of diagnostic interventions are almost endless. The Internet has had a deep influence in crossing international borders and facilitating the humanitarian aim of telemedicine to profit remote communities. The Internet has also facilitated remarkable inroads in health informatics.Web services have offered the middleware that is currently the ‘glue’ that can link many contrasting health information appliances (Sarasohn-Kahn, 2010).

Information and communications technologies have been widely implemented in many Western countries to improve many aspects of healthcare, such as expert diagnostic systems, online patient records, and integrated medical information systems to name just a few. Many of these technologies are expensive and involve sophisticated hardware and services, making them practical primarily in the developed world. In developing countries, universal ownership of a much less expensive, generally available device, the mobile phone, has provoked a lot of new ideas about the healthcare potential for this technology (Kinkade & Verclas, 2008).

2.2.1.2 EHealth initiatives in Saudi Arabia

The healthcare information system in Saudi Arabia is largely not computer-driven. Early efforts to standardize and integrate an ICT-based healthcare system in Saudi Arabia started in early 1996 (Mufti, 2000). A strategy for a national integrated health network was put in place in October 1996 to cover and investigate the potential of integrating healthcare networks for the purpose of service improvement and standardization. The objective was to establish an information and communication infrastructure to improve communication and provide a high-speed and reliable Internet support to connect remote and mobile healthcare units. However, to date healthcare information is, for the most part, not computer-driven and the first emphasis is to improve the level and quality of data/information access (Mufti, 2000).

The main priority in the Saudi Arabian health sector lies in the improvement of quality of health data/information while making sure that experts are able to deliver what the users want. With the advent of high-speed Internet technologies in the Middle East in late 90s, and the introduction of state-of-the-art information and communications technologies these have now made it viable to integrate healthcare systems with remotely located hospitals and clinics. However, the advent of 3G, Wi-Fi and broadband-level LAN technologies has not yet been fully utilized in the healthcare information exchange infrastructure. Such a robust framework can be utilized in various healthcare sectors of remote consultant collaboration, clinical diagnosis, opinion sharing and information retrieval between various hospitals (Mufti, 2000). Such a system or framework would specifically facilitate patients in distant locations where a consultant would be able to connect and take advice from a peer residing in another hospital regarding a complex case. Furthermore, the network has excellent potential to be used for heavy-duty data transfer such as MRI scans, remote surgical operations, non-invasive patient protocols, etc.

A highly connected and ubiquitous healthcare system would definitely assist in interconnecting the most unprivileged groups of Saudi Arabia. For instance, extending mobile healthcare and its benefit to women and children would enable them to seek immediate advice, upload health readings and seek consultations in real time from their homes. On the other hand, for a seven million-strong expatriate workforce largely living in remote suburban work compounds, a cloud computing based mobile health paradigm would improve the speed and quality of healthcare support (Mufti, 2000). The system is highly likely to reduce an immense load from hospitals for tasks ranging from basic appointments to emergency first-aid help calls. An example for this idea would be the development of a ubiquitous healthcare support platform covering various ICT-based paradigms of handheld devices, tablets and desktop computers to share a single audio/visual network with a sensor-based support to monitor/gather a patient's medical readings in real time. The overall framework would operate in multiple modes for doctors, patients and ambulance personnel to interconnect to each other via various forms of electronic devices and sensors.

The development of such an integrated mobile health framework and application would immensely improve a Saudi healthcare system that is already substantially reliant on a healthcare work force largely made up of foreign professionals such as doctors, nurses and support workers (Maisel & Shoup, 2009, p. 199). It would also improve the level of communication between remotely located patients who are unable to regularly attend to hospital appointments due to physical or health-specific reasons. Most importantly, it would be the first attempt to integrate the current developments of mobile health sectors with a sensor-based hardware for the purpose of patient-physician interaction.

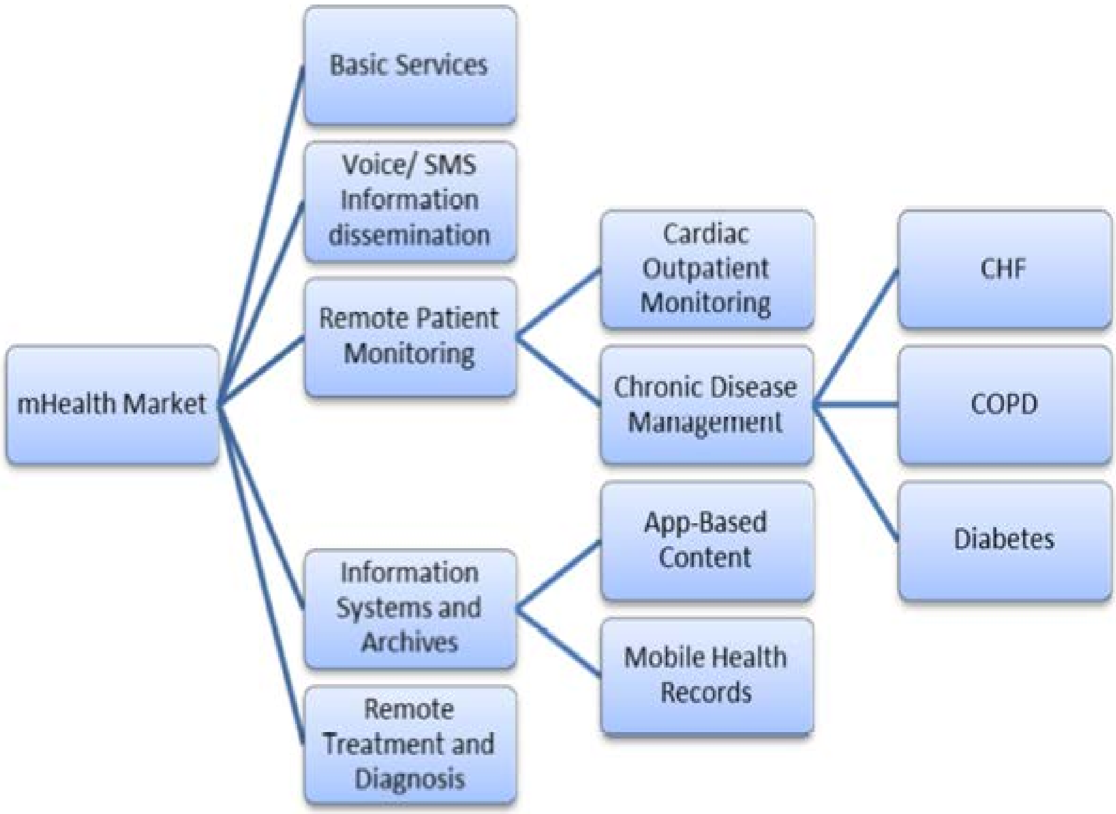
Additionally, individual privacy and data protection in mobile health applications are also regarded as globally paramount issues. Identity management for mobile Internet applications in 3G mobile networks is essential to keep patient/user data confidential and disclosed only to the concerned personnel. This involves the implementation of mutual authentication, and authorization mechanisms in addition to data encryption (Maisel & Shoup, 2009, p. 200). A mobile health security protocol specifically for the Arab world would provide additional confidence to end-users, particularly patients, by ensuring them the required privacy. This would also perhaps increase public confidence into using a wireless/mobile health application.

2.2.2 MHealth

MHealth has evolved from the eHealth sector, which describes the information and communication sector which uses computers, communication satellites and many other devices for the relay and delivery of health needs as well as giving out information on health related issues (Hoyt & Yoshihashi, 2009). In fact, mHealth works with eHealth where for example, an application involving the relay and access of health-related topics, maybe for a disease which requires an eHealth system to organize, manage, store and analyse all data. MHealth can thus be evaluated as a means of acquiring, storing, processing and accessing data from eHealth systems to produce desirable results. Increased performance, miniaturization, availability, data rate enhancement and expected convergence of such future systems accelerate the development of mHealth systems in the next decade, (Istepanian, Laxminarayan & Pattichia 2006).

The growth of mobile technology and its global outreach to a larger proportion of the population has led to the development of numerous health application programmes that use mobile phones. These application programmes are commonly referred to as mHealth apps. According to Istepanian et al., (2011), mobile health (mHealth) refers to the use of small portable and wireless computing and communication gadgets (e.g. Mobile phones, Smart phones, iPads) to provide medical information to both healthcare professionals and their patients or clients. As far as chronic disease is concerned, the continual growth of mHealth applications could be attributed to two factors. Iakovidis et al. (2004) wrote that chronic disease patients require the utmost attention and medicinal adjustment, hence the need to maintain constant communication with medical experts. Secondly, the use of mHealth applications effectively reduces the costs associated with chronic disease management such as travel costs when visiting physicians.

Mobile health covers a range of solutions. The tools of mobile computing—Smart phones, PDAs, Tablet PCs, patient- monitoring devices and laptops are opening new vistas of opportunity for clinical collaboration. Several applications of mHealth—telemedicine, voice recognition and home monitoring have been around for years, but the coming wave of mHealth adoption owes its popularity to a convergence of form and function. Healthcare is one of the largest adopters of the Apple iPad, and major vendors like Vodafone, Verizon and AT&T are making mHealth services available via the Smart phone. In addition to devices, a wide range of peripherals is also available, including blood- glucose meters, electrocardiogram readers, wearable monitors and nanosensors, among many others (Krohn & Metcalf, 2012). The following illustration in Figure 2.2 provides a snapshot of mHealth market that is rapidly evolving.



Source: Juniper Research, 2012.

Figure 2.2 The mHealth market

The range of potential and actual mHealth applications that have been explored in research labs over the past ten years is extremely broad and can be complex. A simpler classification is provided by Laakko et al (2008), who give a useful summary of the main types of application areas (see Figure 2.3). This partial classification shows three major families of application. Wellness applications include programmes such as digital pedometers and 'gym buddies', to encourage and persuade users to adopt a healthy lifestyle, typically in individual mode. Chronic disease management would include medication reminders, glucose and blood pressure measurement applications and so on, with or without the participation of medical staff. Category three, tele-consultation, involves communication either between patient and medical staff or different types of medical staff or both. Patient record management could also be added as a fourth category.

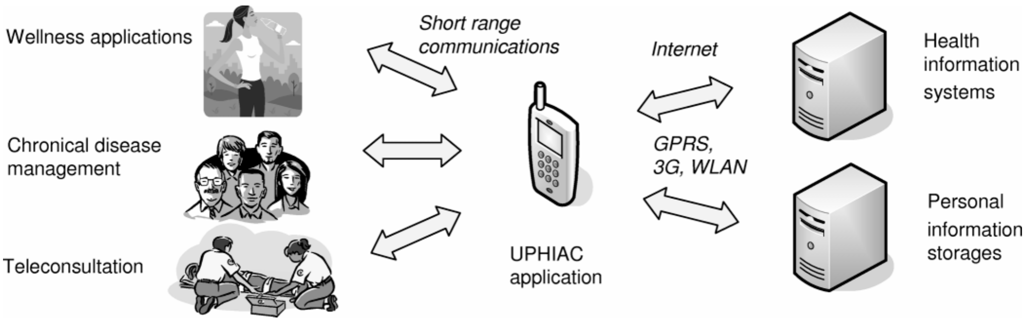


Figure 2.3 Framework for mHealth systems (Laakko, 2008)

2.2.2.1 Types of Functionality - Communication

The simplest and most cost-effective application utilized in mobile health is short messaging service (SMS). SMS is utilized by hospitals in engaging with their patients through sending reminders about their health behaviours, notes, confirmation of scheduled appointments, laboratory results, enquiries on hospital records, and coaching towards healthy behaviours. These initiatives are shown to increase the compliance of patients with treatment regimes (CTA, 2011; WHO, 2011). Moreover, voice communication is considered to be more costly than SMS; however, it enables real-time interaction without the need for face-to-face communication. This is more convenient to use if the patient and nurses prefer seamless communication through 'handoffs and roaming' wherein there is a continuous communication despite the changes in location (Tallukdar, 2010, p.51). Hospitals are encouraging patients to use this application when they live in rural areas that need the immediate attention of medical experts. This application requires no time limit in consulting doctors (Khoumbati, et al., 2010).

The most advanced mobile application is the development of Wireless Application Protocol (WAP) that is similar to the capability of computers or laptops (Erlandson & Ocklind, 1998). This application authorizes patients to look for their medical data and allows practitioners to view and check the patient's status (Teong & Jeoti, 2005). On the one hand, doctors used WAP-enabled technology to review the case of patients and access their medical history, which proved the efficacy of healthcare services (Hameed, et al., 2008).

Mobile health has successfully embedded technology into the health sector, promoting communication and delivery of health services. It has also reduced the costs of health care delivery by ensuring that healthcare systems are effective and swift, and this replicates into better management of diseases. It is, however, notable that all mHealth programmers have standard objectives, which are to increase healthcare information access, promote better diagnosis and tracking of diseases, create efficacy both in time and cost utility, in relaying data on public health, and finally in improving and growth of health practitioners training and ongoing education on health issues. Mobile health, by embracing technology into the health sector promotes efficient health contact; develop quality of healthcare by enabling easy access to data also facilitating quick communication to remote areas in need of healthcare services. It has also assisted health workers to make better decisions when dealing with a condition (Boulos, et al., 2011).

2.2.2.2 Types of Functionality - Voice

Although the majority of mHealth apps are image and text message oriented, there exists speech technology for capturing patients' information. However, Malvey and Slovensky (2014) noted that it was difficult to single out mHealth applications that were predominantly voice-oriented. The majority of the existing mHealth applications incorporate imaging, texting and use of voice to facilitate the transfer of information between the patients and medical professionals. One of the profound findings by Reitzin (2014)indicated that voice recognition apps could be utilized in sensing early signs of mood changes in patients suffering from bipolar disorder. According to the research team from the University of Michigan, the developed mHealth app could monitor the pattern of voice and detect imminent mood changes thus enabling early medical intervention and care. Despite the growth of the mHealth market, there lacks an adequate pool of voice only apps for those who are visually impaired. An examination of the leading apps in the KSA and developed countries indicated that visually impaired patients could not fully access the services of the current mHealth apps on the market. Additionally, literature on mHealth apps tends to be focused on the novel functionality of healthcare-oriented applications as opposed to their usability by all members of the society.

2.2.2.3 Types of Functionality - Pervasive technologies

Further possibilities are opened up by the move away from the desktop culminating in pervasive or ubiquitous computing. Pervasive computing involves three converging areas of ICT: computing ('devices'), communications ('connectivity') and 'user interfaces.' Pervasive devices are likely to assume many different forms and sizes, from handheld units (similar to mobile phones) to near-invisible devices set into everyday objects (like furniture and clothing). These will all be able to communicate with each other and act ‘intelligently’. Such devices can be separated into three categories:

Sensors: Input devices that detect environmental changes, user behaviours, human commands etc.

Processors: Electronic systems that interpret and analyse input-data;

Actuators: Output devices that respond to processed information by altering the environment via electronic or mechanical means; for example, air temperature control is often done with actuators. However, the term can also refer to devices that deliver information, rather than altering the environment physically.

There are many visions for the future development of PCS devices. Several research groups are attempting to produce networks of devices that could be small as a grain of sand. The idea is that each one would function independently, with its own power supply, and could also communicate wirelessly with the others (Satyanarayanan, 2001).

2.2.2.4 Persuasive Technologies

While some health technologies transmit information and monitor symptoms, others attempt to change attitudes or behaviour. Persuasive technology is broadly defined as technology that is designed to change attitudes or behaviours of the users through persuasion and social influence, but not through coercion (Fogg, 2002). Such technologies are regularly used in sales, diplomacy, politics, religion, military training, public health, and management, and may potentially be used in any area of human-human or human-computer interaction. Most self-identified persuasive technology research focuses on interactive, computational technologies, including desktop computers, Internet services, video games, and mobile devices (Oinas-Kukkonen et al. 2008), but this incorporates and builds on the results, theories, and methods of experimental psychology, rhetoric (Fogg et al, 2007), and human-computer interaction. The design of persuasive technologies can be seen as a particular case of design with intent (Lockton et al., 2010).

While persuasive technologies are found in many domains, considerable recent attention has focused on behaviour change in health domains. Digital health coaching is the utilization of computers as persuasive technology to augment the personal care delivered to patients, and is used in numerous medical settings (Elton, 2007). Numerous scientific studies show that online health behaviour change interventions can influence users' behaviours. Moreover, the most effective interventions are modelled on health coaching, where users are asked to set goals, educated about the consequences of their behaviour, then encouraged to track their progress toward their goals. Sophisticated systems even adapt to users who relapse by helping them get back on track (Cugelman et al., 2011).

In 2013, The IMS Institute for Healthcare Informatics (2013) conducted studies to assess how widespread healthcare mobile applications were and what their medical value was to both the healthcare users and the relevant medical professionals. These studies considered over 40,000 health care applications that were available for download on the iTunes platform. The researchers found that over half of these applications were available for download free of charge. Their findings also showed that 10,480 applications were informative; 5,823 gave their users instructions and 5,095 were able to record physiological information and 1,357 provided an alert function. There were also 1,622 applications that did not provide any of these functions. The researchers felt that it was useful to categorize these applications in terms of which part of the patient's journey through the illness they mainly applied to. Thus some applications were designed mainly for the purpose of disease prevention; others were concerned with self-diagnosis and others focused on finding a specialist physician. These apps were concerned with patients in the pre-diagnosis stage. Post-diagnosis, there were apps which focused on education, others which were to do with filling prescriptions and others which were designed to assist the patient to comply with the healthcare regime they had been given. The study indicated that the apps which were in highest demand in the United States were those concerned with healthy living - either pre- or post-diagnosis and those which allowed the user to self-diagnose were in the least demand.

According to Zhenwei et al. (2012), the increase in mobile technologies in developing countries has led to the emergence of numerous studies and innovations in the sector. Today, mobile phones are becoming a significant ICT device with progressive penetration in remote areas. The rapid development in the technologies, ease of use and the declining prices of tools make the mobile a suitable and flexible tool (WHO, 2011). M-technology is progressively being applied in the healthcare field. Government officials utilize mHealth to gather health-related information on the broader population; and mHealth applications have been promoted as cost-effective methods of identifying and monitoring health concerns, also directing the formulation of health plans. Programmes to sustain the professional improvement of people in the health area, by means of mHealth technology, are becoming readily accessible; mHealth also gives health professionals access to patient information as well as admission to different information resources, both of which offer valuable support in the diagnosis and the formulation of treatment. For these reasons, mHealth applications are likely to most benefit physically challenged individuals and those remotely located (W.H.O Global Observatory for Ehealth, 2011). These benefits are summarized in Table 2.1.

Benefits	References
Enhanced communication and interaction at a reduced cost facilitate assessment of patients' conditions, enable patients to check in with their doctors on a daily basis, facilitate constant patient guidance by doctors, provide patients with necessary information regarding their health status and enable a customized service provision for each patient through personalization research data and assessment of accurate medical data obtained from each patient's medical feedback	Iakovidis et al. (2004)
Helps in identifying and monitoring health concerns, provides health professionals with access to patient information as well as admission to different information resources, both of which offer valuable support in the	WHO (2011)

diagnosis and the formulation of treatment	
Medical workers use text messaging applications to monitor the status of HIV patients	WHO (2014)
Service efficiency in areas such as disease management, clinical communications, and patient engagement, remote physician-physician consultations, e-visits,	Phillips, et.al (2013); Turner (2003)
Health education and extension services in developing countries, sophisticated remote monitoring of chronic disease, efficiently allocate healthcare resources and more actively engage patients in their own health management; motivating force in personal fitness	CEA (2012)
Remote patient monitoring saves trips to the emergency room and reduces hospital re-admissions	Spyglass Consulting (2009)
SMS messaging can provide education about communicable diseases, remind patients to take their medication, monitor disease outbreaks, and extend healthcare	Boston Consulting Group (2012)

services to rural areas; access to healthcare for marginalized populations (migrant workers, ethnic minorities)	
Tool for communication and training of health workers; end-to-end wireless health monitoring; the reliability of message delivery to healthcare professionals	Söderback (2009); Kudbaya (2010)

Table 2.1 Benefits of mobile technology in healthcare

Through collaboration with care providers, mobile applications companies have been able to develop patient-oriented programmes that offer medical solutions to both patients and medical services providers. The use of mHealth apps by both patients and medical practitioners results in enhanced communication and interaction at a reduced cost. These applications facilitate the assessment of patients' conditions, enable patients to check in with their doctors on a daily basis, facilitate constant patient guidance by doctors and further provide patients with necessary information regarding their health status (Iakovidis et al. (2004). These applications further enable a customized service provision for each patient through personalization research data and assessment of accurate medical data obtained from each patient's medical feedback. It should be noted that the range of mHealth solutions is constantly expanding. Development stage mHealth technologies include body area networks, robotics, and virtual realities. Scope now exists to fuse mobile health apps with external devices in order to monitor adherence of the patient to the medication regimens. Such innovations have the potential to support patients and health providers in the monitoring of treatment outcomes and medicine usage. In addition, participants can be recommended to use external devices and to consider their level of comfort while using the adherence process. Research has shown that younger participants in the general public are comfortable in using an external device linked to a Smartphone (Krebs & Dustin 2015).

MHealth applications can also help in cases where patients do not take the medication prescribed either at all or erratically. Patient non-adherence to prescribed medication regimens may be either intentional or unintentional. The ability of patients to communicate to healthcare providers through mHealth platforms can offer an effective means by which to resolve issues to deal with unintentional adherences. Research indicates that technology could be used to track a patient's health status on a daily basis in such a way that the extent of their side effects or symptoms can be monitored such as blood pressure, blood glucose level, or heart rate. Educational approaches and related documentation could make health benefits clearer to patients and hence better support their needs. Furthermore, mHealth can be greatly helpful in making complex medicine regimens seem easier to manage as well as make them seem straightforward thus making patient less overwhelmed and more likely to take drugs as prescribed thus overcoming elements of unintentional non-adherence. The most common type of behavioural intervention of the mHealth apps is through reminder systems that can involve various prompts through diaries, alarms, notes or advanced pill boxes. At the moment, mHealth is an emerging concept in most of the developed countries and is not directly positioned at the forefront of healthcare service provision. However, there is great potential for mHealth apps to offer support to the pharmacist on daily activities as well offer support to the patient to the benefit from prescribed medication regimens. There is real potential over time for the integration of the traditional mechanisms of delivery of healthcare supported in mHealth apps and the related technologies in the delivery of healthcare to the public.

MHealth apps offer innovative ways in which to improve patient adherence hence negating the problems that are associated with non-adherence. This technology is important especially to patients with cognitive impairment as well as those with complex medication regimens. These mHealth apps can be applied to remind patients when to take their medication. Here the app is able to remind individuals when the dosage is due and have the capacity to record when medication was last taken. Such apps can also provide important information about medicinal products including instructions from healthcare providers as well as monitor physiological parameters. (Krebs & Dustin 2015).

2.2.3 MHealth in Developing Countries

The increasing prevalence of mobile access in developing countries has significantly contributed to the proliferation of mHealth applications in these states. The primary consequence of mobile phones has been the lowering of the costs associated with relaying healthcare information (Duplaga et al., 2006). Low and middle-income nations in Africa and Asia, due to various constraints in their health sectors, tend to display effective mHealth usage. Additionally, the economic, political and social shortcomings of developing countries have provided suitable platforms for the growth of mHealth applications. These include high population growth curves, high disease quotients, few health practitioners and a lack of finances for infrastructure and health systems.

In Africa for instance, notable for the prevalence of HIV/Aids, which is believed to affect one-tenth of the African population, medical workers use text messaging applications to monitor the status of HIV patients, and their compliance with their process of treatment (WHO, 2014). According to WHO (2014), HIV/AIDS is a public health epidemic in Kenya. The deliverance of Antiretroviral Treatment (ART) is a main chief policy measure by the government to decrease HIV/AIDS connected morbidity and mortality. These efforts are bound to be ineffective due to poor records administration. However, through 3G wireless technology, a decrease in the managerial burden on health care personnel and enhancement in patient care could be attained by intensification of pharmaceutical administration methods for ART. According to an assessment analysis by WHO (2014) “the proportion of facilities effecting reports at the moment of dispensing increased by 70 percent.” The growth of mobile technology in Africa has greatly promoted the development of mHealth mobile applications in the continent. According to a survey by Donner & Mechael (2012), Africa has 60% penetration of cell phones - compared to 50% penetration of cell phones in the United States. The availability of mobile phones and established network providers has impacted significantly on the development of mHealth mobile applications. According to studies by the World Health Organisation (2014), some of the successful mHealth applications in Africa include MoTECH in Ghana, which provides pregnancy information to expectant women and the Wired Mothers project in Zanzibar, which links midwives and expectant women. However, the study of existing mobile health applications indicated that the majority of mobile health applications concentrated on communicable diseases and pregnancy solutions; also, mHealth applications in Africa specifically target those affected by HIV/AIDS and malaria. In addition, the majority of non-governmental organisations also concentrated on funding projects that focused on malaria, HIV/AIDS and maternal health medical solutions.

In addition to focusing on infectious diseases, the majority of mobile health application programmes were based in the rural areas. From the findings, Donner and Michael (2012) noted that it was essential that healthcare providers, in collaboration with mobile application companies, develop mHealth applications specifically designed to cater for chronic diseases patients such as diabetes, cancer and cardiovascular diseases. Furthermore, relevant authorities and programme coordinators should expand the coverage of the mHealth services to urban areas where studies indicate increased prevalence of chronic diseases due to global growth of urban lifestyles.

Pilot schemes in India, along with Sri Lanka, have been very helpful in checking outbreaks of Dengue Fever. Prior to prevalence of mobile communications in the region, it took the provinces 15 to 30 days to count on data about the disease epidemics reaching authorities (Bhattacharya, 2013). However, with the commencement of mobile and digital infrastructure, the waiting time for data on infectious illnesses to reach authorities has dropped significantly. Through the Real-Time Bio-surveillance plan based on mobile gadgets, the public health establishment uses data mining methods to search for “anomaly detection” in illness patterns. Regions reporting major epidemics receive extra resources for diagnosis and handling, and this helps to lower the spread of the illness.

MHealth in developing countries has also progressed in terms of communicating an individual’s data to the relevant medical centre at a fraction of the time that this would take in the past. For example, university engineers have gone into a partnership with specialists in India to develop a distinctive mobile phone health examining system. The system, which was initially revealed in 2005, employs a mobile phone to convey a person's central signs, as well as the multifaceted electrocardiogram (ECG), to a hospital anywhere in the world (WHO Global Observatory for E-health, 2011).

With the increasing priority of hospitals to enhance health services, mobile systems are utilized in many developing countries such as Kenya, India, and Sri Lanka. The medical workers use a text messaging application to monitor the status of patients, and to see if they are adhering to the treatment regime they have been allocated. The information is recorded, which aids the government in terms of their healthcare planning and medical practitioners in determining the patient outcome. It can be concluded that experience has shown that mHealth applications have successfully been integrated with healthcare system in many developing countries. It will be useful to consider in more detail how this has been achieved in a particular case.

According to USAID (2012), an SMS-based support and information system for HIV testing and counselling individuals was successfully implemented in South Africa. The project was primarily aimed at providing support to individuals who had just conducted HIV tests, regardless of the final status. Subscribers chose between 'just tested negative' or 'positive' free SMSs that were available in Afrikaans, English and isiXhosa dialects. After subscription, the service sent over 39 messages over three months. The project commenced in May 2012 and spread to the Overberg and Nelson Mandela Metro districts. The project was highly accepted by the population, indicated by a tenfold increase of subscribers. The majority of subscribers indicated that they had gained new information from the services and did not wish to unsubscribe. In the case of Saudi Arabia, the project could be modified to provide support and information to non-communicable diseases patients, such as diabetics. This will provide patients with pertinent information regarding the prevention, control and treatment of the diseases. Furthermore, lessons learnt from the South African project indicated that the SMS should have an identifiable brand name, SMS's are recommended to be free and be made available to all mobile service providers and individuals who have unsubscribed by mistake should be allowed to subscribe again.

2.2.4 MHealth challenges

Technology may prove to be the easy part of implementing mHealth; but mHealth's contribution to the cost equation of healthcare is not without its critics. In a study of telehealth commissioned by the London School of Economics (Knapp et al, 2013), it was reported that remote monitoring of heart disease patients increased the cost of that care without measurably improving outcomes. The economics of mHealth remain equally uncertain. A sustainable business model of mHealth, whether by license, subscription, or pay-as-you-go, has not yet emerged as the strategy that can sustain long-term growth.

According to Kvedar (2014), the implementation of mHealth also faces the challenge of making the platform systems for mHealth apps interoperable. Interoperability describes the parameters of the systems that facilitate the exchange of information between the different related systems in common formats and which requires common protocols. The need for this interoperability is demonstrated by considering the situation of a patient who may have several clinical conditions, as diabetes patients often do. In such a case, a single mHealth app may be very limited in relation to the range of medical needs that such a patient may have. To overcome this problem, it is important that existing mHealth applications are able to transfer information to a larger range of protocol systems and that the individual components of the mHealth apps – including data standard concepts, data processing protocol and patient identity protocol, be incorporated into the core unit of the interoperability system.

A further challenge facing the development of mHealth, specifically in middle and lower economies has been identified by PLoS Med. This is the closed-source systems that constitute a barrier to the free transfer of software knowledge between developers. PLoS Med (2013) defined open standard as those standard that are publicly available and characterised with the availability of usage and application information. Thus, application interoperability should synergize with open standards for the attainment of mHealth and eHealth equity. It is because of this problem, that it is of paramount importance that international organisations such as the WHO should both regulate and certify open standards for mHealth applications, especially in middle and lower income countries.

Studies by PLoS Med (2013) have also indicated that the lack of evaluation systems for mHealth programmes also constitutes a serious challenge. They point out that, for the most part, feasibility studies in mHealth initiatives in developing countries are of poor quality and have biased results. There have however, been some successes in mHealth initiatives that focus on changing patient behaviour, such as better adherence to treatment or stopping smoking. PLoS Med suggest that evaluation of mHealth intervention processes should include:

- An identification of which indicators will be used to monitor progress
- A formulation of the framework of evaluation, for example, randomized controlled trials
- A timeline for the assessment of the feedback and monitoring
- Evaluation of the data gained from the evaluation process (2013)

An assessment by Kvedar (2014) of feasibility studies of mHealth programmes revealed that there were biases in how candidates were selected for trials or pilot projects. He notes that this selection bias often means that candidates who could offer the most credible results are not motivated to take part in the trials. Furthermore, trials are often characterised by small sample size, which can also skew results by either resulting in exaggeration of the implications of the mHealth programmes or evaluating them as insignificant.

There are other concerns with health care apps that might hinder their future uptake. For efficient uptake of the mHealth, these concerns need to be successfully addressed in the most proactive manner. Although there is great potential for mHealth apps the programmes fail to address the aspects of educational barriers as well as health literacy levels of the population. These aspects can be overcome by utilizing service-driven support mechanisms within the pharmacy setups. Another concern with mHealth apps is that limited regulation can lead to apprehension due to over accuracy and reliability. Another concern is the extent of medical training of the developers of the mHealth apps which has been greatly highlighted. Another important concern revolves around usability especially to the older generation who are unfamiliar with these programmes. However, the older generation are beginning to embrace developments in technology hence with proper training they can be able to use mHealth apps. With respect to provision of healthcare, key consideration would be to strike a balance between the time taken in the usage of mHealth app and the expected direct benefits to the unfolding clinical scenario (Krebs & Dustin 2015).

One of the ethical challenges facing mHealth is the fact that mHealth application programmes are prone to violations of privacy rights. This can happen because mHealth apps gather and store personal patient information which unauthorized people such as medical staff or the patient's family members could access. Linked to this are concerns over how individual consent systems are structured in mHealth. Cultural and political dynamics mean that the situation as regards obtaining consent is complicated. Arguably, there is a need for legislation that will offer effective protection of patient privacy.

Like all technology solutions that incorporate sensitive data, there are questions about mHealth's ability to safeguard patient data, questions about the reliability of mHealth tools and about the culture of resistance to change that has been a constant feature of Health IT. Among healthcare professionals, the intersection of the personal and professional use of mobile tools adds another layer of complexity to the security issue. A lack of uniform data standards, the growth of BYOD ("Bring Your Own Device") in healthcare enterprises, and the difficulty of integration between multiple mobile carriers with internal data systems all contribute to security concerns regarding patient privacy and data integrity. Until there are firm data standards applied to mobile data management, common device integration and interoperability with enterprise legacy and internal data systems, and 'bullet-proofing' of devices containing sensitive data, this issue will remain unresolved. Finally, the regulatory environment surrounding mHealth has not yet come into focus. Issues regarding liability, 'regulate-able' devices, and common standards are still in development.

The following table is a summary of the major challenges that face mHealth as identified in the current literature.

Remote monitoring of heart disease patients may increase the cost of care without measurably improving outcomes	Knapp et al (2013)

mHealth apps require to be interoperable and facilitate the exchange of information between the different related systems in common formats and which requires common protocols; a single mHealth app has limited functionalities in relation to the range of medical needs a patient may have	Kvedar (2014)
The closed-source systems constitute a barrier to the free transfer of software knowledge between developers	PLoS Med (2013)
mHealth application programmes are prone to violations of privacy rights and thereby rendered unethical. Issues of data integrity and lack of regulations surround mHealth	Kvedar (2014)
Cultural differences between the medical fraternity and the ICT professionals, fragmentation of the device operating systems, mobile network availability, cost of the mobile phones, handset exchange and literacy levels	Deloitte (2013)
Rural areas are frequently characterized with limited network coverage, weak data transfer rate and a lack of electricity which can directly hamper access to mHealth services in the developing countries	IMS Health (2014)
Differences between medical community and technology companies	University of Cambridge (2011)

Table 2.2 Challenges in mHealth

2.3 MHealth for Diabetes Management

Mobile health applications have proven to be constructive in managing the health of patients, especially patients with chronic illnesses and we have shown that Saudi

Arabia faces challenges in chronic disease care that could be met by such technologies. In this section we focus more tightly on apps for chronic disease, relating apps for diabetes management with the Saudi context discussed above.

2.3.1 Mobile Health Applications for Diabetes Management

The mobile applications for tablet computers and smart phones range in complexity from products that are as simple as point-of-care physician note applications and patient scheduling to refined remote devices for patient monitoring (Norris et al, 2009). Smart phones, as mentioned previously, are exceedingly promising in the management of chronic diseases once diagnosed, and thus appropriate to the management of chronic diseases in Saudi Arabia. The chronic conditions under management in Saudi Arabia are diabetes, heart diseases, cancer, blood pressure problems, asthma, and HIV and AIDS. The applications for Smart phones from the Android and iTunes markets might be the ones that could be employed by Saudi patients to help in managing these conditions (Williams, 2012).

An example of a mobile application that could be employed to manage diabetes specifically is the Glucose Buddy. This mobile app would make it easy for a Saudi diabetes patient to keep track and record their carbohydrate consumption, glucose numbers, insulin dosages, and activities. The iPhone/iPad application enables the patient to log glucose, activity, medication, and food intake by entering the above details manually. There is also an ACCU-CHEK testing provision in Pairs tools for monitoring the effects of specific events on the blood sugar levels of the patient (Ming, 2012). The Glucose Buddy application is designed well and oriented graphically with log-in reminders, graphs, and the capacity to sync the information to the online account of the patient. The patient simply enters the information then views all their data in their glucose buddy account, which is free (Skrøvseth et al, 2012).

BP Mate is a mobile application for analyzing, logging, and charting a patient’s blood pressure levels. Patients in Saudi Arabia who have blood pressure level problems would find this mobile application useful. The data obtained through the application would be shared with the doctor. Measuring the blood pressure will be helpful both to the physician and the patient in the effort of what action to take so as to manage or prevent hypertension. The BP Mate mobile application provides accurate log and track the blood pressure levels of the patient (Fox, 2010).

Studies on evaluating the efficacy of diabetes self-management through the use of mobile phones have been conducted which provide evidence of its benefits. Mobile health applications for self-management of diabetes have been growing. According to Chomutare et al (2011), there were 60 applications on iTunes for iPhones in July 2009 which increased by more than 400% to 260 by February 2011. Studies conducted on mHealth in diabetes self-management chosen for review are well-designed, small-size studies that generally support the effectiveness of such interventions.

Self-management systems are now being developed to control glycemia and associated problems with blood glucose levels. Different kinds of solutions have been found, such as glucometers being integrated in cellular phones (mHealth). MHealth is the next generation approach for personalized health care system. The Internet of Things (IoT) has been a major communication advance in recent years, and Jara, Zamora and Skarmeta (2011) were the first to address this for personal diabetes management. In diabetes self-management the right insulin infusion calculation needs to be supported by personal-care devices. They therefore developed a solution which supports a patient’s profile management architecture based on personal RFID cards. At the same time, the solution also provides global connectivity between the patient’s personal device, nurses/physician’s desktop application which helps them manage the cards, the glycemic index information system and the patient's web portal. The most important aspect of this solution is that all measurements and interactions with the patient are done at home and conducted through the Internet, which is the preferred solution for Saudi Arabia, particularly in the case of immigrant workers that are discriminated against. In addition, the local women and children that have restrictions in receiving healthcare services can also benefit with such solutions. Restrictions such as not being permitted to drive and insistence on having a male company while leaving the house have been discussed in Section 2.8.2 of this chapter.

User-centered design (UCD) in mHealth has been developed which helps patients in self-management of chronic conditions such as in Type I diabetes among adolescents. Usability feedback is elicited early in the design stage so that user-related issues are addressed in the development life cycle stage itself. McCurdie et al (2012) found that users do not return to the apps that do not immediately engage them. The diabetes app included an iPhone and a LifeScan glucometer with a Bluetooth adapter for automated data transfer to the apps. This was developed after qualitative interviews with adolescent users and their parents. One of the concerns raised was the need for fast and discrete transactions that could avoid social embarrassments, for instance, having to test their blood glucose levels at lunch time. Such apps would be suitable for the social environment prevalent in Saudi Arabia particularly for women. These are key factors in whether an app will actually be adopted by users in this demographic segment. The authors also identified another requirement that entailed the need for sustained user engagement through rewards and incentives. After 12 weeks of using the app, the users reported high levels of satisfaction. Therefore, focusing on user-needs and developing the app can lead to positive health behaviour from the population, particularly in countries where they are difficult to engage in self-management. These apps require minimal intervention by care-givers, thereby enhancing their necessity. As distances and commuting is an issue in KSA, apps such these could benefit Saudi Arabia.

Cafazzo et al (2012) also conducted a pilot study on mHealth intervention for management of type I diabetes in adolescents. Both patients and their primary caregivers (parents or others) were involved in the study. The study found that the use of mHealth apps such as *bant* can be enhanced through the use of gamification incentives. The study found an increase of 49.6% in the frequency of blood glucose measurements at the end of the 12-week period. This helps in improved health outcomes not only in frequency of blood glucose monitoring but also in patient actions and in faster decision-making. Four themes emerged from this study, which call for further action – the need for fast, discrete transactions, process should not be limited to data collection but lead to decision making, overcoming decision inertia and ad hoc information sharing.

Bell et al (2012) examined the efficacy of using mobile phones in diabetes self-care. In a study of 65 patients, one-way video messages on diabetes were sent to the patients to investigate whether it improved hemoglobin A1c and led to better self-monitoring of blood glucose. The study found that patients that received the videos demonstrated a larger rate of decline in A1c than patients that received usual care; which led the researchers to conclude that a one-way intervention using mobile-phone based video messages can improve self-care as the intervention is simple to implement and sustain. However, engagement with technology is important for such interventions, which although not ostensibly a constraint among the KSA population and immigrants in the urban areas may be an issue of technology acceptance linked to concerns about data security. If this is the case, this issue may hinder implementation of such apps which implies that patients need to be reassured of the security of their data to make it operable in Saudi Arabia.

In Switzerland, a remote monitoring watch has been developed, which is basically a wirelessly connected tracking device, a part of a web-based system (Mena Report, 2013). This device can remotely monitor the patient and report position; it has an on-demand panic button for urgent assistance even as the patient's medical records are automatically delivered to the first aid responders. Real-time location of the patient can also be tracked. This might be suitable for Saudi Arabia cities as patients are remotely located which makes it difficult for them to regularly attend the hospital.

In a study conducted at the diabetes outpatient clinic in Vienna, 53 elderly patients with increased cardiovascular risk were evaluated for a mobile health (mHealth) based remote medication adherence measurement system (mAMS). The study found that regular and timely intake of prescribed medication based on doctor's advice lowers the risk of progression of the disease (Brath et al, 2013). Mobile Health based adherence management was found to be feasible and well accepted by the patients under this study. Such management may also lead to increased adherence and lead to improved control of indicators such as blood pressure and cholesterol concentrations.

Ajay & Prabhakaran (2011) highlight the benefits of cell phones in diabetes management. They particularly point to the cell phones as a screening/diagnostic tool for diabetes as it can aid the health workers in screening, diagnostic and follow-up care. Cell phones can also act as a vehicle for continuing medical education, a tool for self-management and compliance. The authors also highlight the limitations such as small-size of the display screen and keypad, which are impediments for diabetes patients. This is a vital finding and suggests that apps could be made available on tablets that have larger screen thereby making the access easier.

Årsand et al (2012) convincingly argue that mHealth will empower patients to take a more active role in managing their own health. This is based on an investigation of a tool - Few Touch Application (FTA) – designed to support self-management of diabetes. This is a mobile phone-based diabetes diary which can be updated manually as well as through wireless data transfer, which in turn helps in personalized decision support for the achievement of personal health goals. The researchers analysed the performance of 10 FTA-based apps –

1. Automatic transfer of blood glucose (BG) data
2. Sms-based education for Type I diabetes management (T1DM)
3. A diabetes diary for T1DM
4. A diabetes diary for Type II diabetes management (T2DM)
5. Patient's diary integrated with health-care providers
6. A food picture diary for T1DM
7. Physical activity monitoring for T2DM
8. Nutritional information for T2DM
9. Context sensitivity in mobile self-help tools
10. Modeling of BG using mobile phones

Each of these apps had different benefits and motivation for users, such as better parent-child communication, reflection possible because data is readily available, identifying treatment obstacles and helping to increase physical activity. However, the researchers suggest some additional elements to be included in the apps such as motivational and visual user interfaces, inclusion of context sensitivity, and apps that offer considerable health benefits in relation to the efforts required. Besides, the services must be cost effective and different needs of users must be incorporated.

Burner et al. (2013) conducted a TExT-MED (Trial to Examine Text Message for Emergency Department Patients with Diabetes) among adult diabetes patients recruited from the emergency department in Southern California, with a predominantly Latino population. TExT-MED is a text based programme designed for low-income, inner-city Latinos as it can help increase their knowledge, self-efficacy, subsequent disease management and glycemic control. The study found gender differences in self-management of diabetes. For instance, men need more help with diet. The desired content for educational content also differed across genders as men preferred information on erectile dysfunction and mental health while women preferred information on menopause, yeast infections and mental health. While the women sourced information from family, friends and physicians, men relied on internet, television and their wives for more information on diabetes. The authors conclude that knowledge and education are essential to change a patient's perception of threat of disease. While Text-MED was designed to increase knowledge, this study did not find it effective among the population studied although the respondents did show improved self-efficacy and health behaviours. However, in the context of KSA diabetes patients, the gender differences have to be noted.

Chomutare et al (2011) studied the salient features of mobile applications for diabetes care and compared it to clinical guidelines recommendations for diabetes self-management. The clinical guidelines come from health associations such as the National Institute for Health and Clinical Excellence in the United Kingdom and the American Diabetes Association. The study found that personalized education, strongly recommended by clinical guidelines, is not present in the current mHealth applications. In fact, several studies (McCurdie et al, 2012; Årsand et al., 2012) also highlight that the efficacy of such apps would depend on meeting the needs of the users. Another important finding by Chomutare et al is that no study has evaluated the social media concept in diabetes self-management on mobile devices although there were some records of using PHR (personal health records). The researchers opine that lack of some designated core features may influence clinical outcomes. These features include personalized education and decision-support features that are not included in the current blood glucose monitoring interventions.

The majority of chronic disease treatment happens outside the four walls of the hospital or the doctor's clinic, according to Nayyar (2012). In the case of diabetic patients, the physician does not really know when they would need to see the patient. Therefore, with mHealth technologies, it may be possible to shift the paradigm of 'just-in-case' care to 'just-in-time' care. This implies that mobile apps and mHealth solutions could play an important role in improving patient care in diseases such as diabetes. However, the power in mHealth is not in simply collecting data but in integrating the data in meaningful ways. AT&T mHealth Solutions' Diabetes Manager is an app that provides coaching tools and useful information to patients – they can enter blood glucose data with a recheck timer which is a reminder to retest. The tool acts as a bridge as it enables health care providers with the greater insight with what is happening with the patient. Of the 181 participants with Type II diabetes enrolled for the study, 72% found the app very useful in managing their diabetes while 81% would continue to use the tool and 91% said they would recommended the tool to others.

Arnhold, Quade and Kirch (2014) conducted a systematic review of all currently available diabetes mobile apps on both iOS and Android operating systems. They used variables such as range of functions, target user groups, languages, acquisition cost, user ratings, available interfaces, and also the connection between acquisition and user ratings. They particularly examined whether the applications served the special needs of diabetes patients aged or over the age of fifty. App review was performed based on the information given in Google Play Store, Apple App Store, and the apps themselves. The study found that most apps offer similar functionalities and combine only one or two functions in one app. There was lack of patient-physician involvement in the development of the apps. Multifunctional apps were not used for all its functionality although the researchers advocate the potential of diabetes apps for assisting and supporting diabetes patients aged 50 or older is large. There exists a need for new app functions to harness the potential. However, both iOS and Android have made efforts to offer different accessibility features to lower the barriers for diabetes patients with reduced or limited cognitive and physical skills.

A study on the efficacy of mHealth interactive voice responsive (IVR) service was conducted by Aikens et al (2014) among older adults with type II diabetes, mostly male Caucasians. IVR is used as a tool to enhance patients' social support for self-management in diabetes. Patients were given weekly automated IVR monitoring and self-care support calls with the aim of assessing self-monitoring of blood glucose (SMBG), medication and dietary adherence, foot inspection, blood pressure levels, and overall functioning. The system provided updated information to a caregiver living outside the patient's home, and the caregivers were notified when the patient encountered difficulty. The study found that the older adult population did answer the IVR calls, which suggests that even vulnerable patients will engage with this type of service. The study was conducted over a period of time and it was found that call completion rates reduced after some time possibly because the patients felt that they had achieved the benefits. Nevertheless, those with inadequate literacy and low income were willing to receive social support so that they could counteract the risks associated with the disease. Those that practiced with the informal caregiver were more likely to participate in the IVR programme, resulting in enhanced self-monitoring and a lower rate in high blood glucose levels. Therefore, IVR can be useful in the KSA environment among the lower income groups and those in rural areas from where regular commuting is difficult.

Another mHealth diabetes programme – CareSmarts – provides self-management support and team-based care management for diabetes patients through automated text messages (Nundy et al, 2014). This is a theory-driven behavioural intervention aimed at improving self-care through multiple mediators such as education, cuing,social support, self-efficacy, and health beliefs. A study among African-American diabetes patients in Chicago was conducted over a six-month period to determine the efficacy of the CareSmarts programme. Nurses enroll members in their programme over the phone, and patients are sent text messages at a time convenient to them. These texts are on self-care and direct the patient when to check the blood glucose levels. It also includes a flexible education curriculum which members follow at their pace. Education is covered on a wide range of diabetes related issues such as foot care, glucose monitoring, nutrition, medication, while one topic relates to living with chronic illness. Each of the topics has a two-week schedule. Patients felt this improved self-care and particularly in foot-care. Knowing that a health-care professional actually reviewed their messages increased patients’ engagement levels. This was studied among diabetes patients in Chicago and the researchers find immense potential although they point out that diffusion and sustainability depends upon a supportive policy environment. There must be increased interoperability with electronic health records and clearer regulatory guidance to derive benefits in terms of behaviour change and chronic care.

Another study was conducted among the rural population in America that suffer from health disparities and poor health status. Most of them are uninsured and the health care system places the burden of their healthcare on the individuals. Based on the Chronic Care Model, the study aimed to evaluate how mHealth interventions among type II diabetes patients could improve the quality of healthcare providers in rural areas and give access to care for the underserved people. Chronic Care Model comprises of health system, community support, self-management support, decision support, clinical information systems, and delivery system design. The study was based on a review of 157 articles on the use of mHealth among diabetes patients in rural areas. The study found that it is possible to deliver care to patients in remote areas as 70% of the rural population in America owns a mobile phone. This is possible through Bluetooth enabled devices and through the use of chat, video and voice communication (Mallow et al, 2015). Both patients and care-givers can be trained for self-management and improved health care. However, to serve the rural population, mHealth technologies should offer live support, be convenient to use, offer face-to-face communication, be cost effective and have back-up interventions.

The mHealth solutions for diabetes management have been tabulated below for easier access to its benefits and shortcomings. This would help investigate into what could work in the KSA.

Table 2.3 MHealth and Diabetes

App	Benefits	Shortcomings Identified	Reference
Internet of Things/RFID cards	Supports a patient's profile management architecture; all interactions are from home through Internet and can be seen by nurses from their desktop		Jara, Zamora and Skarmeta (2011)
User-centered design with an iPhone and a LifeScan glucometer with a Bluetooth adapter	Automated data transfer and user-related issues are addressed in the development life cycle stage itself with minimal intervention by care-givers	Need for fast and discrete transactions that could avoid social embarrassments and need for sustained user engagement through rewards and incentives	McCurdie et al (2012)
Bant (mHealth app)	Increase in frequency of blood glucose measurements through the use of gamification incentives	Need for fast, discrete transactions, process should not be limited to data collection but lead to decision making, overcoming decision inertia and ad hoc information sharing	Cafazzo et al (2012)

One-way video messages	Larger rate of decline in A1c among patients that received video messages than patients that received usual care/simple to implement and sustain	Engagement with technology critical to its success	Bell et al (2012)
Remote monitoring watch (Switzerland)	Monitors patients, on-demand panic button for urgent assistance and possible to track real-time location of the patient		Mena Report (2013)
Medication adherence measurement system (mAMS) (Vienna)	Feasible, well-accepted by patients, regular use can lower the risk of progression of the disease, can lead to improved control of indicators such as blood pressure and cholesterol concentrations		Brath et al (2013)
Mobile phones as screening/diagnostic tool	Aids the health workers in screening, diagnostic and follow-up care/ a vehicle for continuing medical education, a tool for self-management and compliance	Small-size of the display screen and keypad which can impede its use among diabetes patients	Ajay and Prabhakaran (2011)

Few Touch Application (FTA) – mobile phone based diabetes diary for T1DM and T2Dm	BG data transfer, food and physical activity monitoring, food picture diary and sms-based education, better parent-child communication	Must be cost effective, incorporate different user needs, must have motivational and visual user interfaces, inclusion of context sensitivity, and apps that offer considerable health benefits in relation to the efforts required	Årsand et al (2012)
TExT-MED - a text based program designed for low-income, inner-city Latinos	Increases their knowledge, self-efficacy, subsequent disease management and glycemic control	Gender differences in self-management of diabetes/ not very effective among the population studied	Burner, Menchine, Taylor & Arora (2013)
Comparison of salient features of mobile applications for diabetes care with clinical guidelines recommendations for diabetes self-management		Personalized education, strongly recommended by clinical guidelines, is not present in the current mHealth applications, the social media concept in diabetes self-management on mobile devices has not been evaluated	Chomutare et al (2011)
AT&T mHealth Solutions' Diabetes Manager	Shift the paradigm of "just-in-case" care to "just-in-time" care, coaching tools, useful information, they can enter		Nayyar (2012)

	blood glucose data with a recheck timer which is a reminder to retest and gives health care providers greater insight on patient health		
Review of all currently available diabetes mobile apps on both iOS and Android operating systems	Most apps offer similar functionalities and combine only one or two functions in one app, different accessibility features lower the barriers for diabetes patients with reduced or limited cognitive and physical skills	Lack of patient-physician involvement in the development of the apps,	Arnhold, Quade and Kirch (2014)
MHealth interactive voice responsive (IVR) service	Even vulnerable patients will engage with this type of service, beneficial for those with inadequate literacy and low income, leads to enhanced self-monitoring and a lower rate in high blood glucose levels	Attrition was high after some time, call completion rates reduced	Aikens et al (2014)
CareSmarts - theory-driven behavioural intervention	Text messages including when to check blood glucose levels, two-week programme on several diabetes-	Diffusion and sustainability depends upon a supportive policy environment, increased interoperability	Nundy et al (2014)

	related education topics led to improved self-care, particularly foot care	with electronic health records and clearer regulatory guidance required	
Chronic Care Model through Bluetooth-enabled devices and through the use of chat, video and voice communication	Both patients and care-givers can be trained for self-management and improved health care	MHealth technologies should offer live support, be convenient to use, offer face-to-face communication, be cost effective and have back-up interventions	Mallow et al (2015)
Evaluation of mHealth applications for diabetes self-management	Tracking self-care such as nutrition and blood glucose levels	High probability of erroneous data entry as only 62% of the apps enable wireless data transfer, lack of ability to capture enough data to support decision making, apps not evidence-based and do not differentiate between T1DM and T2DM, no integrated self-management tools for non-insulin requiring type II diabetes patients	Goyal & Cafazzo (2013)

The findings of Goyal & Cafazzo (2013) summarize the utility of mobile apps in diabetes self-management. Goyal & Cafazzo found hundreds of mHealth applications for diabetes self-management but it was not always easy to identify them with clinical evidence. Even though the apps enable patients to monitor blood glucose levels insulin doses and nutrition, high probability of erroneous data entry exists. Besides, patients may lack the ability to capture enough data to support decision making, and it is also likely that real-time feedback is not provided to patients to improve their ability to self-care. These errors are likely because only 62% of the apps enable wireless data transfer while all the apps require manual data entry. Unless the apps can bring about behavioural change, they remain as electronic forms of paper-based tools, failing to empower patients. Goyal & Cafazzo assert that most apps are not evidence-based and they do not tend to differentiate between T1DM and T2DM. Most apps allow tracking self-care such as nutrition and blood glucose levels but none offers integrated self-management tools for non-insulin requiring type II diabetes patient.

2.3.2 The Application of mHealth Technology to Manage Diabetes in Saudi Arabia

In this section, the factors involved in the selection of mobile health apps for Saudi Arabia are recapped. The country is currently struggling to curb the prevalence of chronic diseases with most efforts aimed at preventing and controlling diabetes. Concerted efforts focused on neutralizing risk factors associated with chronic diseases are facing a limitation of resources. Cosby (2011) also noted that conservative laws predominantly govern Saudi Arabia and, as noted earlier, certain laws and cultural practices may limit full exploitation of health care services by minority groups, especially women. Mobile health applications present a possible solution to most challenges associated with chronic diseases in the country. Mobile health applications could greatly benefit women who would be able to access medical services without being subjected to cultural traditions and the restrictions of Islamic law.

It is the case that mHealth has been found to be an effective tool in treating chronic diseases such as diabetes, particularly for the underserved (Carter & Bland, 2012) and for extending clinical services reach into rural communities (Gibbons 2012). MHealth also leverages the power of mobile communications, namely mobile phones, to reach transient and culturally or linguistically challenged populations (Tirado, 2012).

Mobile technology has the potential to transform healthcare in developing countries, mostly in the area of health prevention, education and training healthcare workers. Mobile phones are inexpensive to the inhabitants at large, making them more accessible than computers. They are also more cost-effective than hospital beds. Currently this technology is poised to change how healthcare is delivered, the value of the patient experience and the cost of healthcare. Mobile technology is being merged with chronic disease management, empowering the elderly and pregnant mothers, reminding patients to take medications at the right time, broadening healthcare access to underserved areas, and enhancing health outcomes and medical system efficiency.

The infrastructure for realizing mHealth solutions in Saudi Arabia is largely already present. In light of the rapid expansion of the mobile communication industry in Saudi Arabia, the country provides numerous opportunities for the development of mHealth apps and services. A study by Albabtain (2014) identified Saudi Arabia as the second largest market for mobile phones in the Middle East. Developing countries typically had a mobile penetration of 73%, but Saudi Arabia exceeded this by 116% with a penetration of 186%. Fourth-generation (4G) technology has been established in Saudi Arabia, and this offers users a faster data transfer rate and broader bandwidth. The study further revealed that 41% of Saudis were now Internet users. This would suggest that the communications industry in Saudi Arabia presents few barriers to the development of mHealth applications and their implementation as the communications infrastructure is already in place and there is a wide distribution of mHealth tools i.e. mobile phones and computers. This situation means that the cost of the hardware and networking associated with deploying mHealth application would be negligible. Furthermore, the technologies used by mHealth i.e. SMS, web and video, are familiar to both the healthcare providers and the patients. Users are comfortable with using such technology and also recognize its value and these factors act as an accelerator of adoption.

However, mobile health applications will only flourish in Saudi Arabia if they are adopted and used by their intended users and other stakeholders. In the next section we introduce the notion of modeling technology acceptance.

2.3.3 Implications for this study

This study has looked at classification schemes for mHealth and at a range of specific designs, both research prototypes and commercial implementations, assessing their appropriateness to the Saudi context. From this discussion, it appears that this type of application might have potential for being effective as a diabetes self-management tool. Based on the findings of different studies (table 2.3) that have implemented medical apps for eHealth and self-management of diseases (table 2.3), the following important factors need to be evaluated in the Saudi Arabian context:

To persuade diabetes patients in Saudi Arabia to adopt mHealth apps, some sort of hedonic motivation and performance expectancy has to be provided, because that has been found to influence continued usage of apps (Section 2.3.1). Technology acceptance and use will be further explored in the next section. It is through rewards and incentives that sustained user engagement can be achieved and can lead to positive health behaviour in countries where self-management of diseases is a challenge. This may require several interactive audio-visual training sessions to impress upon the patients the benefit of such apps and how easily they could self-management their own physical problems.

Among the medical professionals effort expectancy and the facilitating conditions influence the use of such apps (Section 2.3.1). This suggests that introducing apps cannot be an isolated activity and has to be integrated at the hospitals across the country so that seamless adoption is possible. If all functions and departments within the hospital are connected to the same network and use medical apps to manage eHealth, the medical professionals could experience smooth transition without any resistance.

Since age and level of education are also strong predictors of adoption and hence specific needs of the elderly have to be addressed. Even among the elderly segment needs are not homogeneous but to what extent apps can be modified to suit individual needs, requires further investigation. However, most studies in section 2.3.1 point to perceived ease of use of the app and this can be managed with support and training. Several apps are available both on Android and iOS and smart phone usage is high in Saudi Arabia. However, reassurance of security and data is a major concern which needs to be addressed through counselling and training.

In Table 2.4 evaluation of certain apps or prototypes has been done to examine what would be most applicable in the KSA.

Table 2.4 Evaluation of apps and models for the KSA

Suggested app/model	Benefits for the KSA
Glucose Buddy.	Constantly keeps track and record their carbohydrate consumption, glucose numbers, insulin dosages. Will be able to keep patients engaged as there is constant activity involved such as log glucose, activity, medication, and food intake by entering the above details manually. Such data can be instantly synced with their online account
Remote Monitoring Watch.	Increase in frequency of blood glucose measurements through the use of gamification. While this addresses faster decision-making and fast, discrete transactions, Saudis may not be willing to invest in another device. Smart phones have other applicability and utility and now an essential commodity. **Thus, this does not appear to be feasible for the current environment in Saudi Arabia.**
User-centered design with an iPhone and a LifeScan glucometer with a Bluetooth adapter.	Need for fast and discrete transactions that could avoid social embarrassments and need for sustained user engagement through rewards and incentives. This appears to be very sophisticated as it involves the use of Bluetooth technology. **Initially not practical for Saudi Arabia.**
One-way video messages.	Simple to execute, this can be used in addition to other apps as it keeps customers engaged and is a one-way transmission; customer is not required to respond.

Mobile phones as screening/diagnostic tool. Interesting tool for self-management. Small screen of the display screen and keypad can hinder involvement and acceptance, particularly among the older patients and those with glaucoma. **Not suitable as Saudi diabetics include older patients and those with sight problems.**

It appears that two the most suitable applications for Saudi would be one-way video messages and the Glucose Buddy. Together, these two apps could ensure participation and sustained patient engagement. These two serve to keep patient privacy and can be operated from the comforts of their home, which suits women and the immigration community. However, as of now Glucose Buddy is available only on Iphones/iPad and hence a similar app would need to be developed for Android OS also to cover most citizens. There should also be a provision for patients to call up medical professionals for clarifications after watching the video. Patients may not be all conversant with medical terms and may seek clarifications.

Even mHealth interactive voice responsive (IVR) has been found to be effective in Type II diabetes (section 2.3) where the older patients were responsive. However, the call completion rates reduced after some time. Therefore, messages must change every few weeks to sustain patient interest in the IVR system. This could be particularly helpful in Saudi in rural areas and among the lower income groups.

As shown in Table 2.2, multiple medical apps may be required because each of the apps has limited functionality. Each medical condition requires a different app and hence the first criterion is a diabetes-specific app to be developed keeping in mind the challenges in Saudi Arabia. Since mHealth apps are prone to violate privacy norms

(Table 2.2), regulators in Saudi Arabia would have to develop regulations around the implementation of mHealth apps. Network coverage in rural areas of Saudi Arabia needs to be developed in case the aim is to reach out to all parts of the country.

While costs of the handset and apps is not a major constraint in Saudi Arabia, cultural difference between the medical professionals and ICT professionals is likely (See Table 2.2), which can impact on successful implementation. The way forward is to involve the medical professionals at each stage of the development of the app so that the two sides understand each other's challenges and requirements.

2.4 Modelling Technology Acceptance

The previous sections of this chapter, in reviewing the literature on eHealth and mHealth, have pointed to a number of factors that might influence the successful introduction and continued use of mHealth solutions for diabetes in Saudi Arabia. In order to frame the further explanation of technology adoption issues in this thesis, the major models that have been used to study and explain the adoption and acceptance of information systems in a broader context are outlined.

2.4.1 The Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), developed by Davis et al (1989) and Davis (1993), is an information systems theory that models how users come to accept and use a technology. The model suggests that when users are presented with a new technology, a number of factors influence their decision about how and when they will use it, notably:

Perceived Usefulness (PU) This was defined by Davis as "the degree to which a person believes that using a particular system would enhance his or her job performance" and

Perceived Ease-of-Use (PEOU) Davis defined this as “the degree to which a person believes that using a particular system would be free from effort” (Davis et al, 1989).

TAM is one of the most influential extensions of Ajzen and Fishbein’s theory of reasoned action (TRA) in information systems studies. TAM replaces many of TRA’s attitude measures with the two technology acceptance measures— perceived usefulness and perceived ease of use. TRA and TAM, both of which have strong behavioural elements, assume that when someone forms an intention to act, that they will be free to act without limitation. In the real world there will be many constraints, such as limited freedom to act (Bagozzi et al 1992).

According to the argument by Bagozzi et al (1992), because new technologies such as personal computers are complex, and an element of uncertainty exists in the minds of decision makers with respect to their successful adoption, people form attitudes and intentions toward trying to learn to use the new technology prior to initiating efforts directed at using. Attitudes towards usage and intentions to use may be ill-formed or lacking in conviction or else may occur only after preliminary strivings to learn to use the technology evolve. Thus, actual usage may not be a direct or immediate consequence of such attitudes and intentions. (Bagozzi R. et al., 1992)

For more than two decades, user acceptance of technology has been a field of study that has gained a lot of focus and importance. Many models, however, have been put forward to depict and explain a system’s use, but the Technology Acceptance Model (TAM), has been the only one that has stood out and received the most attention in the community of Information Systems.

The theory has undergone various changes through the years. For instance the updated TAM2 lacks the variable of attitude, but has another variable, the subjective norm variable, which captures the social influence e.g. from bosses or colleagues which compel the end user, to positive evaluation and acceptance of the IT system use (sciencedirect.com). In the rest of this study, we make use of UTAUT (Unified Technology) a TAM-based model developed by Venkatesh et al (2003) to introduce refinements into the original TAM model, and described further in 2.27.1 below.

In healthcare, various reviews and studies have shown that TAM is a model that can be used to evaluate and analyse physician's acceptance and use of IT health systems and mHealth. As an illustration, concentrating on the health professional rather than the patient, the variables in the TAM include behavioural intention to use (whether or not the health professional intends to use the innovation), perceived ease of using the system (how the health worker perceives the ease of using the system), and perceived usefulness (the perception of the health worker on whether the mHealth will make his/her job easier or enhance their performance). With the use of a model in the tradition of TAM, which is well regarded, evaluation can be done on how far the health IT systems has found acceptance and use in the health sector. This will help in planning and decision making with regards to introduction and expansion of acceptance and efficient use of the beneficial IT system in medical practice.

2.4.2 Acceptance Models in Healthcare

It will be useful to see to what extent a TAM-based model can be used to explain the extent to which the mHealth diabetes application might be accepted within the Saudi context. The particular model we are using is the UTAUT (unified theory of acceptance and use of technology) devised by Venkatesh et al, (2003), represented below in Figure 2.4.

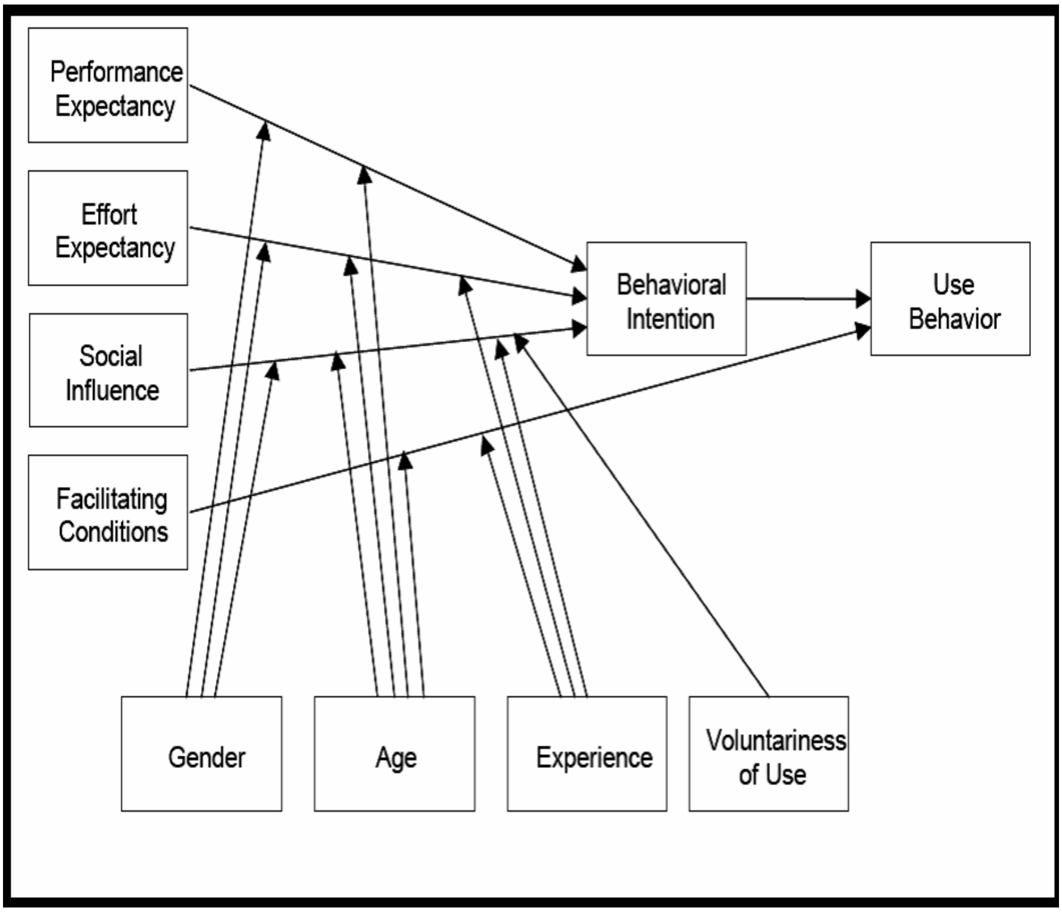


Figure 2.4 UTAUT Model (Venkatesh et al, 2003)

This model will be used as it was designed to incorporate the most reliable aspects of eight theories that related to technology acceptance. These theories and models are Social Cognitive Theory (SCT), Innovation Diffusion Theory (IDT), the Model of PC Utilization, a combined TBP/TAM, the Theory of Planned Behaviour (TPB), the Motivational Model, the Technology Acceptance Model (TAM), and Reasoned Action (TRA).(Venkatesh et al. 2003)

The UTAUT incorporates four major constructs:

Performance Expectancy. "Performance expectancy is the extent to which a person believes that using an information system/technology will assist him/her to gain benefits" (Donaldson, 2011); in this case, whether the patient believes that using the mHealth application will provide benefits in managing their diabetes and communicating with their consultant; or that the health professional believes it will improve outcomes in terms of their patients' health and their communication with the patient.

Effort Expectancy. "Effort expectancy is the degree of ease an individual associates with the use of an information system/technology" (Donaldson, 2011); in this case, how easy the diabetic or health professional perceives it is to use the mHealth application. Ease of use also includes how much time the application is perceived as taking.

Social Influence. "Social influence is the extent to which users perceive that others important to them believe that the users should use a new information system" (Donaldson, 2011). In this case, this would be the extent to which Saudi diabetics' significant others think that they should use the mHealth application. Significant others here would include the patient's physician, family and peers or the professional's peers, patients or managers.

Facilitating Conditions. Facilitating conditions are defined as the "degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system" (Venkatesh et al, 2003). In this case, the extent to which Saudi diabetics and doctors believe that information to and from the hospital is effectively delivered and that data will be acted on. Both patients and doctors have to trust the technology.

There are also the four factors that Venkatesh has shown to be moderating the effect of his four key constructs (ibid):

Gender. As has been already discussed, women patients in Saudi Arabia often have problems accessing specialist healthcare. They cannot travel alone and many will refuse to be examined by a male physician. This study will explore whether such diabetic patients will be eager to use mHealth application and whether and how gender plays a role in the decisions of health professionals.

Age. Elderly patients who live in remote areas may have difficulty travelling long distances to appointments, although this may also apply to disabled patients. These difficulties may make patients more likely to want to use mHealth application. Remoteness may be a more important factor than age and this will also be explored in the study. Age also relates to technology acceptance in that it may have a bearing on an individual's familiarity with a relatively recent technology. For the health professional, age may also play a role for this reason.

Experience. As has already been discussed, Smart phones are widely used in Saudi Arabia and their use is increasing. It is however, useful to ask if respondents have experience of using mobile phone applications as this may affect whether they are comfortable using the mHealth application and also for the health professional.

Voluntariness. This factor may not be relevant to the study of Saudi diabetics as use of the mHealth application will be voluntary. For the health professional, this may not be the case, depending on their work situation, i.e. its use may be mandated by management. However, as at present use of mHealth is not mandatory, voluntariness is not considered a relevant factor in the present study.

Based on the results of the review of literature, the following factors may be shown to have an impact, which will be taken into consideration when assessing the effects of the constructs of the Technology Acceptance model: (a) gender, (b) distance, (c) management of disease, (d) trust in doctors, (e) age, (f) experience of Smart phones, (g) experience with computer technologies, and (h) attitudes of important others. One of the aims of this study will be to gauge how well the constructs and influencing factors in the UTAUT model account for the findings from the questionnaires and interviews, and thus how well the model is suited to the study of mHealth innovations in a country such as Saudi Arabia. The findings from the empirical research will be used to refine the UTAUT model for the specific context of this study.

2.4.3 Studies using the UTAUT to assess mobile health technologies

Several studies have been conducted based on the unified theory of acceptance and use of technology (UTAUT) in the application of mHealth apps in different parts of the world. Some such findings have been presented here which would help in narrowing down what could be feasible in Saudi Arabia, given the limitations.

A study conducted by Yuan et al (2015) on the use of mobile apps for health and fitness from the users' perspective revealed that hedonic motivation, performance expectancy, price value and habit significantly influence continued usage of such apps. At the same time, effort expectancy, social influence and facilitating conditions were not found to predict users' intention of continued usage of health and fitness apps. This study adopted the Extended Unified Theory of Acceptance and Use of Technology (UTAUT2) Model. It was conducted in the United States, among college-aged smart phone users. The same results cannot be expected from the Saudi patients of different age groups because of the socio-cultural differences. Among the strong indicators, focus in the Saudi environment could be laid upon price and performance expectancy to influence the attempt to use health apps in general. Once the habit is formed, perhaps, it would be easier to motivate patients of specific diseases such as diabetes.

Another study based on the unified theory of acceptance and use of technology (UTAUT) was conducted to examine the factors influencing the acceptance of information systems (IS) among healthcare professionals in Canada. Survey analyses of 227 health professionals revealed that their intentions to use IS was influenced by effort expectancy, social influence, compatibility and the facilitating conditions provided by the work environment (Ifinedo, 2012). In this study, performance expectancy was not found to be significant as in the case of students in the study conducted by Yuan et al (2015). Health professionals in Saudi Arabia operate in a different environment to those in Canada. However, concerns in terms of effort expectancy may well be paramount when considering how using diabetes management apps with their patients will impact on their time.

Illiger et al (2014) examined the challenges faced by both patients and healthcare professionals in use of mobile devices for healthcare. In a survey of patients and doctors at Hanover Medical School, the study found that age and level of education are strong predictors of the use of mobile devices in healthcare among the patients as well as doctors. To fully realize the potential of mobile devices in healthcare in Saudi Arabia, the concerns of the elderly and the educationally disadvantaged need careful consideration.

Lack of acceptance of mobile apps by the elderly has also been found by Scheibe et al (2015). This qualitative study focused on the use of diabetes apps among patients 50 years or older in age, and 32 patients were interviewed. Many type 2 diabetes patients fall into this age group and the authors stress that age is an important factor when looking at technology acceptance of mHealth for diabetics. The study found that ease of use and additional benefits (performance expectancy) could enhance the use of diabetes apps among the elderly. However, even among the elderly, the needs are highly heterogeneous due to several factors such as knowledge of the disease, knowledge of the app and previous therapy. The researchers suggest that diabetes app should be individually adaptable but this may be difficult in Saudi Arabia where even the medical professionals are not very comfortable with technology. To suit individual needs would require individual training which might not be a practical solution in the case of some patients.

An adapted version of the UTAUT, i.e. the Mobile Healthcare System (MHS) acceptance model was applied by researchers to examine the use of mHealth apps in obesity management in 94 subjects in the Republic of Korea. They found that behavioural intention to use mobile obesity management apps is significantly affected by perceived ease of use, perceived usefulness and compatibility, which is described as being the degree to which an innovation is consistent with the values, experiences and needs of the potential users (Jeon & Park, 2015). Technical support and training can enhance perceived ease of use factor, which is an important finding, relevant to the Saudi environment, where some patients and even health professionals may not have the skills to use mobile apps. This study demonstrates how important it is to take account of the experience and perception of the patient in determining their needs.

Esmaeilzadeh et al (2015) note that technology acceptance models have been widely used to study user acceptance, but that the study of acceptance in professional groups is very limited. They go on to suggest that, as the physician's acceptance and adoption of clinical IT is the key to successful implementation, it is vitally important to explore how factors such as doctors' perceived ease of use and usefulness impact on their acceptance. The researcher has not found any studies of technology acceptance in Saudi doctors or diabetes specialists with reference to mHealth technologies such as diabetes management applications.

2.5 Research Hypotheses

The literature review, once related to the research questions (see above 1.7) allows us to formulate responses to the first two of the research hypotheses.

There is a significant relationship between application of mobile health services and improvement in the management of chronic diseases (Ha1). A review of the literature supports this hypothesis. In 2014 there were an estimated 95 million users of mHealth (McCann 2014). Although simply owning or using an application does not, of itself, mean that it improves the management of chronic disease, the literature reveals much evidence that this is the case- the field experiments of Hanauer (2009) and Malvey & Slovensky (2014) for example. MHealth applications have many advantages for both doctors and patients and, if properly used can help significantly in the management of chronic illnesses such as diabetes, not least because they make the patient's role crucial in managing the disease.

Saudi Arabia does offer an optimum design and infrastructure for a mHealth system for the management of chronic diseases (Ha2).

It would appear from the literature that Saudi Arabia has the potential for developing mHealth as a way to manage chronic disease, and diabetes in particular. From the point of view of electronic infrastructure and finance available, the literature reveals that this hypothesis is supported. The mobile technology required is certainly there but, as has been suggested, whether Saudi patients and doctors would accept and use the technology requires further investigation, and that is one of the central purposes of this study.

2.6 Chapter Conclusions

A search of the literature revealed an incomplete and unbalanced body of knowledge about the practicality and application of a mobile application for managing healthcare in Saudi Arabia. The literature review indicated that the majority of the mHealth applications were developed under pilot projects. In addition, the majority of existing documentation focused on provision of medical services to patients suffering from infectious diseases such as malaria, HIV/AIDS and tuberculosis. Hence, available research lacked adequate information pertaining to chronic diseases in relation to mHealth applications. This was contrary to expectations as indicated by increased prevalence of chronic diseases conditions in the developing countries. The existence of a knowledge gap regarding assessment of the performance of mHealth applications in relation to chronic diseases such as diabetes, was likely to hinder any evaluation and feasibility study of the acceptability of mHealth application to manage diabetes in the Kingdom of Saudi Arabia

The literature review also provided information as to the likely form of mHealth solution. From a cost and utility perspective, a mobile solution aimed at impacting chronic disease management must conform to several criteria, as revealed in the review of literature.

1. It must be convenient, connected, and controlled by the patient.

2. It must be easy to use.

3. It must not introduce a burdensome workflow addition to physician practices;

4. It must be affordable

5. It must leverage existing communications and healthcare infrastructure.

The literature also suggests gender differences in the self-management of diabetes which is likely to be very high in Saudi Arabia. Avoiding social embarrassment is an important criterion in Saudi Arabia due to which acceptance of mHealth could be high in diabetes self-management. MHealth saves the patient from checking the blood glucose levels in front of others, say a type I diabetes patient at school.However, networking and bandwidth in rural areas could be challenging. Lack of patient-physician involvement in the development of mobile apps has been suggested but to what extent this could be feasible in Saudi Arabia has to be explored.

To enable the focus of the empirical research to be sufficiently narrow so that the respondents have a good understanding of the technology they are being asked to discuss, a concrete solution for evaluation needs to be selected. The solution that most closely meets each of the criteria identified in the literature review is a healthcare disease management application. According to Holtz (2008), a disease management application refers to software that is either installed on personal computers or mobile devices such as cell phones to aid patients manage data and information related to various health conditions. The application is relatively cheap to develop and quick to deploy, utilizes existing communication channels and devices, and can be designed for user-friendliness. The application is built to capture, communicate, and provide actionable information, and yields a tangible benefit. A review of the literature failed to identify any published study of the extent to which a mobile phone diabetes management application would be an acceptable solution to diabetes management within the Saudi context. The following chapter contains a detailed description of the methodology of the proposed mixed-methods study the goal of which is to determine the extent to which Saudi diabetes specialists, Saudi doctors, and Saudi diabetes patients would accept implementation of such application.

CHAPTER III: RESEARCH METHODOLOGY

3.1 Chapter Overview

In this chapter the different research methods, philosophies and approaches are evaluated to determine the approach and design best suited for the purpose of the study, with a brief consideration of why alternative methods were considered unsuitable. Efforts have been made to eliminate the influence of personal bias in determining whether the qualitative or the quantitative method would be more appropriate for the study. This chapter also explains the relevant ethical concerns, and how the reliability and validity of the study has been achieved.

Based on the gaps in the literature, this study seeks to find the most suitable solution to mHealth in diabetes management in the KSA environment within the constraints of lifestyle factors, literacy levels and cultural mindset of people living in the KSA. A methodological approach to develop a deeper understanding on the successful adoption of mHealth for diabetes in the KSA will be selected to ensure academic rigour and maintaining objectivity.

The research methodology consists of interviews which provide data for the design of a questionnaire that seeks to gather information about how diabetes is managed without mHealth technology in order to predict acceptance and adoption if a new technology was to be used. In this case the technology in question is the mHealth application for diabetes management.

3.2 Philosophical Debate

Darlastas-Jones (2007) argues that reality is subjective and socially constructed by and between the persons that experience it. However, individual perceptions differ and hence reality may differ across individuals. In addition, reality may also be influenced and shaped by the current political, social, historical and cultural circumstances. Therefore, reality is completely subjective and can differ across different periods in time. This is the subjective approach based on interpretive philosophy. It must therefore be noted that asking diabetes patients about their experience of treatment and self-managing their illness will elicit subjective responses. What is important in this research is to consider whether people deliberately lie, and whether their perceptions are realistic. For example, when asked about how they are managing their illness, a respondent might lie because they are embarrassed about not managing their illness well. Alternatively, they may believe they are managing well because they do not understand what good self-management is. It is therefore important to take this into account when formulating questions, interpreting answers as well as making sure that every effort is made to reassure participants of anonymity and confidentiality. An account of how these issues were addressed is given in the relevant sections of this chapter.

3.3 Research Phenomenon

While it is important to understand the research process, it is also important to understand why the topic is being researched. Because of the various factors involved in the implementation of mHealth for diabetes management in the KSA, it is of interest to explore how best mHealth could be successfully implemented. This has led to the formulation of the research objectives.

The literature reviewed highlights both positive and negative aspects of mHealth in diabetes while also highlighting the constraints in the KSA. To arrive at an appropriate solution in mHealth requires an evaluation of the constraints and how they could be mitigated.

3.4 Research Design and Justification

The complexity of issues in mHealth and the factors that influence decision-making in implementing mHealth in KSA, make it advisable to adopt a mixed methods approach to research. Quantitative methods would be advantageous in exploring the constraints, the mindset of diabetes patients and doctors and their acceptance of technology. Quantitative data gathered from diabetes patients could serve as a reference point for evaluating mHealth in diabetes in developing countries.

The use of qualitative data allows more in-depth exploration of a complex issue. What is sacrificed in terms of not being able to generalize, is gained in terms of getting greater detail and allowing for participants to express concerns that the researcher may not have been aware of from the beginning. In the case of this study, the researcher is not a specialist in diabetes, and it was useful to gain more in-depth information from doctors who were experts in this area.

Several ways to generate knowledge have been identified in research texts as many theories of knowledge have shaped studies and practices in different fields (Al-Habil, 2011). Generally, research texts link quantitative and qualitative methods of research with positivism and interpretivism, without any guidelines, which only adds to the dilemma of researchers. There is a tendency to adopt the most familiar method or the most commonly used method but this may lead to misalignment between the research philosophy and research methods. Therefore, the two most used research methods, the qualitative and quantitative methods, have been evaluated below and the justification for their adoption for this study provided.

3.4.1 Qualitative (inductive/interpretivism)

Human values cannot be detached from generating knowledge (Al-Habil, 2011) and hence it is important to explore the experiences and suggestion of specialist doctors on the issue of mHealth. This is a valid approach to generate knowledge instead of simply relying on objective knowledge. This, being an interpretive approach, is based on the assumption that the vocabulary of social science is based on action concepts, which help to describe things. This approach also helps to describe behaviour, the aim and intent behind the behaviour, thereby enabling the researcher to gain insight into the meaning that doctors attach to their actions. This method eliminates the possibility of the researcher deriving wrong conclusions from the observations made. Besides, interpretivism is based on the assumption that reality is determined by the lived experiences, and is also influenced by the values, norms, social background and culture of the subjects as well as the researcher (Al-Habil, 2011). The culture of KSA has a major role in determining the impact of mHealth and hence this research approach is justified. This method also helps to first gather data and then develop hypotheses. However, this method is more susceptible to researcher bias. To address this, efforts will be made not to allow previous beliefs and values to influence the outcome of the study. The advantage of this method is that the research strategy can change as the study evolves.

3.4.2 Quantitative (Deductive/Positivism)

This is a scientific method and the data gathered is empirical in nature. This method eliminates the disadvantages of the qualitative method such as interpretations based on preconceived ideas, selfish interests and values (Al-Habil, 2011). As the researcher remains more detached from the subject, researcher bias is minimized and the values and ideologies of the researcher do not influence the outcomes to the same degree as they are likely to do when a qualitative methodology is adopted. Subsequent recommendations are more likely to be based on generalisations made from representative samples. Data from patients and doctors is essential to develop insight into the concerns, problems and queries about diabetes management, which would help derive solutions. Therefore, in addition to specialist doctors' opinions, empirical data from patients and doctors engaged in delivery of healthcare would be crucial and surveys of these groups will also be conducted. A discussion of the reasons online surveys rather than ones that use hard copies of questionnaires as well as the sampling methods used are considered later in the chapter.

It thus appears appropriate to adopt a mixed method as the disadvantages of one method could be overcome by the advantages of the other method. For instance, through the positivist approach it is more difficult to develop insight into human behaviour and actions. Communication with specialist doctors would therefore not be as productive through the positivist approach and the patients may not be as willing to communicate through an interpretivist approach. In this study, the social context is as important as individual beliefs and values, and both objective knowledge and subjective reality is essential. Thus, a combination of data from interviews, from questionnaire survey and literature review would help corroborate findings. Use of multiple research methods can be essential in understanding and evaluating certain activities, projects or processes (Wynekoop & Russso, 1997).

The focus of the mixed methods study is to explore the experiences of a purposive sample of Saudi diabetes specialists and Saudi diabetes patients about the extent to which a mobile phone diabetes management application would be an acceptable solution to diabetes management within the Saudi context. Oncea mobile phone diabetes management application was identified (see previous chapter, 2.2.8) as suitable for use in the Saudi context, primary data in the form of semi-structured interviews and online surveys were collected and analysed to determine to what extent this would be an acceptable solution.

3.5 Specific Methodological Advantages and Disadvantages

Advantages and weaknesses of mixed methods have been discussed in the literature (Chamblis et al., 2006; Creswell, 2002; Creswell et al., 2003; Creswell, 2010; Maxwell, 2005). Some advantages specific to the proposed study include:

a) The sequential exploratory mixed methods design will allow for examining the quantitative results in more depth and in context, and

b) The mixed methods design could be useful to explain unexpected quantitative results.

Some limitations to a mixed methods design are that:

a) It may be more time-consuming to conduct than a single method

b) It requires the resources to collect and analyse both quantitative and qualitative data

c) It may yield data that shows no significant findings.

3.6 Phased Research Design

Semi-structured interviews were conducted to gain rich information about the problems that Saudi diabetes specialists believe their patients have in accessing healthcare and managing their illness and to gauge their reactions to a diabetes management application. Two surveys (Patients and Doctors) were conducted online to identify what patients and healthcare professionals working in healthcare (the stakeholders) would accept in an mHealth application that would enable patients to communicate with their healthcare providers and to receive feedback from them. The surveys were specifically aimed at stakeholders involved with diabetes. The aim of the surveys was to provide information with which to determine the appropriate mHealth application suitable for Saudi patients with chronic diseases such as diabetes and identify any possible obstacles as well as benefits of such an application.

The conduct of the study is divided into two phases. Phase 1 entailed a semi-structured interview conducted with five diabetes specialists and Phase 2 consisted of quantitative survey questionnaires delivered to doctors specialists and diabetes patients over 18 years old and participants in remote areas, women and non-Saudi citizens that meet the selection criteria and to diabetes doctors. Selection criteria for diabetes specialists include licensed practitioners who have five or more years of experience and criteria for Saudi diabetes patients were that they are having active treatment for diabetes at the time of data collection.

Creswell (2014) terms this type of mixed methods approach as 'Exploratory Sequential' where the initial qualitative phase is used in part to form the quantitative phase. The reason for using this design is to see if the detailed information gathered in the first phase can then be used to design a research instrument which will allow quantification and thus generalizations; as well as highlighting what factors need to be addressed. The best option for sample selection is that the samples in each phase are drawn from the same target population, but that the same people are not used. In this study the interview sample is drawn from diabetes specialists, whilst the survey samples are drawn from populations of Saudi diabetes patients and general practitioners.

The overall goals of the study in relation to the population of the study were to determine:

1. Current experiences and attitudes of Saudi diabetes specialist doctors in delivering care and communicating with their patients and what difficulties these doctors may have.
2. Current experiences of Saudi type 1 and type 2 diabetes patients in managing their illness and what difficulties they may have.

The specific objectives of the online surveys were to determine:

1. How patients in Saudi Arabia with type 1 and type 2 diabetes self-monitor their health.
2. How these patients take care of themselves in terms of factors such as diet, exercise and keeping themselves informed about their illness.
3. What problems (if any) these patients have in self-monitoring and self-care.
4. Whether these patients have Smart phones and how open they are to using applications to send and receive information with their healthcare providers.
5. What doctors with diabetes patients expect these patients to do in terms of self-monitoring and self-care.
6. What ongoing care doctors are currently offering to diabetes patients.
7. How frequently and with what media doctors communicate with their patients between visits.

8. What problems (if any) these doctors have in delivering healthcare effectively to their diabetes patients.
9. Whether the doctors and patients are open to using mHealth and what they would expect from a diabetes application.
10. What barriers exist to the adoption of a diabetes management application.

3.7 Phase One: The Interview Study

The qualitative study was planned as an exploration of the perceptions, attitudes, and lived experiences of a small number of participants purposively selected from among Saudi diabetes specialists. The following section contains a discussion of the nature of the qualitative portion of the proposed study and the techniques used for data collection and analysis. The approach is based on phenomenology, a research philosophy focused on the lived experiences and worldviews of a small number of people with which to obtain in-depth meaning of a particular aspect of an experience (Rossman & Rallis, 2003).

3.7.1 Appropriateness of the Research Design

Semi-structured interviews were conducted during Phase One in order to get a rich understanding of the issues from the specialists' point of view. Qualitative research is often characterized by personal contact, semi-structured interviews, and open-ended interview questions (Ibarra, 1996).

Semi-structured interviews for the proposed study offer a way to gather data essential for understanding the perceptions, attitudes, and lived experiences of Saudi diabetes specialists. The results will provide information that might be missing if a quantitative research method alone was chosen (Denzin & Lincoln, 2005; Ibarra, 1996). Data collection is focused on face-to-face interviews with which to explore themes as they arise to “explore, process and find meaning” in the participant’s experiences. (Creswell, 2012 p.146)

An alternative approach to gaining qualitative information from diabetes specialists would have been to use a focus group**.** This would have been useful, as discussion among specialists would have possibly generated more issues around treatment and self-management of diabetes and in particular would have allowed the specialists to discuss their reactions to the video on the diabetes management application. This method was however rejected for the following reasons:

- The difficulty of having to find busy specialists who were willing to give up their time to attend such a group.
- The impossibility of running a focus group with specialists of both genders, given the cultural restrictions on mixed sex activities in Saudi Arabia.
- Having to find and train another interviewer to run a focus group for female specialists.
- Individual interviews ensure that each specialist is given the opportunity to give his/her views; whereas in focus groups the more powerful personalities can dominate the discussion.

For these reasons, the use of focus groups was not considered appropriate for use in this study.

3.7.2 The Role of the Researcher

In the qualitative study, the role of the researcher is to conduct semi-structured interviews with Saudi diabetes health specialists, in order to collect data with which to test the hypotheses. Specialists were contacted, reassured of anonymity and confidentiality and told what the research is for and what will be expected of them at interview. The researcher was aided here by his existing work role in the Saudi health service. They will also be informed of the approximate length of the interview. The researcher must record, transcribe and analyse the interview data with awareness that his perceptions of the topic may affect its interpretation.

3.7.3 Participant Selection

A purposive selection was made of one type of participant (Saudi diabetes specialists). Referred to as purposive sampling, this method is often used in qualitative research (Creswell, 2012). Marshall and Rossman (2011) suggested that no more than 10 purposively selected participants should be interviewed due to the volume of data anticipated from long, open-ended questions, transcription, and analysis of the data collected. Selected participants provide historical information that helps the researcher understand the problem and allow control over the line of questioning (Creswell, 2009). Thus, the researcher had to identify, contact and recruit Saudi diabetes specialists as participants. The researcher recruited five such participants.

3.7.4 Procedure

The conduct of the study proceeded as follows: a covering letter (Appendix A) asking potential participants to engage in the study was sent to a selection of participants characterised by their status as stakeholders. Those not responding within two weeks were sent a follow-up letter. From those that responded positively, a selection was made to balance the numbers among stakeholders. Appointments were made for 25-30 minutes with each participant at a time and place convenient to them. This is less time than ideal, but considering that doctors are particularly busy professionals, it was considered to be a realistic time frame. The procedure and conditions of the study were reviewed prior to audio-recorded interview. A semi-structured-interview (Appendix D) was designed, to be delivered orally. The results of the interview would be used to develop a picture of each participant for use in Chapter Four to identify the general circumstances of each participant as well as their experiences of the difficulties their diabetic patients may have and their reactions to a diabetes management application.

3.7.5 Instrumentation

A semi-structured interview containing open-ended questions based on the research questions shown in Chapter 1 was developed, consisting of several questions with which to develop information about each research. This was done to assess what problems the doctors perceive their diabetes patients have with managing their illness, in terms of receiving adequate treatment and information, being able to communicate with the specialist and managing their illness at home; also, to ascertain what doctors think of the mHealth solution to diabetes management. The use of an interview protocol ensures all participants are asked the same questions, to make good use of limited interview time, and make interviewing multiple participants more systematic and comprehensive (Van der Putten, 2008). Patton (2002) stated that interview protocols are particularly beneficial for in-depth interviews because they help the researcher keep focus on the subject by guiding the direction of the conversation. However, participants will be allowed enough latitude to give their perspectives and experiences (Patton, 2002). The Interview Protocol is also used to record the time, date, and place of the interview, and special conditions or circumstances that may affect the interview. With the guided interview, Marshall and Rossman (2011) found this method, in fact, is based on an assumption fundamental to qualitative research: the participant's perspective on the phenomenon of interest should unfold as the participant views it, not as the researcher views it. This is something that the researcher must endeavour to keep in mind during the interview at all times.

3.7.6 Data Analysis

Theme discovery was implemented as the data analysis method, which is appropriate to respond to the questions: "who says what, to whom, why, how, and with what effect" (Babbie, 2013). Patton (2002) argued that data collection should be followed by inductive reasoning, a process for developing conclusions and generalizations. Qualitative data needs interpretation and should be organized into categories to enable construction of a picture. Storage of data collection, the transcription of audiotapes and data analysis will be maintained on computer files with backup copies created. The anonymity of participants will be protected during the study.

3.7.7 Ethical Considerations for the Semi-structured Interview

Cozby (2004) emphasized that "ethical concerns are paramount when planning, conducting, and evaluating research". Ethical concerns should be minimized because of the confidential nature of the study. Participants were assured during the interview that their identities would be anonymous, though they would be afforded the opportunity to provide information about basic demographics of their lives such as gender, age, education, and position with the organization they represent. Ethical concerns are inherent in any form of research study involving the use of human subjects. Procedures for protecting confidentiality during data collection, analysis, reporting, and storage were observed to reduce the risk of causing harm to the human subjects as well as the reputations of the cooperating organizations where the study was to be conducted and conducted from (Bond**,** 2004) and the University's ethical research guidelines were observed.

The researcher protected the safety and identity of the participants as (a) a pseudonym (Dr A, B, C etc) was assigned to each participant replacing their actual names, (b) only the researcher exclusively would know the actual identity of the participants, (c) shared data would contain no identifying information that could identify the participants by name, and (d) participant interview responses would be kept confidential until the end of the project and then destroyed. The initial letter of invitation to participate and consent form emphasizes that the researcher will maintain anonymity indefinitely (Appendix C).

Leedy & Ormrod (2005) asserted that research participants must be protected from harm, be guaranteed privacy, and sign an informed consent form. Participants were questioned to ensure they understand the nature of the study and that participation was voluntary. No rewards were offered to encourage participation, nor were there any sanctions applied if the participants declined or withdrew from the study. No information regarding participation was communicated to the employing organization. No identification information about the participants was used in any publication or presentation based on the study. Participants were informed that the results will be used only for purposes of the thesis, but also may be used for scholarly and professional journal articles or presentations. All materials relevant to the data will be retained in a secure location until research is finished, after which all documentation will be destroyed.

3.7.8 Informed Consent for Interviewees

During the initial contacts with the prospective participants, the researcher provided a description of the study, described the approximate amount of time needed to complete the interview, and after the participant agreed to be interviewed, obtained informed consent from each participant. The following procedures were implemented to protect the participants' rights:

1. Participants were advised in writing of the voluntary nature of their participation and the ability to withdraw from the study at any time without penalty. They were advised that at any time during the process they could decline to answer any question.

2. The research objectives have been clearly delineated in writing and articulated to the participants.

3. The participants have been informed in writing of all data collection methods and activities.

4. Provisions were made for monitoring the data collected to ensure the safety of the participants' identities.

5. Written transcriptions and interpretations of the data will be made available to the participants.

6. The participants' rights, interests and wishes will be considered first when choices are made regarding reporting of data and the final decision regarding participants privacy will rest with the participant.

The researcher and participants determined the place for conducting the interview in a quiet location free from distractions and ascertain if the location lends itself to audio recording (Creswell, 2012; Marshall & Rossman, 2011). A schedule for a follow-up meeting with participants to review responses to interview questions and plans for using the results from the interview may be discussed (Creswell, 2012; Marshall & Rossman, 2011).

3.8 Phase Two: The Survey Studies

The quantitative survey studies explored the experiences and perceptions of diabetics in Saudi Arabia and of doctors who treat the illness. The following section contains a discussion of the nature of the quantitative study and the techniques used for sampling, data collection and analysis. It was hoped that the surveys would attract up to 300 or more patients, and up to 30 doctors.

Quantitative research is a statistically-based deductive approach used to answer questions that quantify the characteristics of a target population and measure specific attributes (Cooper & Schindler, 2008). Quantitative studies begin with well-defined research questions and purpose statements, which lead to logical hypotheses. This part of the research was based on the hypotheses stated in Chapter 1 (Pelosi, Sandifer & Sekaran, 2001). The benefits of a quantitative approach include the ability to provide consistency and eliminate bias as a result of the objective nature of the statistical methods and the consistency of data collection (Creswell, 2009).

3.8.1 The Samples

According to the Saudi Ministry of Health (2008), diabetes costs Saudi Arabia approximately 51 billion Riyals (£8.5 Billion) per annum. They cite information from the International Diabetes Federation, which estimates that approximately 25% of Saudis have some form of diabetes. This makes the total target population a very large one. With regard to diabetes specialists, there is usually one such doctor in each hospital. The Director of the Diabetes Centre in King Saud University in Riyadh has pointed out that this is only 10% of what is required. He also confirmed that about a quarter of the total Saudi population were diabetes sufferers (mbc.net, 2012)

According to Oates, a sampling frame "is a list of the whole population of people (…) that could be included in the survey" (2012). This means that the total target population for the diabetes survey is potentially enormous. The sampling frame for the patients consist of patient lists held by doctors who specialize in diabetes as well as any lists held by the Saudi Diabetes and Endocrine Association (SDEA), which works under the aegis of the International Diabetes Association. It should be noted that these sampling frames are probably incomplete for a number of reasons. First, they may not contain all Saudis suffering from diabetes, as not all will have necessarily been diagnosed. Secondly, the lists may be out-of-date. As not all doctors will be asked to pass on the survey link, it will not be possible to contact all patients in the sampling frame. In order to widen the number of respondents, each patient contacted by their doctor or by the SDEA were asked to pass the survey link on to other people they knew of who have diabetes. To avoid duplication, very clear instructions were given that respondents are not to fill in the questionnaire more than once.

Because the number of Saudis with diabetes is very high, around four and a half million, it would be a major task to use a rigorous probability sampling technique such as random, stratified random, systematic or cluster sampling, to obtain a sample. However, as "non-probability sampling provides at best only a weak basis for generalizations to the wider population" (Oates, 2012), steps are needed to be taken to try and ensure that the sample was representative of the wider diabetic community. The researcher used an opportunity sample of hospitals in Saudi Arabia to gain access to respondents. The sampling frame for patients was the list that hospitals have of diabetes patients. It may also be possible to approach organisations such as Saudi charities that help people with diabetes and may have lists of these patients. As the lists of patients will be confidential, the researcher will contact organisations and ask that patients be given the link to the questionnaire on the understanding that confidentiality is assured and that no pressure is put on patients to respond. The researcher also sent the link to doctors and patients that he knew or had direct contact with.

It might have proven difficult to ask doctors to send the link to patients with certain characteristics such as sex or age. For this reason, the survey included a number of questions aimed to obtain a personal profile of respondents so that the researcher would be able to show how these demographic factors are distributed in the final results. It was possible to compare the demographic distribution of the survey respondents with the distribution in the population of Saudi diabetics. The researcher aimed to get about 300 patient respondents and about 30 doctors. This sample size should prove relatively easy to obtain as the researcher had contacts in the Saudi Health Service.However, if there is a good rate of response this could be significantly higher.

There are other factors to be considered when deciding whether the sample is representative. Firstly, although hospitals in cities serve city populations, many of their patients come from remote areas. The biggest hospitals were selected, as these are most likely to have a large number of patients. Secondly, a number of female doctors, who will have female patients, were approached to send the link. Thirdly, older patients, who may not have their own computer, would be able to access the survey as the relatives who live with them will have access to a computer and it is their e-mail contact address that doctors will have. Finally, the questionnaire contained a section where the respondent is required to give information about their age and gender so that the survey was able to record how many respondents in each category have taken the online survey.

The sampling used to obtain patient respondents would therefore be non-probabilistic. Oates notes that this has to be used when “the time and costs of obtaining one (a representative sample obtain through probabilistic sampling techniques) are too great” (Oates, 2012). The sampling methods used to obtain the diabetic patient respondents were three-fold. Firstly, the researcher visited hospitals and obtained information from doctors as to where the patients come from, so as to try and get the questionnaire link sent to patients in rural areas. The researcher also visited rural areas in order to ask diabetes patients to fill out the questionnaire. This was to ensure the survey adequately represents diabetes patients from rural areas.

Secondly, purposive sampling was used, and particular doctors were approached to send the link as they worked in large hospitals and had many patients. These doctors were asked specifically to send the link to patients coming from remote areas. Also doctors who were personally known to the researcher were approached, as they were more likely to agree to send the link to their patients. Thirdly, snowball sampling was used when asking respondents who live in rural areas to pass on the survey link to people they know who have diabetes. The researcher comes from a rural area and was able to use contacts to achieve this. Similarly, doctors were asked to pass on the request to send the link to diabetic patients to other doctors they knew who have such patients. Oates notes that snowball sampling “can be used in conjunction with purposive sampling (and)…is useful when the researcher does not know how to get in touch with the target group” (Oates, 2012)

These measures in part ensured that the link was at least sent to patients in rural areas It is, however, difficult to predict the response rate from this group. No specific question about patient’s area was included in the questionnaire. In Saudi Arabia there is a lot of prejudice against people in rural areas, which are seen as deprived, and they are often judged on this basis. There is no discomfort with being asked about age but asking questions about where someone comes from can be a sensitive issue. According to Al Arabiya News (2014) the majority of the rural dwellers have been termed as ‘stateless’ as they lack Saudi Arabian citizenship. The Bidoon who are the descendants of Bedouins are not eligible to register for marriage, enroll in public schools or access medical treatment.

Issues of confidentiality preclude a researcher having direct access to patients’ e-mails and so it would not be possible for the researcher to obtain sampling frames to conduct probabilistic samples. For this reason, purposive and snowball sampling was used. With regards to the sample of doctors who were approached to fill in the online survey, those who are most likely to answer the questionnaires were approached. These were those who have been approached to pass the survey link on to diabetic patients.

3.8.2 Web-based Surveys

Fowler (2009) notes that utilizing Web-based surveys are cost efficient and effective; this method facilitates both the process and consistency of the data collection. Aiman-Smith and Markham (2004) identified these survey instruments as an effective way to measure attitudes.A survey-based quantitative research design was used to implement data collection and statistical testing (Cooper & Schindler, 2008). The goal of the present empirical study was to quantify the characteristics of the target population and to look at the research question from a broad perspective based upon the sample characteristics. The survey questionnaire study approach seemed an appropriate method of data collection for Phase 2 of the proposed study as it would be impossible to travel to all areas in Saudi Arabia and question respondents face-to-face given the cost and time restrictions. There are other difficulties such as the objections to a male researcher having face-to-face contact with female Saudi respondents. Distribution of questionnaires to Saudi Arabia would be expensive and difficult if questionnaires had to be mailed to respondents. Thus, the on-line questionnaire survey is the most efficient way of collecting the data required. Given the nature of the Internet, the location of the respondent is not a problem and the survey can be instantly accessed and returned. This survey was cross-sectional and collected data on the current situation in Saudi Arabia. This study merely seeks to look at the current situation, so it is not necessary to monitor changes in attitudes and behaviour over time. For this reason it was not seen as necessary to carry out a longitudinal study.The survey questionnaire was conducted to identify what diabetes patients and doctors (the stakeholders) were looking for in an m-Health application that would enable patients to communicate with their health care providers and to receive feedback from them. The survey was specifically aimed at stakeholders involved with diabetes. The survey would then allow the researcher to decide if an m-Health application would be suitable for Saudi patients with diabetes and identify any possible obstacles as well as benefits of such an application. The responses of patients and doctors could also be compared.

A quantitative questionnaire was able to reach female participants not accessible face-to-face as the researcher would not be allowed to interview female participants. Furthermore, the stakeholder groups are spread over a wide geographical area so the research would attempt to include patients with limited access to specialist hospitals and clinics, and healthcare professionals who served a geographically wide range of patients. An electronic version of the survey questionnaire was chosen as this was far easier, quicker, and cheaper than sending paper questionnaires to Saudi Arabia. Many people in Saudi Arabia use a personal computer so distribution was not a problem. Survey Monkey® was chosen to manage and distribute as it is easy to use and provides results automatically when the survey is completed. Having a survey tool that allows the automatic capture and cataloguing of respondent data saves time. It was decided to limit the number of questions to fewer than 25 so that respondents would not be deterred by a lengthy questionnaire, while still allowing depth of questioning.

3.8.3 Questionnaire Questions

The questionnaires for both doctors and patients were divided into three main sections. The first section was designed to obtain information about the respondents (age, gender and so on); the second section involved questions about problems with managing diabetes in terms of giving and receiving treatment and information and the last section looked at their level of acceptance of an mHealth solution.

It should be noted here that there are limitations to the use of a technology acceptance model such as the UTAUT in predicting intention to use a specific piece of technology such as a diabetes management application in a specific context like the Saudi health system. Studies on technology acceptance of mHealth have shown that the UTAUT constructs have varied ability to predict intention to use (Iakovidis et al. (2004); Cugelman et al. (2011); Ifinedo (2012); Yuan et al.(2015)) which suggests that the model needs to be refined to fit the context. Furthermore, there is a gap between stated intention to use and actual use behaviour which can only really be bridged in a situation where actual use can be investigated. In this study, which explores a situation where mHealth is in its infancy, only intention to use can be explored.

Nevertheless, the surveys are in part designed to test acceptance of mHealth technology. The four major constructs: Performance Expectancy (PE); Effort Expectancy (EE); Social Influence (SI) and Facilitating Conditions (FC) will be tested as follows:

Patients' survey (Twenty-one questions)

Performance expectancy

The potential usefulness of a diabetes management application was explored by identifying patients' needs in relation to managing their diabetes. This was to ascertain if there were genuine needs which could be filled by the use of an application; notably being alerted to check blood glucose and take medication; acquiring the information needed to manage diabetes successfully and to save having to go to appointments; all of which were identified in the interviews as being the source of possible problems with self-management (See questions 7,9,10,12,13,15 and 17). Identifying needs that could usefully be solved by an application does not of course mean that this useful technology will be perceived as useful by the people it is intended for, in this case Saudi diabetics. With new technology, the participant needs to know what it does before they can comment on its perceived usefulness. For this reason, specific questions tested PE after the participant had been shown a brief video of what the application could do. They were asked about whether they would feel comfortable sharing medical information in this way (Question 16) as technology will not be perceived as useful if its security is mistrusted. Participants were also asked which features of a diabetes management application would be particularly useful to them (Question 18) as well as if there was anything that would prevent them from using the application (Question 21). The option "I don't think it would help me manage my diabetes' was specifically aimed at testing PE. This construct is of great importance when testing for acceptance of medical technology as users need to trust it if they are to make it part of their treatment routine.

People must be certain that a piece of technology is suitable for them to adopt it. In this case, the design of the questionnaire regarding the mHealth in Saudi Arabia had to seek diabetics’ as well as medical practitioners’ perception about its performance. In line with this requirement, questions were designed in part to test trust in the performance of the technology.

Effort Expectancy

This is difficult to test for in a population where some individuals have never used a mobile application and have little experience of using electronic equipment. The interviews revealed that diabetes specialists thought that older patients with low levels of education might particularly have problems. The other factor to take into account is that 'degree of ease' could mean how easy it is to operate the technology or it could mean the amount of time that is taken up by using the technology. The two are linked as it will take someone who is unclear as to how to use the application more time to use it and there is also time taken up by becoming accustomed to the process. For this reason there were two options in Question 21 which were designed to test for EE; namely 'Sounds too complicated' and 'Takes too much time'.

Technologies that are inefficient in the sense that they require a lot of time, or they are too complicated to use are less likely to be adopted. This construct played a crucial role in the design of questions. The government and Ministry of Health would need to be sure that the level of ‘ease of use’ was known before introducing the technology. For this level to be known, questions regarding the complexity of the technology had to be introduced, hence influencing the design of the questionnaire.

Social Influence

The main area that was focused on was the possible social influence of physicians and how patients perceived their relationship with their doctor. The question on how patients acquire medical information (Question 11) contained the option 'My doctor gives me information' and Question 18 about what features of an application were perceived as useful contained the option 'Feedback from my doctor'. Positive responses to these questions suggest that doctors are looked to for help and could be key in encouraging the use of an app.

Customs and traditions play a critical role in any population. People tend to cling to what they have been doing for a long time and are usually uncomfortable with change. Questions had to be introduced to test the level of willingness on the part of diabetics to change from the traditional ways of getting information.

Facilitating Conditions

Again this was difficult to test as the participants needed to access and be able to use a computer to complete the online survey. Thus in theory 100% of them would have access to a computer and be able to use it even if they did not have a Smart phone. Secondly, the sale of Smart phones in Saudi Arabia has been shown to be escalating (Albabtain, 2014) so even if the survey revealed that some participants did not have a Smart phone, this situation could change. It was more important to find out if the Saudi health system had the facilitating conditions that would support a diabetes management application (See doctor's survey). However, three questions were designed to test facilitating conditions. Firstly, participants were asked how they obtained medical information (Question 11). One option was 'The internet'; if a high number responded that they obtained information that way, it would suggest that the facilitating conditions for receiving medical information electronically was in place and seen as usable. Question 20 asked

what platform would be preferred; giving the option for using both a computer and Smart phone and one for 'neither'. The final question on barriers to technology acceptance gave the option 'no access to a Smart phone or computer'.

For any technology to penetrate to the intended population there must be an infrastructure sufficient to support the technology. In this case, the mHealth technology heavily relies on availability of Smart phones and PCs. Question had to be designed to capture information about the level of penetration of Smart phones and PCs in Saudi Arabia and the ability to use them. These two requirements were the facilitating conditions for this piece of technology to penetrate the patient population.

Doctors' survey (Seventeen questions)

Performance Expectancy

Doctors were asked to focus on their patients' needs (Question 10) as a way of gauging what they would expect of an application. Question 4 specifically addressed the issue of female patients refusing to see a male doctor, as remote monitoring and communication, such as that done by an application is a partial solution to this. The doctors were shown the same information video about how a diabetes management application works. Interviews with diabetes specialists had indicated that not much was known about this technology and it was deemed important to make sure that doctors knew what the app could do before commenting on it. They were asked whether they would consider it as a means of facilitating monitoring and communication with their patients (Question 11) and Question 12 asked about their perceptions of the benefits for their practice of patients using diabetes management application. As with patients, doctors were asked about their perceptions about mobile data security as a lack of confidence about this would affect perceptions of PE (Question 15). This issue was brought up again in Question 16 where doctors were asked what factors might affect their decision to introduce the app. in their practice another aspect was 'cost to the hospital' as technology that was thought to be too expensive is not so likely to be considered as a useful solution. In the last question, where doctors were asked about the 'drivers' of adoption of solutions like the diabetes management application, one option was 'Clinical quality improvement'.

As mentioned earlier, for the technology to be adopted, every party must be convinced that the technology was going to work otherwise the technology would fail as a solution to the management of diabetes. In the survey, the questions had to elicit the doctors’ perceptions about a piece of technology. If the doctors discarded the technology as a solution by viewing it as not adequately performing, introducing the technology would be unwise.

Effort Expectancy

The interviews had revealed that although doctors were concerned that their patients might not be able to use the application, not much was said about their own abilities. They seemed to be more concerned with the possible increase in workload that the app would generate and suggestions were made that data from the apps could well be monitored by staff allocated for that role. Question 16 about what might affect the doctor's decision to introduce the app as a solution contained the option 'This solution could be difficult to use' which is a direct question about effort expectancy. To the doctors as well as the patients, the technology had to promise reduced efforts. If the doctors anticipated that it would require too much effort to use the technology, then the adoption of the technology would be problematic. To test this aspect, questions had to be designed to elicit doctors’ expectations of this aspect.

Social Influence

In a situation where a particular piece of technology, such as the diabetes management app is not already in place, it is not easy to gauge the effect of social influence on acceptance. It was not considered appropriate to make questionnaires to busy doctors too long, and including hypothetical questions about whether they thought their colleagues and managers would encourage them to use the app was asking the doctors to answer for other people on a subject they had probably never discussed with them. However, the last question on the 'drivers' of technology adoption did include the category 'Government mandate' in order to see how doctors perceived the impact of the Ministry of Health as social influence. Doctors also could have opted to retain their traditional ways of administering treatment compared to changing. The questionnaire had to gather information about the doctors' willingness to change.

Facilitating Conditions

Exploring this factor formed a substantial part of the doctors' questionnaire. They were asked what technologies they used to monitor their patients between appointments (Question 5); send lab reports (Question 6); send treatment recommendations (Question 7)and appointment reminders (Question 8). This was both to get a picture of the monitoring and communicating with patients and to see what technologies were in place. Question 13, however, specifically asked doctors if the resource capacity at their practice could integrate patient communication and data shared via an app, which is a direct way of measuring perceptions of facilitating conditions. It was also critical to get information about the level of infrastructure to support the technology that the doctors had. Without the necessary infrastructure the technology was not going to work and hence necessary to design questions that would make this information available. From the above constructs it is very clear that UTAUT highly influenced the design of the surveys.

The constructs were used to formulate specific hypotheses that related directly to each of the four main constructs of the UTAUT model as apply to this context as follows:

H1: mHealth can be largely adopted if the facilitating conditions like Smart phones and computers are made available. (i.e. adoption correlates with the facilitating conditions.)

H2: mHealth can be largely adopted if it is made easier to use. (i..e. mHealth adoption correlates with effort expectancy)

H3: mHealth can be easily adopted if the privacy of patients and the security of patients are guaranteed. (i.e. adoption correlates with social influence).

H4: mHealth can be adopted if it seen to have high performance. (i.e. adoption correlates with performance expectancy).

There are distinct advantages to using pre-existing questions in research. Firstly, the compilers of such questions are generally experienced in questionnaire design and pre-test the questions before using them in a survey. Secondly, this means that using pre-tested questions can save time. There are pitfalls in that there is no guarantee that exactly the right question will be found, and researchers need to consider the context in which the question was asked and whether it is suitable for their survey. It may also be necessary to be aware of copyright issues, although 'with most questions these do not pose any problems" (Hyman et al., 2006). The questions in the survey were pre-tested questions, as far as possible; however, some of these needed to be adapted to suit the Saudi context. For example, Question 2 on a diabetes questionnaire was on gender and asks: Are you Male__ Female___ Rather not say____ (http://www.surveymonkey.com/s/D6STG79). This question might be considered confusing in the Saudi context. As an Islamic state, Saudi Arabia does not recognize transsexuals and transsexual behavior is identified as homosexual and therefore punishable by law. Operations on people whose physical sex is indeterminate are permitted, but not operations on people of a determinate sex who wish to alter their gender (BBC, 2004). Respondents who may prefer not to answer this question would simply have the option of leaving it out, as instructions would make it clear that there was no compulsion to answer every question. The first draft of the questionnaires will therefore indicate if there are pre-tested questions, if, how and why they have been amended or whether there are questions, which have been designed by the researcher. The questionnaire will therefore use pre-tested questions where possible.

The results of the survey will be used to inform and define what characteristics an m-Health diabetes application should have in the Saudi context to be well accepted. It may highlight what difficulties diabetics and their doctors in Saudi Arabia have in monitoring and treating the illness and any barriers to effective provider/patient communication. It may also pave the way to identifying and testing an m-Health diabetes application with Saudi patients and their doctors.

There are however limitations to using a questionnaire. The number of questions must be restricted so that respondents will not lose interest. There is often a high non-response rate when using questionnaires, and this may bias the results if certain types of respondents reply more than others. Questions have to be very simple and clear as respondents may misunderstand them, and the researcher cannot explain questions to the respondent. However, the non-presence of the researcher means that there is less likelihood of bias caused by the respondent reacting to the researcher in a positive or negative way (University of Portsmouth, 2012).

3.8.4 Ethical Considerations for the Online Survey

As with any sharing of medical information, there is a concern about patient privacy. In some countries, like the UK, US, and other developed countries, patient privacy has been legislated on and stiff penalties are given to institutions and individuals who violate these rules. Trust is a major issue in deploying any healthcare solution in which patient information will be exchanged, and patients must be given the opportunity to opt-out if they choose not have their information shared by means that they do not trust. The danger of data breaches, security and confidentiality are all related and significant issues for both consumers and providers. To gain the trust of participants, and particularly among consumers, the mobile health and chronic disease management surveys must be accompanied by a narrative describing what mHealth is, how it works, and what benefits it delivers to patients. The narrative must also clearly explain the protections the research will provide regarding patient privacy and the right of the participant to opt-out of the research at any time, and have any identifiable information removed from the research records at such time.

The Academy of Management (2011) outlined three core principles that govern the regulation and code of ethics relative to research; these are summarized by responsibility, integrity, and respect for people's rights and dignity. The ethical considerations for this survey should be minimal. The study does not involve special populations and the responses are anonymous. Participation in this research study was entirely voluntary and coordinated through SurveyMonkey®.

The survey instrument was administered online in an anonymous format. A covering letter (Appendix A) asking potential participants to engage in the study was sent via SurveyMonkey® to a selection of participants characterized by their status as stakeholders. Those not responding within two weeks would be sent a follow-up reminder by SurveyMonkey®. Although the survey included demographic questions for the purpose of categorizing the responses no identifying features are included. Respondents had the option to terminate the survey at any time or skip any questions that they are not comfortable answering. No one, including the researcher, had access to individual survey results. The aggregate data will be retained electronically until research finishes, after which it will be destroyed.

3.8.5 The Video

One of the major difficulties in judging future acceptance of technology is in finding a way to give stakeholders a realistic idea of what is being proposed. Videos of possible scenarios, widely used in user-centered design, are proposed as an effective way of reducing this difficulty.

All participants of the survey (as well as the diabetes specialists who were interviewed) were able to access a short video, made by the researcher, about the diabetes management application as part of the online survey. They were asked to view the video before they were asked questions about their reactions to the application. The video shows two typical scenarios in which the app might be useful to a diabetes patient and also mentions some of the main functions of a typical diabetes management application. The video was deliberately kept short and simple so that participants would not become bored and would understand the language. The script was also shown as subtitles so that anyone with hearing impairment would know what was being said and to circumvent any technical problems they might have with hearing sound clearly on their PC. The video was made available in both English and Arabic. This was so that any non-Arabic speakers who participated in the survey could view the video in English and so that Saudi participants could view it in their mother tongue.

The video shows two common scenarios for diabetics as follows:

Scenario 1 – Amina

> Amina is shown as needing advice from her specialist as she has been feeling very tired. The hospital she would need to go to is 100 km away and Amina is unable to find a male relative to drive her there for an appointment. Amina is

introduced to the application by her daughter who suggests that she use it to send her recent blood glucose readings to her specialist. Amina does this and is later able to use the app to communicate with her doctor about the results via Skype. She also discovers that she can use the app to track her weight, count her calories and record her exercise; and that there is a food data base she can refer to in order to know the calorific content of different foods. Amina can also use a desktop version of the app on her PC if she needs a bigger screen.

Scenario 2 – Abdullah

Abdullah is shown as finding it difficult to take in all the information his specialist has given him. He has just been diagnosed with Type 2 diabetes and his feelings about this have made it difficult for him to retain all the information. Self-managing diabetes is not easy and he is confused about everything he has to do. Abdullah discovers the existence of the diabetes management app on the Internet and the basic functions described in Scenario1 are briefly repeated. Abdullah also finds it useful to access a diabetes social networking site where patients can swap information about the illness via the app. The video ends with an image of some of the information that is available in this way.

3.8.6 Data Collection

The third-party online survey vendor SurveyMonkey® was used for the data collection of the self-administered multi-part survey. Internet surveys have several advantageous for both the researcher and participant including speed, efficiency, cost effectiveness, convenience, and flexibility (Fowler, 2009). The use of a third party to collect data provides confidentiality and privacy protection for the respondents (Cooper & Schindler, 2008). SurveyMonkey® will distribute covering letters to participants (Appendix A) together with the Survey Questionnaire (Appendix B).

3.8.7 Data Analysis.

SurveyMonkey® electronically collects and reports on the outcome of the self-administered survey. The collected information was downloaded into an Excel file and uploaded to SPSS for data analysis. The Excel spreadsheet was reviewed initially to ensure that the responses are complete and to determine if there were any outliers that would skew the data. Both descriptive and inferential statistics were examined for the purpose of analyzing and evaluating the data.

Descriptive statistics were calculated for all variables of interest, for example, age, gender, ability to self-manage, difficulties with appointments and so on. Individual questionnaire responses were summarized using counts and percentages and relevant variables correlated. Following the descriptive analysis, a bivariate analysis was conducted to assess for differences in relevant groups (gender, age, etc) for key outcome study variables such as communication with specialist, acceptance of mHealth app and so on. Bivariate correlations describe the effect that two phenomena occur together and are therefore linked. It is important however, nit to confuse correlation and causation, as two variables may be linked but this does not necessarily imply that one causes the other (Statistics Solutions. 2015)

It was felt that, in the case of patients, bivariate analysis might reveal important links between the demographic variables of age and gender with behaviors related to receiving treatment, confidence in self-managing diabetes and willingness to share medical data via Smart phone/computer in the case of patients. Bivariate analysis of doctors' results will concentrate on the relationship between the socio-demographic variables of gender, experience and number of patients and use of text messaging to remind patients of appointments, a behavior which indicates experience in using mobile technology. Also a bivariate analysis of how the demographic factors linked to acceptance of the technology, confidence about patient data security and worries that the solution could be difficult to use (effort expectancy) will be carried out.

3.9 Preparatory Work

"Do not take the risk; pilot test first" (De Vaus, 1993). One of the advantages of conducting a pilot study is that it could show you if you can achieve the aims of your primary research. According to Waite (2002) a pilot study is a pilot project or study as an experimental, exploratory, test, preliminary, trial to try out investigation.

I have chosen a mixed methods approach to my primary research and needed to check the following research instruments: a questionnaire for Saudi diabetes patients, a questionnaire for Saudi doctors and a semi-structured interview for Saudi doctors. My aims in conducting the pilot studies were as follows:

- To check the wording of the questions for clarity – were they understood?
- To check whether any of the questions were seen as inappropriate – either too intrusive or irrelevant.
- To check how long the respondent would have to spend, and whether respondents would be happy to spend that length of time.
- To see if there were other questions that I might have asked.
- To check if the video accompanying the questionnaires was clear, well-paced and gives sufficient information.

- To check if the covering letter was sufficiently clear and reassuring about confidentiality and anonymity as well as making it clear that participation was entirely voluntary and that there was no obligation to answer questions.
- To check if all my questionnaires and interviews were going to cover my aims and objectives and would also improve my primary research.

There are different issues that apply specifically for each of these instruments. The patients' questionnaire needed to be very clear, as it had to be understood by people who are not necessarily well-educated. Also, as these questionnaires were aimed at people who have an illness, it is especially important to make sure that questions are worded sensitively. The questionnaire for doctors, on the other hand, can use complex language, but there may well be questions that the doctors feel would be useful to include. Or they may have useful comments about the video. The semi-structured interviews needed to be piloted to measure the time such interviews take and whether the environment in which the interview takes place was important. The interviews needed to be as free of interviewer bias as possible, so it is important to get feedback about this. The researcher had only a little experience in interviewing, so it was important to get feedback as to whether he is able to establish rapport, elicit full responses and not to 'lead' the interviewee into answering in a particular way.

The pilot interview schedule, questionnaires and video on the diabetes management application had to be prepared. The diabetes survey would use, where possible, questions that have already been used in research. This will mean that the clarity and acceptability of the questions will already have been tested. The questionnaire was also shown to the researcher's supervisors, in order that they could give feedback on the English version of the questions and check the wording of the instructions and covering e-mail. Furthermore, the first draft of the diabetes questionnaire was sent to

Saudi people with diabetes, who were asked for feedback and comments on the Arabic wording. The questionnaire for healthcare professionals was similarly sent to Saudi doctors for their feedback. These respondents can also be asked to make suggestions about questions, which, though clear, they feel should be excluded as well as additional questions that could be included. The reason for this is that treating and having the illness can provide insights, which the researcher may have missed.

The researcher decided to make the video rather than use one that was already in existence for a number of reasons: Firstly, there could be copyright problems; secondly, the video had to relate specifically to Saudi diabetics and finally the video had to be the right length for inclusion in a semi-structured interview and for participants answering an online questionnaire. According to Chan et al (2010), the usual length of a video clip on medical consultation is about three minutes. Furthermore, the video hosting site Wistia publishes their research carried out over a period of three years on how long people watched informational videos. They found that shorter videos are better for ensuring that people watched the whole thing. For these reasons it was decided to make the video three minutes. Two typical scenarios were chosen and the researcher animated these using two characters ‘Amina’ and ‘Abdullah’. In very simple language, the video explained how a diabetes management application could help each of these patients. The video was made in both English and Arabic. (Pratt, 2013)

3.10 Testing the Methodology

3.10.1 Pilot study for semi-structured interviews

The pilot studies for the interviews were conducted before the piloting of the patients' and doctors' questionnaires. This was because this pilot study could also show what important concerns Saudi health professionals might have about their diabetes patients' ability to receive healthcare and manage their condition as well as their reactions to the diabetes application. This would be useful in designing the questionnaires as well as checking on the suitability of the interview schedule. The doctors were personally known to the researcher and approached to participate. After agreeing to do this, the following steps were taken:

- A telephone call was made to arrange a convenient time for interview.
- The interview was carried out and timed.

The doctors were asked to give verbal feedback about the interview.

3.10.2 Pilot study for the patient questionnaire

Oates states that the questionnaire needs to be piloted in order to check that the questions and the instructions are worded in a way that is absolutely clear and unambiguous and that the pre-defined responses cover all possibilities. Also, to ascertain how long the questionnaire takes to complete and whether this is a reasonable time. She suggests that this can be done using experts and people who are similar to the respondents for whom the questionnaire is intended. (Oates, 2005/12)

However, as there would have been ethical implications for using actual diabetes patients, and the pilot study was being carried out in England, it was felt that the pilot study respondents could reasonably be conducted using medical students. The respondents needed to fulfil the following criteria:

- They needed to be Saudi. This was because they would need to understand the language used in the questionnaire (Arabic). They also needed to be representative of a Saudi population.
- They needed to have lived in Saudi Arabia in order to have an understanding of the culture there as well as the geography.
- They needed to have an understanding of diabetes as the questionnaire asks specific questions about managing this illness

Thus, although Saudi diabetics would have been the ideal group from which to select respondents for the pilot study, Saudi medical students were chosen. Medical students would have an understanding of diabetes and the problems that self-managing this disease could have for patients. Three students agreed to participate in the pilot study. A friend introduced these students to the researcher. After the student had made an initial verbal agreement with this friend to participate, the researcher phoned the student and the following steps were taken:

- An explanation was given of who the researcher was, how the student's number had been obtained and what the research was about.
- The student was asked to pass on his email address so that the

Covering letter and link to the questionnaire could be sent.

- The covering letter and link was sent if the student agreed, as well as a request to arrange a face-to-face meeting.
- At the meeting the researcher showed his identification and asked the respondent for their feedback on the covering letter, questionnaire and video. The researcher wrote down the students' answers.

- One student gave feedback over the phone; the reason for this was that the student had to be away at the time.

3.10.3 Pilot study for the doctors' questionnaire

Again, the ideal group from which to select the pilot study subjects would have been Saudi doctors. However, there would have been ethical issues in bothering busy professionals as well as practical problems in questioning someone in another country. For these reasons, it was decided to use medical students to get feedback on the doctors' questionnaire. Respondents chosen would have to fulfil the following criteria:

- They would have to be Saudi and need to understand the language used in the questionnaire.
- They would have lived in Saudi Arabia so as to have an understanding of the cultural and geographical background of patients there.
- They would have to have medical knowledge so as to understand what diabetes management entailed.
- They would have some understanding of what the work of a doctor in Saudi Arabia might consist of.

It was thus felt that Saudi-born medical students at least in their second year of medical studies would be chosen.

A friend of the researcher made the initial contact. After the students had expressed an agreement to participate in the pilot study the following steps were taken:

- The student was telephoned and the researcher explained who he was, how the student's number had been obtained and what the research was about.

- When the student agreed to participate he was sent the covering letter, the questionnaire and video and a further questionnaire to fill out after having viewed the questionnaire and video.
- The student sent back the feedback.

A final call was made to thank the student, to see if there was anything extra they wanted to add and to clarify anything on the feedback questionnaire that needed further discussion.

All pilot respondents were asked to fill in questionnaires and then questioned with an aim to discovering whether they found the wording of the cover letter and questions appropriate and understandable. They were also asked about the length and layout of the questions, whether they were appropriate and easy to respond to. Their ideas about questions that they felt were redundant or needed to be added were sought. Once the pilot study had been evaluated, the questionnaires were re-worded as necessary and the full survey conducted.

3.11 Pilot study Results and discussion

3.11.1 Pilot study for semi-structured interviews

The semi-structured interviews were piloted with two male doctors. Two female doctors were also contacted but as the researcher was male, there could be no face-to-face interview. The two female doctors were simply sent a list of questions that would be covered at interview and asked to send their replies in an email. One of the female doctors was contacted by phone in order for the researcher to introduce himself and his research, the other was not contactable by phone as she has cultural values that preclude her from talking to men outside her family and contact could only be made by email. Although this does not constitute a pilot of the interview, it was felt that it would be useful to get more in-depth answers from female doctors, given that female patients have been identified as a group that might benefit from a mobile diabetes application. The male and female participants in this pilot are thus reported on separately.

3.11.2 Female diabetes specialists

Doctor A. Has been practicing for 14 years, seven as a diabetes specialist. She holds 2-3 clinics a week and sees 30 patients in each. Her patients have difficulty attending appointments for reasons of transport problems and she is sometimes too busy to see all her patients owing to staff shortages. She believes her patients have problems in self-managing their illness, not having information about diet and exercise, remembering appointments and communicating with her and the hospital. Her hospital uses electronic systems but does not email patients. She herself has no knowledge of mHealth or diabetes management apps. She believes that elderly and uneducated patients in rural areas may have difficulties using the application, but it would be very useful for doctors, although it could not be used in her hospital. This might be because of staff shortages, or technology, the answer did not specify. Patients who would be able to use the app would benefit in particular from having alerts for medication and appointments.

Doctor B. Has been practicing for 25 years, 15 as a diabetes specialist and treats 25 patients a day. Patients miss appointments because of transport problems and forgetting appointments. Like those of Doctor A, her patients have problems with all aspects of diabetes management. The hospital uses electronic systems but does not email patients. She herself has a little knowledge about mHealth and diabetes apps and thinks such an application would be a useful tool for doctors to monitor patients' glucose levels remotely. However, she believes that her patients would have many problems in using the application:

- Lack of electronic possibilities
- Low level of education
- Lack of awareness of the importance health monitoring and disease management.
- Neglect of patients. Patients will not be shown how to use the application.
- Lack of the means of raising awareness about patient health in the region.
- Elderly and illiterate patients may not be able to use the app.

3.11.3 Comments

Both female doctors trained in Saudi Arabia**.** Both doctors were aware that there might be issues of technology acceptance for their patients, but felt that the app would be useful if patients did use it and the hospital was able to use the data for monitoring. It would be useful to question female doctors more closely but the problem of having a male interviewer seems to be a major one. Questions about whether relatives of elderly patients could be co-opted could be explored in the interviews. The comment about illiteracy highlights one very important feature of technology acceptance – the person has to have the skills needed to use the technology.

3.11.4 Male Diabetes Specialists

Doctor C has been practicing as a doctor for 13 years, five as a diabetes specialist. He trained in Canada and sees 44 patients a day. He reports that most miss appointments and that there are no reminders sent out and a long waiting list that makes rescheduling difficult. His patients had problems with all aspects of diabetes management except getting information on diet and exercise. His hospital uses electronic systems but do not email patients. He has no knowledge of mHealth but liked the app and could not think of any problems for either doctors or patients in using the application.

Doctor D has been practicing for 25 years, ten as a diabetes specialist. He trained in the UK and sees ten patients a day (of the 1,000 on his list). Patients missed appointments owing to transport problems and it was difficult to reschedule appointments. His patients had problems with all aspects of diabetes management. His hospital uses electronic systems but does not email patients. Although he knows very little about mHealth, he was positive about the application saying that "language" was the only problem with it.

3.11.5 Comments

These interviews were both conducted at the workplace. Both doctors were very busy and, although the researcher had explained that the interview would take a minimum of 30 minutes, they terminated the interview very quickly. Doctor C allowed 15 minutes and Doctor D only 10. The researcher gathered the impression that both doctors were anxious to get the interview over quickly, and for this reason gave short answers; they were not willing to expand on their answers, saying that they had to go.

3.11.6 Pilot Study for Patient Survey

The average amount of time to complete the questionnaire and watch the video seemed to be about eight minutes and there were no adverse comments about the length of time. The questions seemed to have been clearly understood. There were however, some interesting comments made which need to be looked at in detail:

3.11.7 Feedback on the video

- ‘Some slides were not clear due to due to low quality’
- The sound was a bit low
- “Easy and exciting but add more, like how you could send data or check on the best exercise and diet”
- “How can we find this app?”

The problem of quality can be addressed. The low quality is due to making the quality low so that it would be quick to upload. However, it is important that the quality is good, so the video will be switched to a higher quality even if that means a slower time to upload. The low sound was probably due to the respondent’s speakers or computer. However, given that survey subjects might have similar problems, the sound will be made louder. The comments on adding more to the video so as to give details about how to send information show that the respondent wanted to know more about the application, as did the comment about how the app could be found. However, adding this information might appear as a kind of 'selling' the application to the patient, which would raise ethical issues. There were no adverse comments on the length of the video.

3.11.8 Comments on the covering letter

- “Add the consent form with the covering letter” This is a matter of design. The researcher prefers to have the two separately so that the consent form stands alone and gives the respondent time to think what they are consenting to.

3.11.9 Comments on questions

- “Question 16 could be made easier”. This question says “Which would be the most useful aspect of the diabetes management application for you personally?

  1. A useful tool to help me manage my condition

  2. A way to deliver “actionable” information to my doctor

  3. Both 1 and 2 equally.

  The word ‘actionable’ was removed, as it was not strictly necessary and might not be understood by patients.

- “Add images of the app. Features to Q.15.” The video has been seen before Q15 and the researcher felt it would complicate the questionnaire to add in images at this stage.

3.11.10 Pilot Study for Doctors’ Survey

- The average length of time taken to read the covering letter, complete the questionnaire and view the video was 12 minutes. There were several comments that needed consideration:

3.11.11 Comments on the covering letter

- “Add how long the questionnaire will take “Judging by the average time taken by the pilot respondents (12 minutes), it seemed a good idea to add “The questionnaire should take no more than 15 minutes” in the covering letter. Doctors are busy people and this may be a useful piece of information for them to have.

- "The covering letter needs to include technical information about the application". This comment is interesting, but putting technical information into the covering letter would make the process of completing the questionnaire longer. The video explains the application and there are questions that relate to functions of the application in the questionnaire itself.
- "You should add 'If you have any concerns, questions or require further details about the current study, do not hesitate to contact me using the details below" This was a useful comment and the researcher added it to the covering letter.

3.11.12 Comments on questions

- "You need to see if the patients and hospitals can operate the application." This is actually covered in the questionnaire itself (See question 11)
- "The question 'Where did you train?' is not relevant. The student does not see the relevance of this question, but in the experience of the researcher, this is a revealing question, as training abroad suggests to what extent the doctor has trained in their specialism and become familiar with medical technology.
- "You need to add one more question after Question 4 asking why the female patient refused to see the doctor- if he is male." Given the cultural situation in Saudi Arabia, we think it is safe to assume that it is obvious why a female patient would not see a male doctor - the culture forbids it.
- "Maybe if the app contacts directly with the hospital, like when you have an appointment, it comes directly to the app without sending reminder text" This is a criticism of the application rather than a criticism of the questionnaire.

- Under ‘further information about the application’ was the comment “I would like to know about the ability to update the application and if it is compatible for blind people”. These comments will be taken into consideration when further research into what other forms the application could take for use in Saudi Arabia. For the purposes of this research, doctors are being asked to comment about the application as it stands. Also, the doctors responding to the survey will be themselves sighted and be able to see the questionnaire and video. However, it is useful to note that the comment highlights that the application is aimed at sighted people and as such is potentially excluding visually impaired patients with diabetes

3.12 Conclusions on Pilot Studies

This section summarises the changes that made as a result of the findings from the pilot studies of all three research instruments.

3.12.1 Conclusions on the pilot study for semi-structured interviews

The pilot study highlighted several issues that needed to be taken into consideration when carrying out the interviews for the main study:

Firstly, the difficulty of engaging with female participants- this is a very important issue within the Saudi context. The two contacts with Saudi female specialists showed that some female doctors would not (for cultural and religious reasons) even speak with a male researcher over the phone. This means that these female specialists can only be contacted by email or letter and so, in practice, cannot be interviewed at all. The other female diabetes specialist agreed to talk over the phone, although there could be no face-to-face meeting. Telephone interviews are different from face-to-face interviews (can't see the interviewer to gauge their response, can seem to go very quickly, without giving much time to think about the answers) (University of Kent, 2014). Even if a female specialist were happy to give a face-to-face interview, in practice this would be virtually impossible. Female doctors work in women's hospitals and clinics or in the women's department of a big hospital and men cannot go in there. It would not be acceptable to meet a woman on her own in a place outside the working environment such as a café or restaurant as the religious police could arrest both the doctor and researcher. As an Islamic scholar explains "Islam does not allow men and women to meet each other whenever and however they like. It has placed clear regulations and restrictions upon such behavior and has defined the limits of interaction between men and women." (al-Majid, 2014). It would also be unacceptable to conduct the interview at the home of either the researcher or the doctor. Male relatives of the doctor would object strongly and maybe even make problem to the researcher. The reputation of the woman would suffer and she would be seen as a person of loose morals if there isn't a strong reason to meet.

This is a problem for the researcher as it would be interesting to interview a female Saudi diabetes specialist. The reason for this is that she would most likely have female patients and this group has been identified as likely to benefit from using a mobile diabetes management solution. There are a number of alternatives to conducting these interviews:

- Interviews can be conducted with female diabetes specialists who work in Saudi Arabia, but are not Saudis
- Interviews are conducted by telephone with a Saudi female diabetes specialist.
- Interviews can be conducted with Saudi female diabetes specialists living in the UK

The last solution was not really feasible as it might be difficult to find such a doctor, and would necessitate the researcher travelling back to the UK to conduct the interview. The telephone interview was a possibility, but has many disadvantages, which have been considered above. Therefore, the researcher tried to find a non-Saudi female diabetes specialist who has been practicing in Saudi Arabia and conduct a face-to-face interview.

3.11.15 Male Diabetes Specialists

The main problem here was finding diabetes specialists that had the time to give a full interview, with time to expand on answers or explore areas properly. There are a number of ways in which this could be overcome:

- Finding diabetes specialists who are not so high up the hospital hierarchy. Such doctors may well have a little more time for interview and are more likely to see the researcher as a social equal.
- Finding diabetes specialists who are younger and thus more likely to be interested in mHealth. Neither of the pilot participants knew much, if anything about mHealth. If criticism of the application are to be discovered, this is perhaps more likely to come from doctors who have some knowledge of how these work.

Conducting of interviews outside work environment If the doctor is in the working environment he is more likely to be in ‘work mode’ and unable to fully concentrate on the interview. Doctors are used to being ‘on call’ and have pagers that can ask them to attend to any emergency. This does not make for a relaxed interview. The decision was for the researcher to try to find male diabetes specialists who were still ‘working at the coal face’ i.e. not so far up the hospital hierarchy that they have no time for interviews and are less likely to see the researcher as an equal. In Saudi Arabia, people are very conscious of social position. The social position of a person rests on family background and profession and it can really affect how they treat others. It is better if the researcher is seen as an equal. There is another factor to be considered here and that is the matter of social tribe. Members of the same tribe (identified by surname) are more likely to help each other. Ideally, the tribal background of a diabetes specialist would be one that would not affect how the doctor answers questions i.e. neutral. Interviewees must neither be concerned to give answers that they feel would be helpful to the researcher, nor have any tribal animosity towards the researcher.

The researcher would also try to conduct interviews outside the workplace so as to allow the doctor to relax and focus on the interview. The researcher needs respondents who are relaxed and unhurried so that the issues are fully covered. If the interviewee perceives the interviewer as an equal, it is more acceptable to question short replies by saying things like "What exactly do you mean by that?" "Can you give me an example?" or "Why might X be a problem for your patients?"The actual questions asked by the interviewer seemed to cause no difficulty to the participants who said they were happy with the wording and the way that the questions were asked. However, their responses identified that there was one question that was ambiguous. The question "What area do you cover?" was intended to elicit responses about the medical area covered by the doctor; however one doctor (D) interpreted this as meaning geographical area. This could be easily rectified by explaining to the interviewee what is required "What medical area do you cover?"

3.12.2 Conclusions on the pilot study for the patients' survey

- The video was adjusted so as to give it better quality and a louder sound. This is to compensate for any possible deficiencies in respondents' computers.
- Question 16 was changed by removing the word 'actionable', in order to make it easier to understand.

3.12.3 Conclusions on the pilot study for the doctors' survey

- The covering letter was adjusted to include the sentence "The questionnaire should take no more than 15 minutes."
- The sentence "If you have any concerns, questions or require further details about the current study, do not hesitate to contact me using the details below." was added to the covering letter.

3.13 Validity and Reliability

Establishing the validity and reliability of the process used to collect and analyze data lends credibility to the research process (Creswell, 2012). Reliability has a less significant role in a qualitative research process than it is in a quantitative research process, but still remains necessary (Leedy & Ormrod, 2005)**.** The structure of the research questions and their associated interview questions will allow other researchers to conduct the same study. The interviews used in this study were semi-structured, which means that the research could be built on by questioning other health professionals with a view to establishing technology acceptance. The questionnaire can be replicated and used with other groups. The collected data should produce the results the research questions were designed to produce (Golafshani, 2003). This will be discussed as part of the next chapter.

It is important to ascertain whether the questionnaires are both valid and reliable. Asking for feedback on the questions at the pilot study stage of the survey is a way of seeing if the questionnaire has content validity and has “a well-balanced sample of the domain to be covered” (Oates, 2012). It is also useful to use pre-tested and used questionnaires that have been examined for content validity (Kissinger). Oates (2012) notes that it is also essential to test whether the questionnaire has construct validity and actually measures what it says it is going to measure. It will therefore be important to test the diabetes questionnaires for this and make sure that nothing is assumed. For example, when asking about difficulties in getting to a hospital, asking about the last visit to a hospital may not accurately measure this, as that visit may be atypical. It may, for example, have taken much longer than usual because of a car breakdown or other atypical problem. Asking for feedback and using pre-tested questions will reduce these problems.

It is also important to make sure that the questionnaire is reliable. ‘Reliability’ is defined by the Dictionary of Epidemiology (2010) as “[t]he degree of stability exhibited when measurement is repeated under identical conditions”. There are ways of testing for reliability, but these are not always practical to implement. For this reason pre-tested questions were used where possible.

3.13.1 Internal and External Validity

Validity is often discussed and viewed from two perspectives, internal and external validity. Internal validity is the certainty that the study results produced were a result of the research process and not from other factors (Richards, 1999). Internal validity is a confirmation of the correctness of the study design and is assessed to ensure that no alternative explanations or errors will exist within the study (Neuman, 2007). In a thematic analysis of the participants’ responses, there is a possibility of the introduction of researcher bias or errors in coding due to the researcher being an instrument for collecting data. Such factors potentially could influence the findings. To guard against this, the interviews will be processed twice – inductively and then deductively. This is to check that important issues are not ignored because they do not fit into the pre-existing themes designated by the researcher.

External validity represents the extent to which the results of the study can be expected to reflect similar outcomes in other populations and therefore, be useful for other studies (Richards, 1999). External validity is the ability of the study to be extrapolated from the population and setting that was used in the study to additional research in additional settings and other populations with similar results. It is one of the aims of this thesis to highlight any further areas of investigation that need to be explored in order to ascertain technology acceptance with particular populations within the Saudi context. A further concern is to design research methods that can be applied to studies of similar populations in other contexts

3.10 Summary

The content of Chapter 3 included a review of the appropriateness of the mixed methods design and the methods of data collection for both Phase One and Phase Two. Ethical considerations were reviewed. The approach to the analysis of data for Phase One and Phase Two were discussed. Reliability as well as internal and external validity were defined and addressed. The limitations of the methods have been anticipated in this chapter and the way in which they possibly affected the results of the interviews and surveys will be discussed in the following chapter, which will contain the results of the main studies, i.e. the interviews and two questionnaire studies.

CHAPTER IV: RESULTS

In this chapter the results of the three investigations are set out, with an initial analysis, and a consideration of how the results fit in with the Technology Acceptance model.

4.1 Interviews with Saudi Diabetes Specialists

4.1.1 Introduction

Specialist doctors were given semi-structured interviews in order to ascertain what their perceptions were of the problems their diabetes patients had in self-managing their illness and in obtaining and attending hospital appointments. The interview also sought the doctors' feedback on the diabetes management application as a possible solution to these problems; to what extent they would accept the technology and perceived their patients as accepting the technology. Below is a discussion of how this was done, and how the data thus acquired was analyzed.

4.1.2 Conducting the Interviews

The researcher conducted the interviews in three main stages:

First Stage – Acquiring interviewees

Doctors for interview were chosen according to pilot study recommendations

- Finding diabetes specialists who are not so high up the hospital hierarchy; and thus more likely to see the researcher as a social equal.
- Finding younger specialists who are more likely to be interested in mHealth; as the pilot showed that older doctors don't know much about mHealth.

- Finding doctors who would be interviewed outside the work environment. The pilot highlighted that the workplace was not a good environment to conduct a relaxed interview.

In practice, it proved difficult to find doctors to interview at home. Female doctors would not accept being interviewed by a male researcher at home, and male doctors would not want a male stranger in their homes if women were there. The doctors selected for interview were obtained through the researcher's contacts and so it did not prove possible to find doctors that were younger and lower down the hierarchy. Interviewees ranged from 10-24 years' experience.

I started by contacting doctors by email, and then phoning them to give them an idea of what the interview would consist of. If they were agreeable, I tried to ascertain a convenient time for the interview and made an appointment. I felt it was essential to make sure that the doctors were giving informed consent to the interview, given that they were busy doing important work.

Second stage – Before the interview

On arrival, I introduced myself and briefly re-iterated the purpose of my interview.

The interviewee had already been told this in the covering e-mail and had signed a consent form agreeing to the recording taking place.

I furthered explain how the interview will be recorded and re-iterated that all data would be confidential and secure. I also mentioned that I might take some written notes of the main points. The interview was then conducted and recorded.

Third Stage- after the interview

At the end of the interview I briefly summarized the main points of the interview and checked with the interviewee that I had understood what they said about (a) patient problems (b) reactions to the mHealth app.

I recapped the major points made by the interviewee about:

- Attitudes towards a mHealth diabetes app solution
- Benefits to provider and patient
- Any obstacles to adoption
- Essential features of a diabetes app
- Opportunities to expand mHealth solutions beyond diabetes

I told them I appreciated the time they took for this interview.

Finally, I reminded the doctors how to contact me if they had any further questions about the research.

4.1.3 Data Analysis

The questions in the interview schedule designed for the pilot study appeared to be adequate to answer the research questions. Looking at the data which had emerged from the pilot study raised the question of how this data could be analyzed using the thematic approach. As there had been questions devised to elicit specific information, such as one about how the doctor perceived their patients could manage their diabetes, it was apparent that there would be particular themes embedded in the data – 'Problems patients have in managing their diabetes' in this case.

Boyatzis (1998) says that thematic analysis is a process of 'encoding qualitative information'. The researcher develops 'codes' that serve as labels for sections of the data, thus putting it into themes. This coding into themes can be done inductively, where the themes are strongly linked to the data itself and not pre-planned by the researcher. In this approach, the researcher should tackle the material with an open mind and allow the data to speak for itself. Conversely, the deductive method means that the researcher always has themes in mind when doing the analysis, although they need to be aware of other themes in the data (Oates 2006)

Braun and Clarke note that it is important to realize that these themes do not actually 'reside' in the data. The themes are in the head of the researcher who creates links between discrete bits of data through understanding them (Braun & Clarke, 2006).

As the researcher had expectations of what the doctors might say, it was important not to let these lead the analysis to the point that important unexpected themes would be ignored. Consequently, it was decided to use a deductive approach first, whereby the interview transcripts would be analyzed for information that would fit into themes contained in the Interview Schedule (See Appendix D); for example, difficulties patients had with attending appointments. Following this, the interview transcripts would be read with a view to seeing if other themes were contained in the data.

4.1.3.1 Results of Semi-Structured Interviews with Saudi Doctors.

Five doctors were interviewed, four male and one female. Their length of service ranged from 10 to 24 years. Three of the doctors had specialized in diabetes for ten years or over. All the male doctors had trained overseas. The majority of the doctors saw around 15 diabetes patients a day, but often saw more as they accepted walk-in cases. Two doctors said they could see as many as 30 patients a day.

The following topics and themes arose from the interviews:

Missed Appointments

Only one doctor said that this was a rare occurrence, and this was because patients were reminded by phone the day before the appointment. One doctor said that patients who had to come in from outside the city often missed appointments: he believed that this could be due to their being unable to take off work, bad weather or traffic jams. Another said that students often missed appointments as they did not like to miss lectures. Not receiving reminder calls was another reason given. Doctor E said that since his clinic had started to send SMS messages the day before the appointment, missed appointments had been significantly reduced. This was the case when people forgot; however, some patients who had to come in from outlying areas missed appointments owing to not having transportation. This doctor also commented that this was particularly the case for women as they were not allowed to drive in Saudi Arabia.

Summary: Missed appointments causes: unable to take time off work, bad weather, lack of transport, traffic jams, not receiving reminder calls, women not allowed to drive in KSA

Area Covered

Hospitals cover a wide area necessitating long journeys to appointments by some patients. Three of the doctors said that they treated patients from remote areas, one saying that some had to be airlifted in.

Problems with Self-Management

There was variation in doctors' responses here. Doctor B, who mainly treated university students, said that there were no problems as his patients were 'highly educated'. Both Doctor A and Doctor D stressed that self-managing diabetes was not an easy thing for patients to do without medical assistance. Doctor A commented that glucose levels can fluctuate a lot and this can be difficult for patients to control. This improves with experience and patients with Type 1 diabetes are often more adept at self-managing and injecting insulin themselves. He believed that not being able to control one's own diabetes was linked to a lack of education. Doctor D said that self-management was 'very demanding' and some patients had to monitor blood glucose up to 4 times a day. He pointed out that diabetes is 'unique' among chronic illnesses in requiring such a high level of self-management. Again, Type 1 patients were more adept at doing this. He believed that good self-management was crucial and 'the outcomes are not good if the patient is not involved in their own care. Doctor E said that problems with self-management were common, as diabetes was a complex disease that relied on the patients for 90% of the care. Education about diet and exercise were the key to effective self-management. He went on to say that there are too few diabetes educational centers and those that exist are too busy to see everyone who wants to come.

Summary: Problems with Self-management: Difficult without medical assistance as glucose levels can often fluctuate, lack of education, managing was demanding, lack of patient involvement in their own care and too few diabetes education centers.

Information on Diet and Exercise

Doctor A thought that lack of information on diet was a problem for his patients. He cited the example of patients who think they know what to eat but do not. For example, some were not aware that eating dates increased blood sugar. The hospital did provide a member of staff who could educate patients about this, but not all made use of this service. Doctor D also mentioned the problem of patients being unaware of what to eat. He stated that although, they all knew that they had to lose weight, they did not know how. He gave the example of a patient who said she regularly ate about 30 dates a day (the maximum should be only seven). His patients were lucky in that they had a lot of time spent on educating them about diet. He believed that the time was needed to sit with patients and get them to list everything they had eaten the previous day. That way he could explain what was and was not an acceptable diet for diabetics. Doctor C also said that her patients often had insufficient information about diet and exercise. She said that this was because the diabetic specialist simply did not have the time to do this. There was a dietician available at the hospital, however as this service was not covered by health insurance, many patients chose not to use it as it was expensive. In contrast, Doctor B believed that this was not a problem as his patients were well-educated. Doctor E believed that all patients needed this education and this was a huge number as he understood that 23.8% of all adults over 30 had the disease. He commented that there are websites where patients can get such information, but something like a Smart phone app or You Tube videos would be more effective.

Summary: Information on diet and exercise: Patients know what to eat but do not follow advice; patients want to lose weight but do not know how. Lack of information on diabetic nutrition was the cause.

Technology Infrastructure

Doctor A's hospital has a database with patients' records. Hard copies of this are made and put into files.

Doctor B's clinic has no electronic systems. He has suggested to the administration that this should be installed, but has yet to receive a reply on this matter.

Doctor C's hospital has electronic patient records and an electronic appointment system. She was unsure as to whether lab reports were available electronically. It only has an internal email system.

Doctor D's hospital has all-electronic files. There is a computer outside the office where patients can download and print their medical test results.

Doctor E's hospital is 'well-advanced in implementing technology'. There are electronic systems for patient records, results of medical tests, patient appointments, pharmacy and medical imaging as well as a website with medical information. The hospital does not, however, use emails with patients.

Summary: technology infrastructure: some hospitals do use technology for patients' record, not all. Only internal email systems exist and no emails are used with patients.

Communication with Patients

This was done almost exclusively by phone. Doctor A's patients are given appointments and reminded of them in this way as well as being given the results of tests. Doctor C said her patients were given appointments this way; also, she spent a fair amount of time on the phone with her patients. They all had her mobile number and would call her even when she was at home. This was important as many of her patients were pregnant and regulating their blood glucose was imperative. She could not email her patients as the hospital has no facility for this. Doctor D's patients were contacted by phone and he believed this was better than email. Doctor A felt the same. Doctor E however, said that patients who phoned the hospital with medical queries during working hours could often not be answered as staff members were too busy. He had his own website and his patients could communicate with him through that. *Knowledge of mHealth*

Four of the doctors were not conversant with this. Doctor A suggested that this was because it was very new to the Middle East. Doctor B admitted that although he had heard of it, he had no idea about how it worked. Dr C had heard about it as the sister of one of her patients was doing a Masters in the UK involving the subject of mHealth, but she had never seen a diabetes management app. Doctor D had previously seen a mHealth app, however, they were not in use at his hospital. In contrast, Doctor E was highly knowledgeable about mHealth and had looked into how this could help his patients. He understood that there were several such apps and they had many useful functions such as logging and sending data such as blood glucose levels, receiving useful information about how to manage the disease and keeping track of food eaten and exercise taken.

Summary: Knowledge of mHealth: only one doctor was knowledgeable on mHealth while others either had not heard of it or were only vaguely aware

Attitudes towards Using a Diabetes Management Application

Generally the doctors' reactions were positive. Doctor A said that they allowed direct communication between doctor and patient. This might save time as some patients actually booked appointments just to ask questions. They were often unable to speak to the doctor when they phoned, as he was busy seeing patients. Doctor B said that anything that could help manage diabetes sounded like a good idea and that it could save time for doctors and patients. He commented that in the last 10-15 years, the number of patients with diabetes had risen dramatically from one in five to one in four of the population of Saudi Arabia. Also, that given the size of the country it would be difficult to provide adequate care for all these diabetics. The app would be able to transmit information that was now being given face-to-face and that this would help those patients who lived far away. Doctor C was more cautious, but identified the app as being useful in providing the patient with information about diet and exercise and how to administer insulin. Doctor D felt that introducing technological solutions like the diabetes management app was inevitable "Like it or not, life is moving in that direction". He believed that it would be useful; if it allowed email communication to answer patients' questions and concerns. It could also be a means of passing on accurate and up-to-date information about the disease. He commented that many patients just go to the Internet to get an answer to their questions about diabetes and "they end up getting confused". It was important for patients to get clear and accurate information in a language that they could understand and certain websites provided this, but other didn't. He thought it would be useful if the app was a means of passing on useful website links to patients.

Doctor E (who knew most about mobile health) believed that this technology was 'the future of medical care'. This was because it had many benefits for both patients and healthcare providers; not least because it cuts time and healthcare costs. He went on to say that healthcare accounts for about 10-15% of government expenditure, so introducing mobile solutions could cut these costs as well as improving patient quality of life and patient health.

Summary: Attitudes towards using a diabetes management application: all had a positive attitude

Technology Acceptance by Doctors

Two of the doctors brought up the issue that the introduction of a diabetes management app by their hospital might result in increasing their workload. Doctor A suggested that, given he spent 8 hours a day face-to-face with his patients, he did not want to spend additional time dealing with patients' questions. He felt that if the hospital adopted this system, doctors would have to be given time to deal with this. If doctors were expected to answer patient requests once they had gone home, this would lead to work overload. He was also concerned that there might not be a way to identify which queries were the most urgent. If a patient had an urgent request, it would be very worrying not to receive an answer to it quickly. Also, it was important for the doctor answering the query to be able to identify the patient's file number, so that their medical history could be called up, as a doctor needed to see this to give accurate advice. He gave the following example:

> "A patient might have a question about diabetes, but also have renal problems which he did not mention in the message. The doctor might send a message recommending an increase in the dosage of insulin to 10 units, which would not be correct for a patient with renal problems."

If the doctor was out of his office, he might not easily be able to access patient records, unless there was way that this could be done through the application itself.

Doctor C pointed out that there was no time to attend to patient queries by app. during clinic hours as she was busy with patients. Having to deal with them at home would add to the pressure as she already gets urgent phone calls on her mobile after clinic hours. She believed that the hospital could allocate time to doctors to answer patient queries. Alternatively, these could be dealt with by staff at the Diabetic Centre who could refer questions to the diabetes educator or the doctor if necessary.

Doctor B felt that he would be happy to use the app to deal with patients that could not come to an appointment. He was however, careful to point out that the doctor-patient relationship is of paramount importance for providing good healthcare. Doctor E would be happy to use a mobile app himself but commented that some doctors, especially those from an older generation might be reluctant. The younger generation of healthcare providers would however be “enthusiastic and happily adapt to this kind of communication”.

Summary: Technology Acceptance by Doctors: problems identified – increase in workload, insufficient patient information on app could lead to wrong prescription through the app, personal interaction preferred over app interaction. Suggestion from doctors: that a member of staff needed to be dedicated to deal with app queries.

Perceived Technology Acceptance of Patients

All the doctors agreed that potentially the app could be useful to their patients. Doctor A said that how easy this would be for them to use depended on the programmed and patients' willingness to learn how to use it. Doctor B said that as his patients were well-educated and young, he did not foresee any problems with them adopting it. He did think that older patients who were less used to using technology would be more resistant and suggested that they would need the help of younger family members to use it. Doctor C agreed that older patients would find such an app difficult to use and for this reason younger patients would probably be the greatest beneficiaries. She added that willingness to adopt the app might also be related to the patient's personality. Doctor D also identified age as a crucial factor, with older patients being more resistant. He was, however, optimistic saying "People are getting used to technology and many (Saudi) people have Smart phones". Doctor E concurred saying that younger patients would benefit especially as Smart phone are widely used in Saudi Arabia, but that older patients and those with literacy problems might not be able to use the app. He said that this might be possible through a caregiver in the family – a son or a spouse for example.

The doctor's transcripts were then read through again to see if there were additional issues contained therein.

Summary: Perceived Technology Acceptance of Patients: All the doctors agreed on the perceived technology acceptance, particularly by the younger patients; the senior patients could be assisted by family members or care givers.

Doctors' suggestions about workplace use of the application

When doctors were told about the application, some made suggestions as to how these could be implemented at their hospital. Doctor A suggested that both doctors and patients would need training in its use and that time could be set aside for dealing with communications received via the app. He also felt that each communication could be prefaced with a patient ID number to allow doctors to access the relevant file. Doctor B said his hospital needs to introduce electronic systems and that training on using apps could also be extended to family members of older patients. Doctor C suggested that staff other than the specialist could deal with queries and data and refer to the doctor or diabetes education specialist if necessary. Doctor D wanted to be able to use the app for email communication and to pass on links to websites with reliable and up-to-date information.

Doctor E wondered if it would be possible for patients' apps to be able to communicate directly to an app on his phone. The patients would be given a special code to allow their app to 'talk' to his app and pass on data. He could use this feature to communicate directly from his app to an individual patient's app.

Summary: Suggestion for the usage of the app at the workplace: have a separate team to deal with app queries, training for doctors, patients and family members, patient code embedded to help doctors extract patient record

Unnecessary Visits

Doctor A stated that some patients made appointment simply to get information, and Doctor B said that an app would be useful if an appointment was not possible. However, he was at pains to say that the doctor-patient relationship was crucial. This was borne out by Doctor D who described how sitting with a patient and going through their diet was essential.

Doctor E said that he wanted his patients to do well and not have to come to the hospital, especially not as in-patients. Using the app to 'catch any problems early' would prevent them from having to be admitted. To do this would mean that the app would effectively transmit data about the patient's blood glucose and allowing the doctor to make correct judgments. Younger patients would probably want to use the calorie and carbohydrate counter and remain healthier through eating correctly.

Summary: Unnecessary visits: app could help avoid visits if patient just seeking information

Patients' Level of Education

This was considered to be a factor, in that highly educated patients were considered more able to make use of an application. Illiteracy was a problem.

The results for the interviews with Saudi diabetes specialists are summarized in the table below:

Figure 4.1 TABLE SHOWING SUMMARY OF RESULTS

THEME	SUMMARY OF KEY POINTS	RELEVANT UTAUT CONSTRUCTS
MISSED APPOINTMENTS	Causes: unable to take time off work, bad weather, lack of transport, traffic jams, not receiving reminder calls, women not allowed to drive in the KSA.	. [PERFORMANCE EXPECTANCY, GENDER] CULTURE and LOCATION also important.
AREA COVERED	Many patients from remote areas; some needed	[PERFORMANCE EXPECTANCY]

	airlifting which is costly and time-consuming	INCOME LEVEL and LOCATION also important.
SELF-MANAGEMENT	This is difficult without medical assistance as glucose levels can often fluctuate, lack of education, managing was demanding, lack of patient involvement in their own care and too few diabetes educationcenters.	[PERFORMANCE EXPECTANCY]
DIET AND EXERCISE	Patients know what to eat but do not follow advice; patients want to lose weight but do not know how. Lack of information on diabetic nutrition was the cause	[PERFORMANCE EXPECTANCY]
TECHNICAL INFRASTRUCTURE	INFRASTRUCTURE Limited: only some hospitals use technology for patients' record, not all. Only internal email systems exist and no emails are used with patients; only one hospital had a website.	[FACILITATING CONDITIONS, PERFORMANCE EXPECTANCY]
COMMUNICATION WITH PATIENTS	Mainly by phone, limited emailing. Some patients could not get through at busy times.	[FACILITATION CONDITIONS, PERFORMANCE EXPECTANCY, SOCIAL INFLUENCE]
KNOWLEDGE OF MHEALTH	Only one doctor was knowledgeable on mHealth while others either had not heard of it or were only vaguely aware	[EXPERIENCE, EFFORT EXPECTANCY]

ATTITUDES TO MHEALTH	Doctors all had a positive attitude to mHealth in terms of saving time, communicating with patients and passing correct information.	[PERFORMANCE EXPECTANCY]
DOCTORS' TECHNOLOGY ACCEPTANCE	Problems identified: increase in workload, insufficient patient information on app could lead to wrong prescription through the app, personal interaction preferred over app interaction. Suggestion from doctors: that a member of staff needed to be dedicated to deal with app queries.	[EFFORT EXPECTANCY]
PERCEIVED TECHNOLOGY ACCEPTANCE OF PATIENTS	All the doctors agreed on the perceived technology acceptance, particularly by the younger patients; the senior patients could be assisted by family members or care givers.	[AGE. EXPERIENCE] EDUCATION also important.
WORKPLACE USE OF APP.	Suggestions: have a separate team to deal with app queries, training for doctors, patients and family members, patient code embedded to help doctor's access patient record.	[FACILITATING CONDITIONS, EXPERIENCE, SOCIAL INFLUENCE]
UNNECESSARY VISITS	Doctors agree that although direct doctor-patient face-to-face rapport is initially essential, visits made just to get information are unnecessary.	[PERFORMANCE EXPECTANCY, EFFORT EXPECTANCY] LOCATION also important.

PATIENT LEVEL OF EDUCATION	Level of education, especially literacy considered crucial.	

4.1.3.2 Discussion of Results

The interview results can usefully be related to the constructs and influencing factors that make up the TAM and UTAUT models.

Gender

Doctor C's patients included pregnant women who needed urgent advice on controlling blood glucose. They would phone the doctor at home for this. A diabetes management application that provided instant advice for such patients would be useful to this doctor. Her patients might find talking to the doctor reassuring, but with training might be happy to get advice via the app.

Doctor E said that female patients sometimes missed appointments because of transportation problems exacerbated by the fact that in Saudi Arabia women were not allowed to drive, again underlining a gender specific problem within a particular cultural context. This suggests that technology acceptance of mHealth is influenced by a combination of gender and culture. Location is also an important factor, as women who live far from the hospital may be more likely to miss appointments.

Age

The age of the diabetes patients was clearly a factor, with younger patients being identified as probably being more able to use such an application; older patients might be more resistant. Doctor E also mentioned that older healthcare providers might be more reluctant to use a mobile solution. However, the age factor is linked to education level as doctors felt that older, well-educated patients were less likely to struggle.

Experience

Technology experience was linked to age, as doctors felt that younger patients might have more experience of using mobile phones and related technology. However, older patients could be trained, or a younger family member could be trained to assist. The personality of the older patient might also be a factor, as some might be more resistant to change than others. Education (and possibly income level) is also a factor here as Saudi higher education is more likely to involve digital technology.

Voluntariness

There was some resistance to accepting the technology if it was imposed in a way that generated more work for doctors. However, this is not an important factor in this study.

Performance Expectancy

Communicating with patients seemed to be one of the main uses of the application from the point of view of the doctors. They also felt that transmitting reliable and up-to-date information this way was useful. Recording diet would also be useful especially as some hospitals do not have the time to provide the service that the patients at Doctor D's hospital had (going through diet record books initially on a weekly basis to effect changes in diet). Reminding patients about appointments would be useful in case patients had not received reminder calls. One doctor said she would also welcome instructions about exercise and how to self-administer insulin. Doctor E identified the three most important features of an app as firstly, doctor patient communication; secondly, being able to receive data such as blood glucose level and thirdly using the app to record diet.

Effort Expectancy

The doctors felt that generally it would require some effort to learn how to use the technology, but that from their point of view, it would be worth it if it didn't generate extra work. They believed that older patients would find it more of an effort to use the technology but that younger, especially well-educated, young people would welcome it. It might not be possible for illiterate patients to use this solution, unless they had assistance from a literate caregiver who also was comfortable with the technology. This shows that education and income level (which is linked to education) are important related factors.

Social Influence

Given the importance of the doctor-patient relationship, it would appear that if doctors recommended the application, patients might be more willing to accept it. (There are other factors such as family and peers, as well as the attitude of the patient to their doctor).

Doctor E worked in an environment where modern technology was clearly used by colleagues, as the hospital had all-electronic systems. Possibly physicians might be more accepting of the technology, if using it was a norm among their colleagues and valued by their institution.

Facilitating Conditions

The increasing use of Smart phones is seen as a strong facilitating condition. The hospitals would also need to have systems in place which would support the use of the diabetes management application in terms of both the technology required and the staff hours to deal with it. Location is also a factor as some areas may have problems with mobile connection.

Behaviour Intention

All of the doctors said that they would use the diabetes management application if they were given the required time to do so and if the system was adapted to meet their needs – for example being able to identify the patient's record number and accessing their medical files.

Results from the semi-structured interviews with doctors reveal that the following factors were also important in determining technology acceptance: culture, education, income level and location, and could usefully be taken into consideration when modeling a theoretical framework for technology acceptance by Saudi diabetics, doctors and diabetes specialists of a mHealth application.

4.2. The Patients' Survey

4.2.1 Introduction

a) The diabetes patients' survey was conducted over a period of two months, using a Survey Monkey online questionnaire. The results of the survey are outlined below in terms of the respondents' profile, patients' problems and their reaction to the diabetes management application. A bivariate analysis was then conducted to ascertain the correlation between three main variables. These were: confidence in managing diabetes

b) Difficulties in accessing specialist care and

c) Willingness to share medical data via Smart phone / computer, together with other variables such as age, gender and so on.

4.2.2 Results of Patients' Survey

4.2.2.1 Descriptive Analysis

The descriptive results of the patients' survey can be seen in chart form in (Appendix B). I will present a summary of these findings here along with a commentary, annotated with reference to the doctors' interviews as appropriate. Percentages will be given in round figures, as the more precise figures are given in the Appendix. The filter questions asking respondents whether they agreed to take part in the survey and stipulating that they had to be over 18 and receiving treatment for diabetes meant that of the initial 1,275 respondents, 355 completed the questionnaire. Answered: 1,275 Skipped: 0

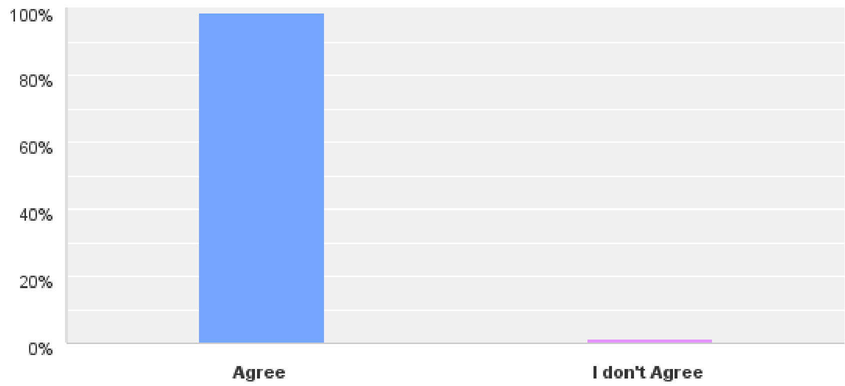


Figure 42Response rate

Profile of Respondents

The largest cohort of respondents were aged 31-40 (27%) followed by those 21-30 and 41-50 (23% respectively) Respondents 51 and over represented16% of the total and under 20s, 12%. (Figure 4.3) Males made up 56% of the sample and females 44%. (Figure 4.5) The average length of time respondents had had diabetes ranged from under 2 years (26%) to over 10 years (34%). (Figure 4.4) These results showed that the survey covered a good range of respondents from all diabetic patients in Saudi Arabia which represent 28% from all population (Ministry of Health, 2012)

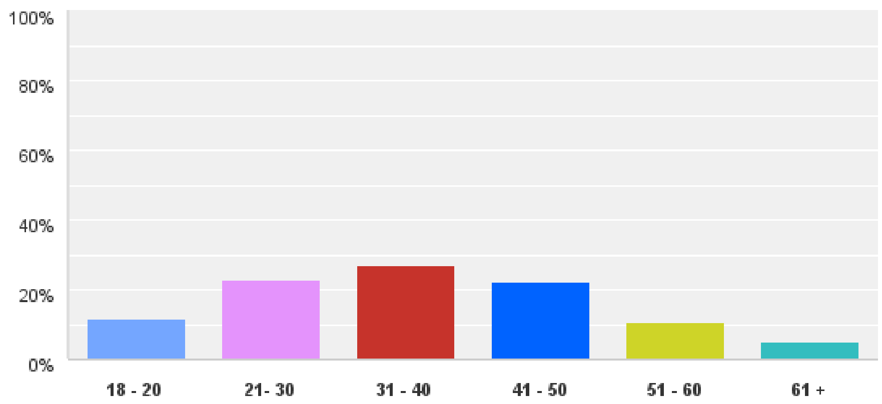


Figure 4. 3 Age Profile

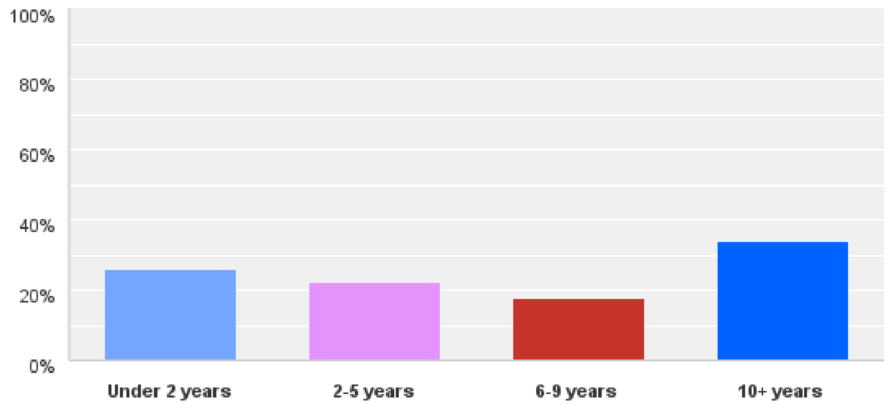


Figure 4. 4 Length of Time Having Diabetes

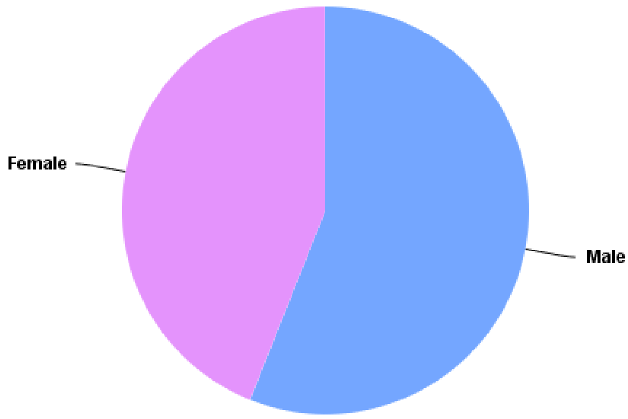


Figure4.5Gender Distribution

Over half of these respondents (53%) monitored their blood glucose at home, only 17% saying this was done by a doctor. The rest had their blood glucose monitored by a doctor and also did it at home. (Figure 4.6) The majority (63%) checked it once per day or less, but 6% of respondents said they did this five times a day or more. (Figure 4.7) This result shows that the monitoring or blood glucose is crucial for diabetes patients who are encouraged by doctors to do this for themselves. One of the doctors interviewed said that the patient's progress depended on good self-management. Also, most of the respondents (93%) were on medication.

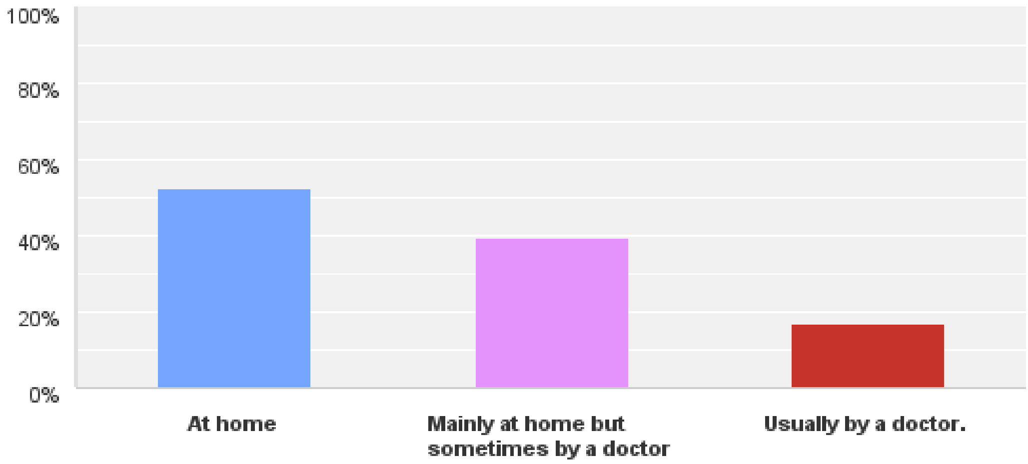


Figure 4. 6 Glucose Monitoring

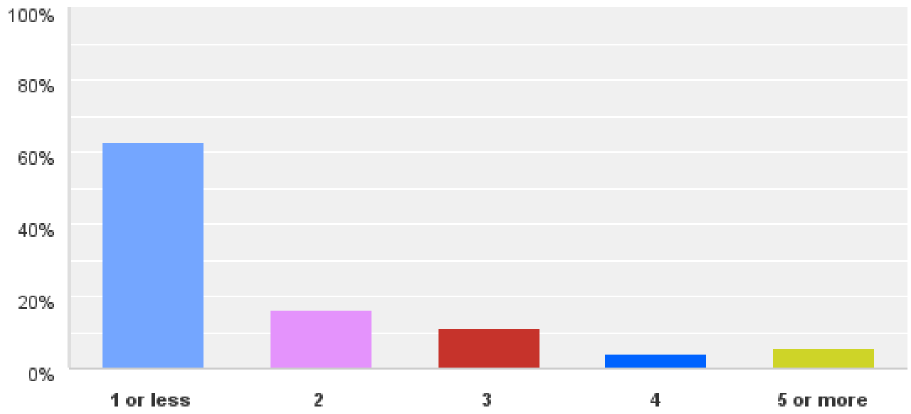


Figure 4. 7 Frequency of Monitoring Glucose Levels

<u>Patients' Problems</u>

85% of respondents tested their blood glucose. Only 20% of them claimed that they never forgot to test it, 28% sometimes forgot and 40% often forgot (Figure 4.8).Forgetting to take medication seemed to be less of a problem, with 41% saying they never forget; however, the rest did forget with nearly 6% saying that this happened ‘often’. (Figure 4.9) This shows that an alert system for glucose testing and taking medication could potentially be useful to the majority of the diabetes patients questioned.

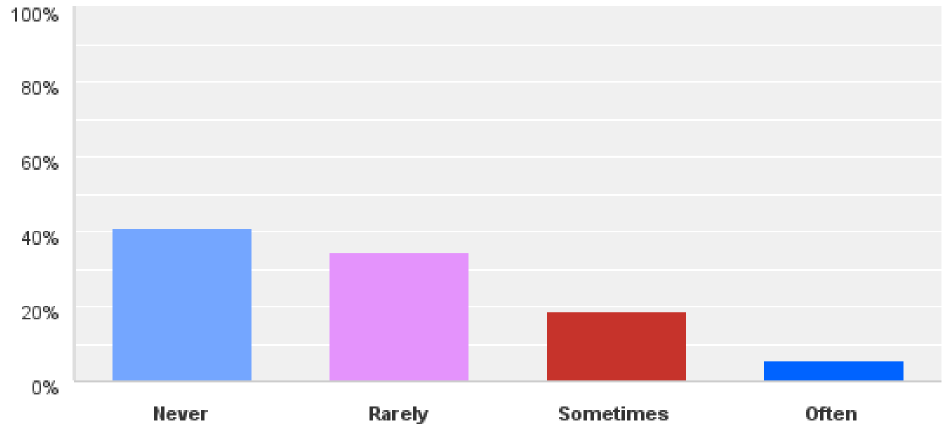


Figure 4.8 Forgetfulness about Taking Medication

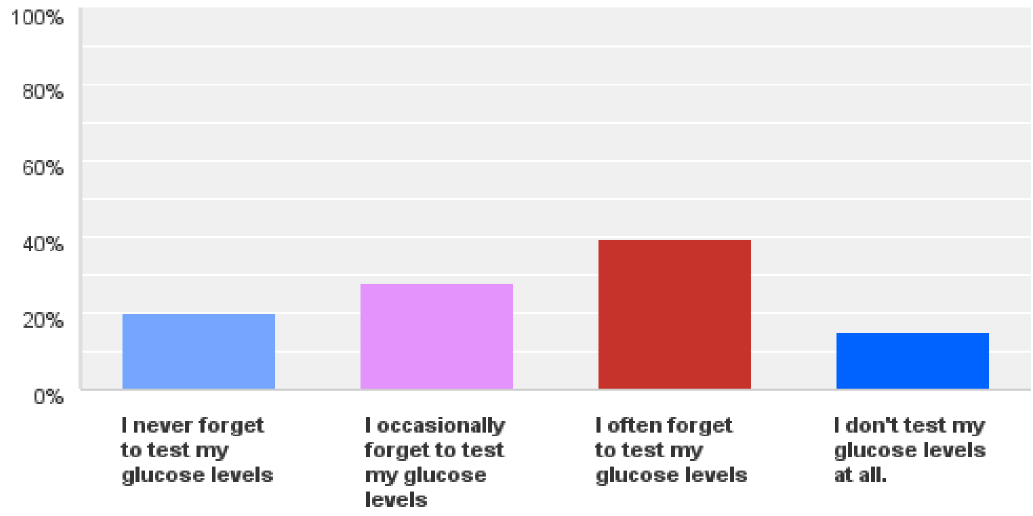


Figure 4. 9 Forgetfulness about Testing Glucose Levels

There was also a desire to receive more information about managing diabetes (61%), diabetes and diet (57%) and diabetes and exercise (49%) (Figure 4.10)These are all functions that can be performed by a diabetes management application. Responses to the question about where patients currently obtained information showed that they were already turning to electronic sources, with over half (52%) saying that they looked on websites. This was a more popular source than even doctors' leaflets (51%), other media (33%) or family and friends (26%) (Figure 4.11)

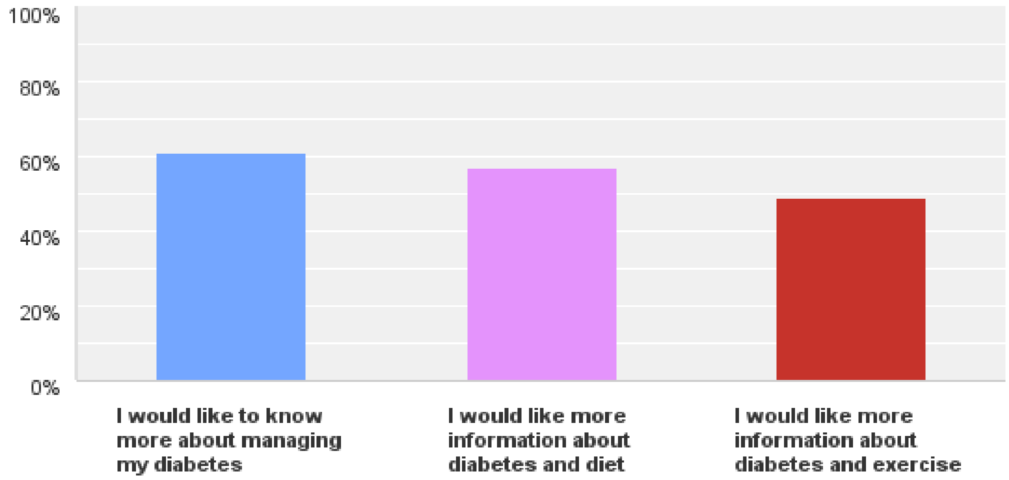


Figure 4. 10 Need to Receive Additional Information

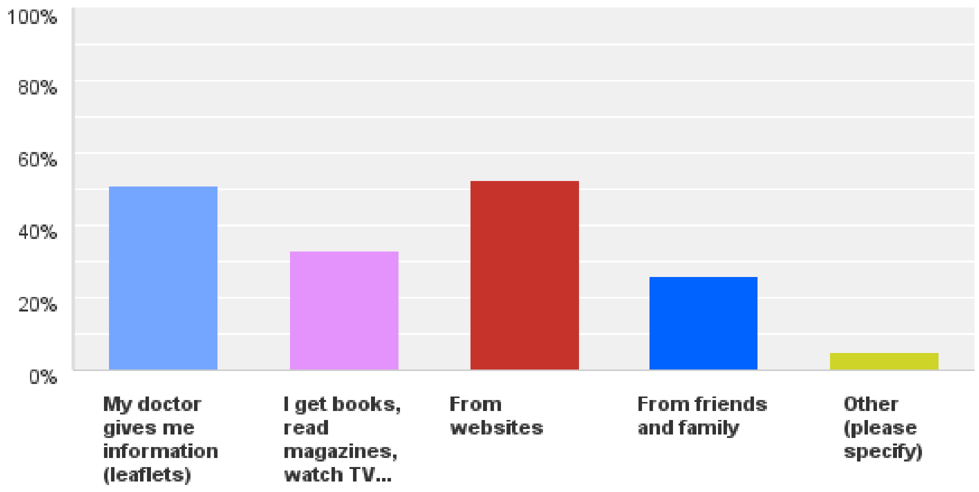


Figure 4.11 Channels Where Additional Information Is Currently Obtained

Few respondents (11%) believed that they were successful at controlling their diabetes; and 22% said they simply 'get by'. Over a quarter believed that they were not controlling their illness 'at all'. Almost half of them (43%) felt they still needed help and/or instruction (Figure 4.12). At interview, one of the doctors said that diabetes is unique in requiring a lot of self-management and monitoring by the patient and anything that could help this, such as a diabetes management application could be useful if the patient was willing and able to use it. This is reflected in the results of the following question which asked patients if they felt their doctor was sufficiently engaged with their treatment: 23% of respondents treated themselves and 30% saw doctors 'infrequently'; 31% saw the doctor 'regularly' and 16% reported that their doctor monitored them 'continually' (Figure 4.13). Engagement with specialists could be done via an application which allows patients to be both more independent and to be monitored by a specialist.

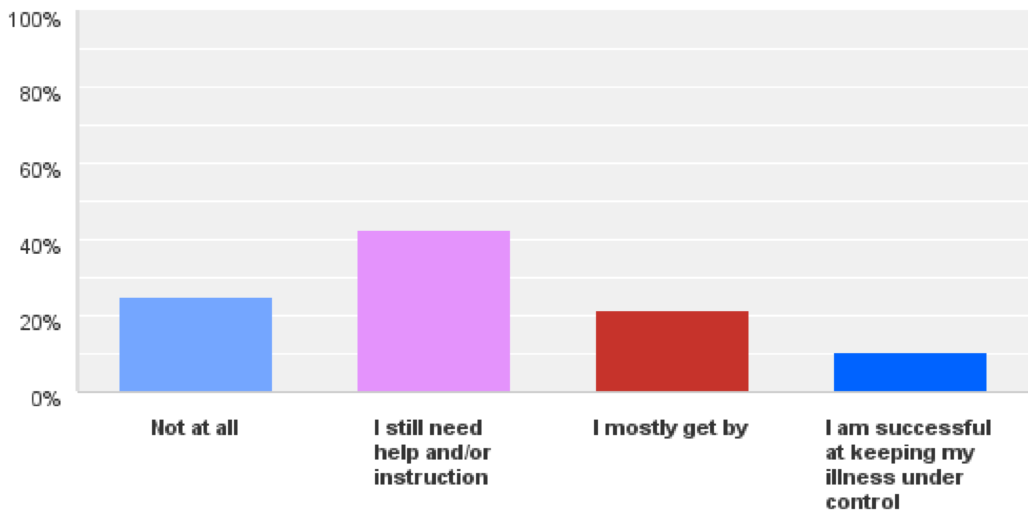


Figure 4. 12 Confidence in Managing Diabetes

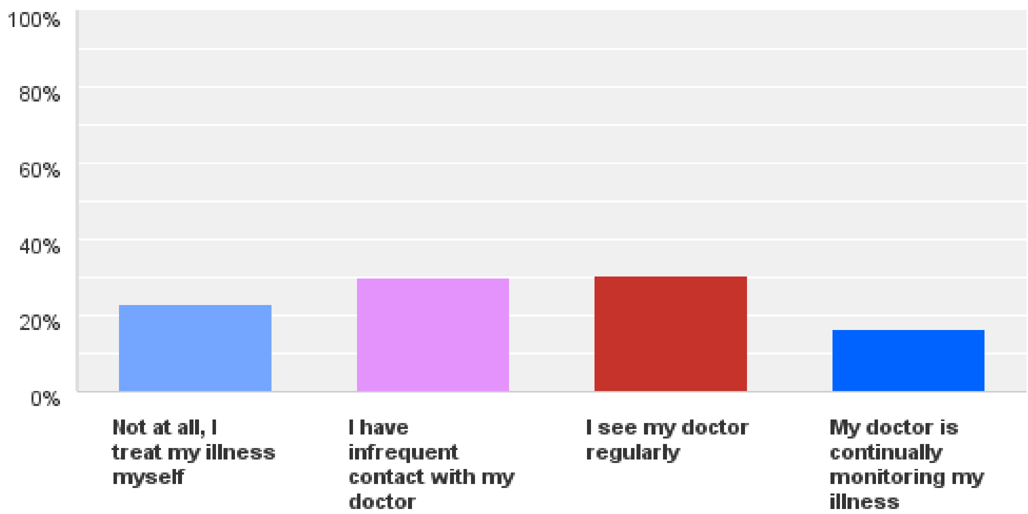


Figure 4. 13 Doctor Engagement in Treatment

The results of the next two questions give a picture of patients' experience of hospital appointments. Although 40% of patients reported that they had 'no problem in getting an appointment', 60% said it was difficult to get one when needed. 33% reported problems in going to appointments with 12% not being able to afford the travel, 6%

saying that travelling was difficult and 13% (females) saying that no female specialist was available. (Figure 4.14) This result shows that there is a real problem in getting to appointments for a significant number of diabetes patients. Furthermore, this is a problem that doctors may not be fully aware of, as patients who cannot afford to travel would probably not make appointments in the first place. Although a diabetes management application may not be a replacement for visiting a specialist, it could provide some means of communication with a specialist and a way of getting information for these patients.

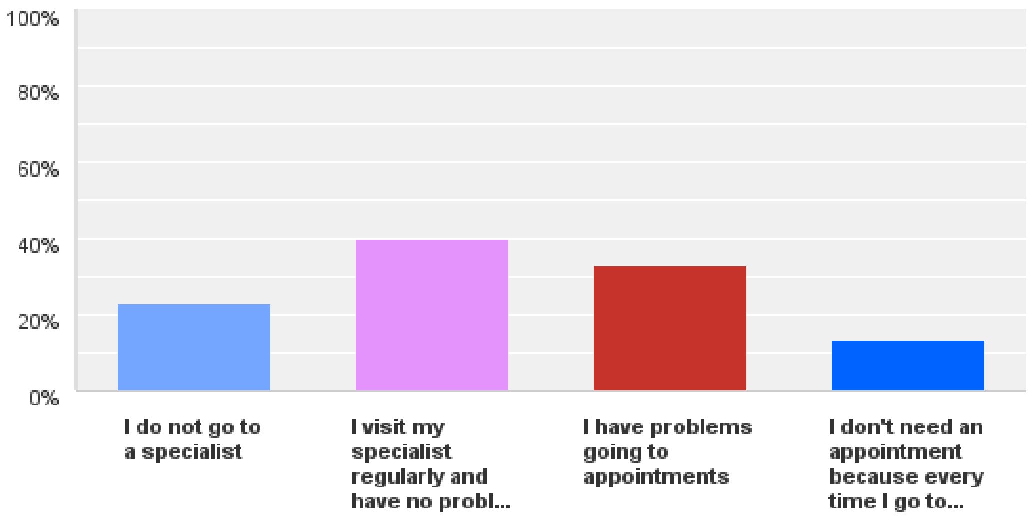


Figure 4. 14 Difficulty Getting Appointments

Patients' Reaction to the Diabetes Management Application.

After watching a three-minute video on the Diabetes Management Application, 92% of respondents said that they would feel comfortable sharing their data in this way (Figure 4. 15).

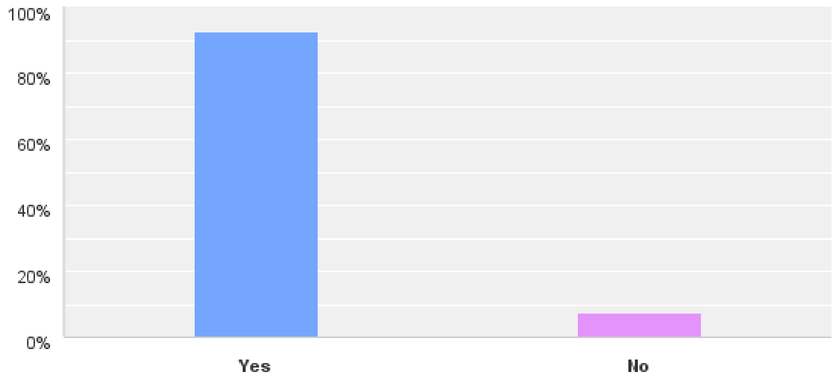


Figure 4. 15 Acceptance of mHealth App

As far as features that patients would expect to see in a diabetes management application, the most popular was a record of blood glucose test results (57%), about 50% wanted advice and information about diet and feedback from their doctor; this was closely followed by automatic submission of blood glucose results to the doctor (48%); advice and information (47%); ability to communicate with the doctor (43%) and alerts to take medication (42%). Advice and information about exercise (40%), appointment reminders (37%) and ability to make appointment (35%) were seen as slightly less important. Perhaps what is interesting about this result is that features were not ticked more often, given that respondents could tick as many as they wanted. It is possible that respondents may not have felt qualified to answer what feature an app should have and simply focused on what their most pressing needs were. Similarly, with answers to the next question where patients were asked whether the diabetes management application would be more useful as a tool 'to help me manage my condition'; as a 'way to deliver information to my doctor' or both. Although 54% clicked 'both', the rest chose one or the other and the result showed that using the app to manage the diabetes was more important than communicating with the doctor. The penultimate question was concerned to see how patients would choose to use the app.

By far the most popular way was on a Smart phone (61%), 30% said they would use it on both a Smart phone and computer, only 5% said just a computer and 4% that they would not use the app. It seems then that the application would be most used on Smart phones (Figure 4.16).

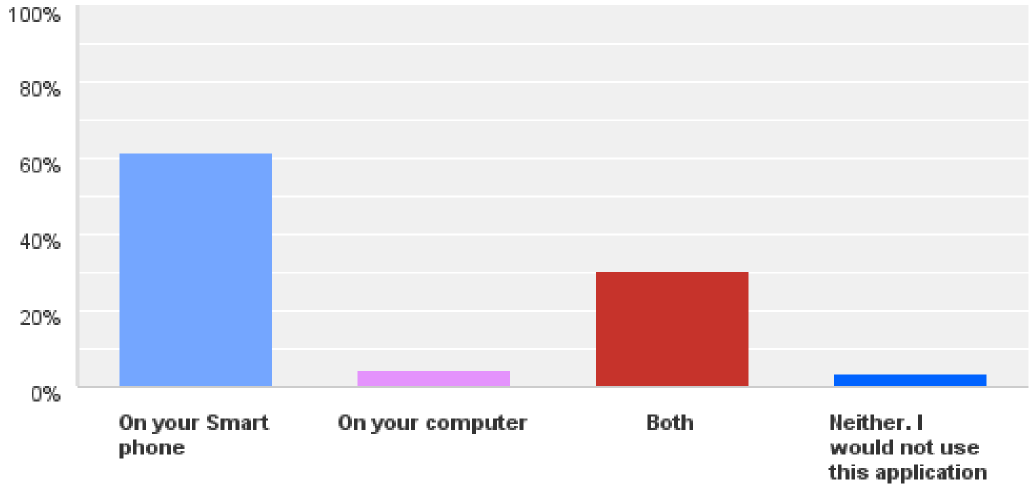


Figure 4. 16 Preferred Platforms to Use App

Finally, patients were asked what would be a barrier to using the app. (Figure 4.17). Of the 306 who replied, 26% said ‘no access to a Smart phone or computer’. As they were answering the survey on a computer, it has to be presumed that this situation is hypothetical; for example, at a future time when they were away and had no access. The other responses ‘Sounds too complicated’ (15%), ‘Takes too much time’ (25%) and ‘I don’t think it will help me manage my diabetes’ (19%) shows that many diabetes patients would need training in order to accept this technology comfortably. The Technology Acceptance Model suggests that the potential user’s perceptions of how easy it would be for them to use the technology are of great importance when assessing whether technology would be accepted. Twenty-seven percent of patients responded ‘Other’ and, as can be seen in the ‘Patients’ Comments’ section, the majority of these said that there would be no barriers to accepting the Diabetes Management Application.

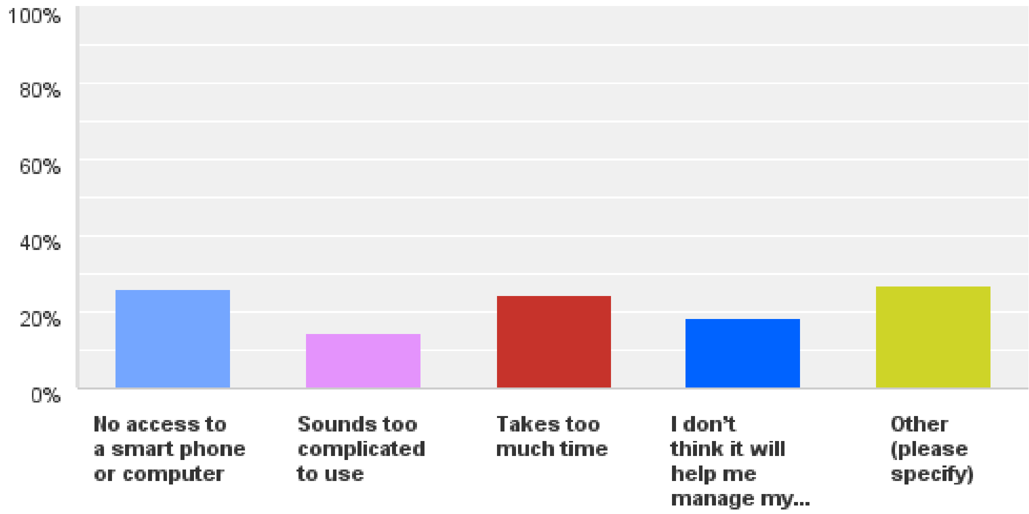


Figure 4. 17 Potential Barriers to Using App

4.2.2.1.1. Comments in Patients' Questionnaires

The comments included in the patients' questionnaires revealed data about where they obtained information about diabetes (Question 11); attending appointments (Question 15); the features they thought a diabetes management application should have (Question 17); how a diabetes management app would be of use to them (Question 18) and what might prevent their use of such an app (Question 21). The comments were made in Arabic and translated and summarized by the researcher.

Information about Diabetes

Seventeen respondents commented on this. Although the sample is very small, it is still interesting to consider these comments in terms of patient needs and use of technology. Five people mentioned the Internet and three more mentioned online social media such as Twitter and Face Book. This would suggest that some diabetes patients are already used to getting information from electronic sources and using these to ask questions. Healthcare professionals were also mentioned with four patients mentioning their doctor and one a nurse. One of these said that they asked their doctor online which shows that diabetes patients are communicating in this way.

'Other people' were also a source of information, notably friends (2 mentions) and 'other diabetics' (3 mentions). One respondent said she acquired information through her 'Diabetic Girls' Group'. Such groups, whether virtual or face-to-face, might be a useful way of disseminating information about Diabetes Management Applications. Four respondents obtained information through 'deep research' or 'studies' which shows a willingness to acquire knowledge. In contrast, two respondents commented that they 'don't care' or 'don't read about it'. More research would need to be done to ascertain the reasons for this latter response as the doctors' interviews revealed that they believed that patients were anxious to know about managing their illness.

Attending Appointments

Forty-nine people commented on this. Ten people said that they did not attend appointments because they were 'too busy', mostly because of work. It is interesting to reflect on this as two of these respondents said that their workplace did not permit them to take the time to attend appointments. Resident foreigners may have to get permission from employers to travel to another city for appointments and this can be denied. One such patient commented that he did not take appointments as he was a resident foreigner and appointments 'cost too much' and another simply said 'expensive'. One respondent said 'language' was a problem. This highlights the special difficulties that diabetic resident foreigners have. There were also practical difficulties even if the patient was not too busy and could afford to go. Five respondents said that they could not get convenient or adequate appointments as the doctor was too busy; four specifically stated that there was no diabetes specialist at their hospital; seven cited difficulties with transportation.

Other factors that featured in the comments about appointments were dissatisfactions with the treatment and emotional factors. Three respondents commented on the former e.g. ‘I don’t like my diabetes doctor and the way he treats me’ and seven respondents gave emotional reasons for not going to appointments. For example, ‘I hate to recognize that I have diabetes’, ‘I don’t like to go because they might admit me’ and ‘I am afraid to go and see the doctor for fear he will discover complications’. A lack of trust in hospital treatment also featured. Patients who have such problems may well find that communicating through an app is preferable as they are receiving information in their own home and not having the emotional as well as the practical discomfort of going into a hospital environment.

Benefits of the Diabetes Management Application

Comments to questions 17 and 18 yielded 23 responses, which referred to the perceived benefits and features required of a diabetes management application. These comments generally perceived positive aspects to the application, and some were expressed in a general way, for example ‘Help to accept my diabetes and manage my life’. Other comments about perceived benefits were more specific, in particular the way that the app allowed communication with a specialist (8 comments). Other requirements ranged from wanting the app available in Arabic (2 mentions); reminders for insulin injections (1), and nutritional database for information about carbohydrates with portion size (1). There was only one negative comment ‘No benefits, these come from treatment', which echoes some of the findings in the interviews, where doctors stated that the relationship with a physician was crucial. However, the app was seen by some patients as helpful when this relationship was unsatisfactory; for example 'No connection between me and my doctor, only 5 minutes when I see him'. One patient asked enthusiastically 'How can I download it onto my laptop?'

<u>Factors Preventing the Use of the Application</u>

Question 21 produced by far the greatest number of written comments – 83. However, 48 of these stated that nothing would prevent them using the app. Of the remaining 35 comments, eight said that language was the issue, of these only one said that literacy was an issue, the rest said that the app would have to be in Arabic. Five people thought the problem would be their doctor's reluctance for them to use it. Four people identified that the problem would be their own reluctance 'Boring sometimes', 'Forget to use it', 'Not caring to use the app will make me neglect it' and 'I love my mobile phone, it makes me happy, I don't want it to remind me of my disease'. Only one person said that they worried that 'It publishes patients' personal data (privacy)' and one that it might be too complicated for older people.

Four respondents cited technological reasons: two had no Smart phone, one said 'Our hospital has no modern technology system' and one, who had clearly had experience with such apps, stated 'The apps I've tried have a complicated interface for entering blood glucose results which takes too much time with options such as tagging. If, for example, there was a wireless method that communicates results from my meter directly, I'd consider it.' This comment reveals how the next stage to exploring technology acceptance would need to entail a trial of the application with Saudi diabetes patients. One patient even commented ‘I haven’t tried it yet, how can I decide?’ and four others said ‘Don’t know’. These doubts were in contrast to the four comments that specifically asked whether they could get this app as they wanted to use it.

4.2.2.2 Bivariate Analysis

To carry out the bivariate analysis I selected the following questions:

Q12: confidence in managing diabetes

Q14: difficulties in accessing specialist care

Q16: willingness to share medical data via Smart phone/computer

I looked at the relationship of these key variables with demographic variables, i.e. age, gender, years with disease and diabetes-related behaviors.

Firstly, the variable of *confidence in managing diabetes* was not significantly associated with gender. It appears that men have somewhat more confidence than women in managing their diabetes although the differences observed are not statistically significant (Chi-sq=5.62; p-value=0.132). Next, confidence was not associated with age. I recoded the age variable into broader categories because the last category had few observations. There is no significant relationship between confidence in managing diabetes and age (Chi-sq=5.89; p=0.436). Similarly, there is not a clear relationship between more years with the disease and more confidence managing it. The p-value indicates that the differences observed are significant at an alpha level of 10% but not at a 5% level, which is the usual set level of type I error in most studies. What seems clear is that even patients with more than ten years living with the disease still feel that they need help managing it (over 60% of them).

According to the Chi-square test there was a significant relationship between confidence and daily frequency checking glucose levels. Because there are some cells with less than 5 observations, I collapsed the last 2 categories into one “4 or more times” and re-ran the Chi-square test. As expected, it seems that those that are more confident managing diabetes are the ones that check their glucose levels more often (Chi-sq=18.8; p=0.027). There is also a significant association between confidence in managing the disease and forgetfulness regarding checking glucose levels. Those who never forget are the ones with more confidence (Chi-square=58.62; p=0.000). There seems to be a clear negative association between confidence in managing the illness and forgetting to take meds. Those more confident are the ones that are less forgetful about their meds. For instance, among the ones who often forget meds, more than half (55.56%) declared themselves as being not at all confident managing diabetes compared to 15.22% among the ones that never forget meds (Chi-square=34.944, p=0.000).

There is also a significant association between confidence and doctor engagement. Patients that see their doctor more frequently show the highest percentages of confidence (14.02% and 22.81%). This is also consistent with the 39.51% of patients that don’t see their doctor at all who also declare being not at all confident in managing diabetes (Chi-sq=36.22; p=0.000).

There is an association between *access problems* and age although it is not very clear. The biggest observed difference is for age group 31-50 which shows the lowest rate of visiting a specialist (31%) as opposed to 48% among patients over 50. They also show the highest percentage of ‘not having specialist’ (24.14%).

Finally they also shows the highest rate of ‘having problems going to appointments (30.46%) although they are followed closely by the 18-30 group (30.33%) and by the over 50 group (26.79%). (Chi-square=13.00; p=0.043)

There is also a different pattern of care access across genders. Almost twice as many males do not go to a specialist (23.74% vs. 12.42%). Both genders however are similar in terms of having problems going to appointments with females showing 30.72% and males 28.79%. (Chi-square=9.93; p=0.019) No significant differences were found between access to care and years with diabetes.

There is a clear relationship between going to a specialist and checking glucose levels more frequently. Among those that check glucose levels 1 or fewer times a day, 34% go to a specialist compared to 62% among patients that check their glucose 4 or more times daily (Chi-square=18.66; p=0.028).

There is a significant association between the access to care and self-testing blood glucose variables. Patients who don’t test their glucose levels show the lowest percentage of visiting a specialist (28.85%) compared to 48.53% among those that never forget testing their glucose. (Chi-sq=20.48; p=0.015) A similar pattern to the one seen with forgetting testing glucose is seen with ‘forgetting taking meds’. Those that visit a specialist are less likely to forget to take their meds. (Chi-sq=42.28; p=0.000) Also, those who see their doctor more frequently are also the ones that are more likely to visit a specialist.

Acceptance, measured by Question 16 was tabulated against age, gender, years with diabetes, frequency testing glucose levels (Q6), forgetting about testing glucose levels (Q7), forgetting about taking meds (Q9) and doctor engagement (Q13) and no significant association between acceptance and any of these variables was found.

4.3 The Doctors' Survey

4.3.1 Introduction

The doctors' survey was conducted over a period of two months using a Survey Monkey online questionnaire. The results of the survey are outlined below in terms of the respondents' profile, perceived problems, communications with patients and reactions to the diabetes management application. A bivariate analysis was also conducted to ascertain the relationship between the socio-demographic variables (gender, experience and number of patients) and the following selected variables:

- Use of text messages for appointment reminders
- Acceptance of the mHealth solution
- Confidence about security of patient data
- Belief that the solution could be difficult to use

4.3.2 Results of the Doctors' Survey

4.3.2.1 Descriptive Analysis

The results of the doctors' survey can be seen in chart form in (Appendix C). A summary of the findings together with a commentary is provided here. Percentages are given in round figures as more precise figures are available in the Appendix. After having read the e-mailed information and signed the consent form, a total of 29 doctors responded to the questionnaire. No respondents skipped any of the 17 questions.

Profile of Respondents

19 of the respondents (66%) were male and 10 (34%) were female. This is a good gender spread, given that there are more male than female doctors. According to the Ministry of Health, there are 29,288 male doctors (74%) and 10,176 female doctors (26%). There were no figures found for diabetic specialists alone. Thus, in the sample, female doctors were somewhat overrepresented

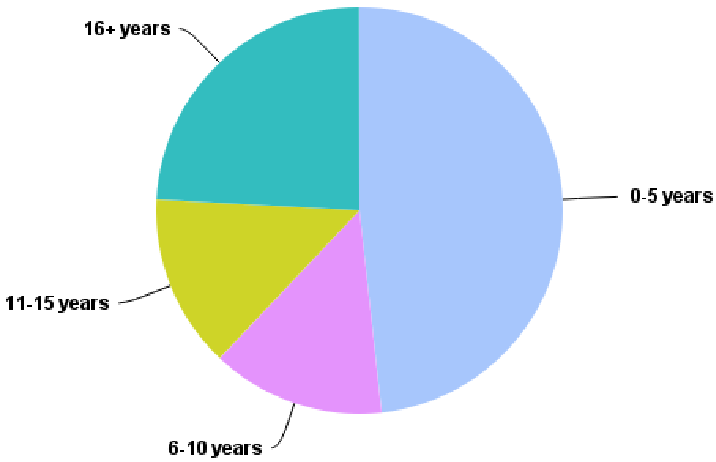


Figure 4.18 Years of Experience

Nearly half (48%) of doctors had been specialists for five years or less; however, the next biggest cohort was doctors who had specialized in diabetes for 16 years or more (24%). The rest had served 6-15 years. (Figure 4.18) There was also a wide spread in terms of numbers of diabetic patients. Nearly half (48%) had 100 or more patients, but the next biggest cohort was doctors with 20 patients or less (21%). Doctors with 51-60, 81-90 and 90-100 patients formed just under 7% of the total respectively, and those with 21-30, 41-50 or 71-80 formed just under 3.5% of the total respectively (Figure 4.19).

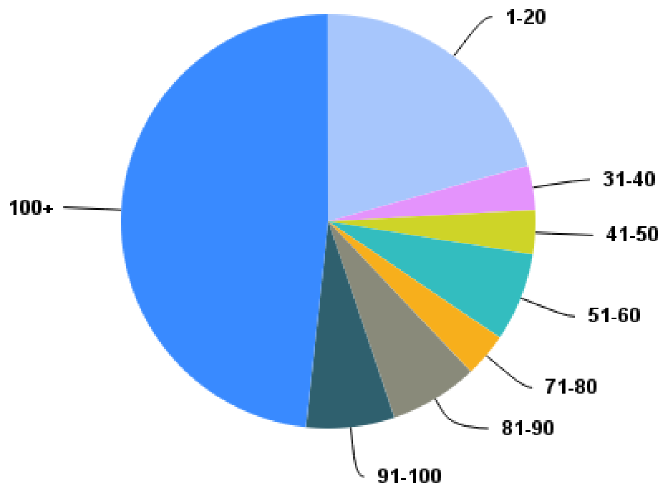


Figure 4.19 Numbers of Patients

Patient Problems as Perceived by Doctors

Of the male doctors questioned, six said that female patients had refused to see them because they were male. This highlights the difficulties faced by some female patients who may well benefit from having contact with specialists through an application. In terms of problems with not seeing patients, 41% of doctors felt that they did not see their patients as often as necessary, 45% felt they had too many patients to monitor effectively and that patients did not communicate data as often as necessary. Only 17% reported that there were no problems. This shows that there are serious problems in monitoring patients and that doing this via an application could be partly a solution if patients were to accept the technology and hospitals have the infrastructure to support it. Doctors identified that their diabetes patients had many needs. At the top was 'regular reminders to monitor important factors such as blood sugar, blood pressure and heart rate' (86%). This echoes findings from the interviews where doctors said that effective monitoring on the part of the patient was the key. Most doctors (76%) said that more information about diet was needed, closely followed by 72% who felt their patients needed more information about exercise. These factors are all about patients gaining more independence from doctors in self-managing their illness. 65.5% of doctors felt their patients needed regular reminders about appointments, 58% thought they needed a better way to send their data and 55% thought regular reminders to take medication would be useful (Figure 4.20). All these are needs that could be provided by effective and regular use of a diabetes management application.

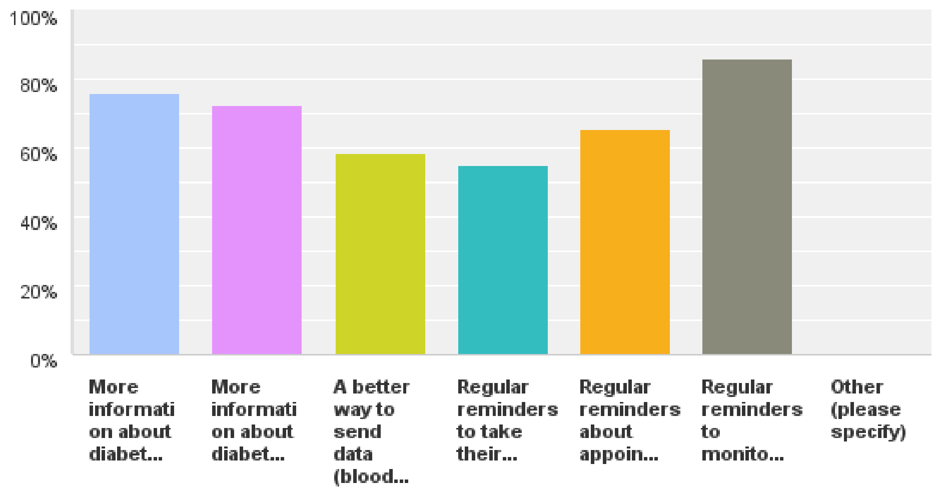


Figure 4. 20 Patients Needs As Perceived By Doctors

Communications with Patients

Doctors were asked how they monitored patients between appointments. The vast majority (90%) said this did not happen and that patients simply brought their results at the next appointment. Texts and emails are rarely used for this (7%) and 3.5% said patients phoned. This clearly shows a need for a quick and easy way to send data, especially if the patient has worrying changes. Communication from doctor to patient showed a similar pattern with 90% saying that lab results of tests were simply handed to the patient at the next appointment.

Given that there are admitted problems in seeing patients as often as required, this is an area of concern. A minority of doctors (7%) said that results were given by phone and 3.5% by text or email respectively. Treatment recommendations were also only given in person (100%), with one doctor mentioning that this was sometimes done by text or email. This shows that doctors should be the ones giving treatment recommendations, but that patients may have to wait a long time for this if they are not getting to see their specialist when they need. Using texts to remind patients of appointments, is clearly being used (45%), with phone calls used by two doctors (7%). However, the majority (52%) said there were no reminders.

Reactions to Diabetes Management Application

No doctors said that they would not welcome the application, nearly half (48%) said that they would really welcome it as a solution, 21% said that they would have reservations and 31% did not know (Figure 4.21). This shows that whilst there is a definite interest in the application, many doctors would still need to know more about it before accepting the technology. Most doctors (83%) thought it would help them to monitor and manage patients more effectively, and 72% believed it would provide better engagement and communication with their patients. Over half (55%) said that an application would extend the reach of their practice to rural and underserved patients and 51% thought that it would provide convenient access to practice appointments, prescription renewal or other services for their patients. (Figure 4.19) There were mixed responses about whether the application could be integrated into their practice. With regards to workflows and current staff, 38% thought it would and 17% thought would not. With regards to clinical records and communications systems the response was rather more positive, with 45% saying ‘yes’ and only 3.5% saying ‘no’. This echoes concerns raised by doctors in the interviews, who raised the issue of not having the time to attend to data streams from the application and requiring other staff to deal with it, or allocated time for this themselves.

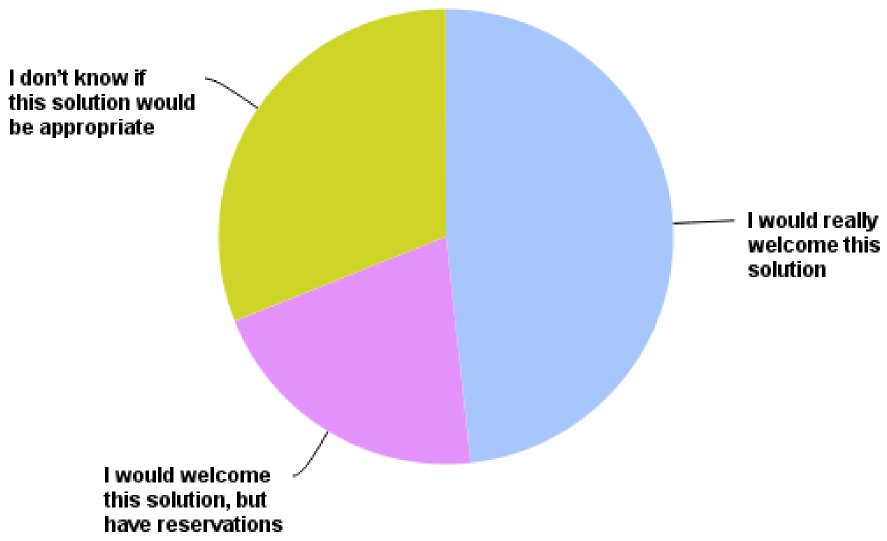


Figure 4. 21 Doctor's Acceptance of mHealth App

Doctors were almost equally divided when asked to consider whether their current IT infrastructure would be an enabler or obstacle in implementing a diabetes application patient monitoring program; 52% thought I would enable an application and 48% said it would not. This is a vital point when considering implementing the use of a diabetes management application. The security of patient data was also of concern to 24% of the doctors, although the rest said they would be confident of the security of data.

Finally, when it came to possible barriers to using this technology in their practice, nearly half (48%) wondered if it might be difficult to use. Around 27% mentioned privacy and data security, the same number was concerned about costs to the hospital and 24% did not see any objections and said they would welcome the application (Figure 4.22). In the last question, doctors were asked what they considered to be the 'drivers' of widespread adoption of technology solutions like the diabetes management application. The majority (65.5%) thought that clinical quality improvement would be a factor; 48% went for government mandate and patient access to care, closely followed by a wider transition from paper to digital systems (45%), only 10% went for 'revenue opportunities'. (Figure 4.23)

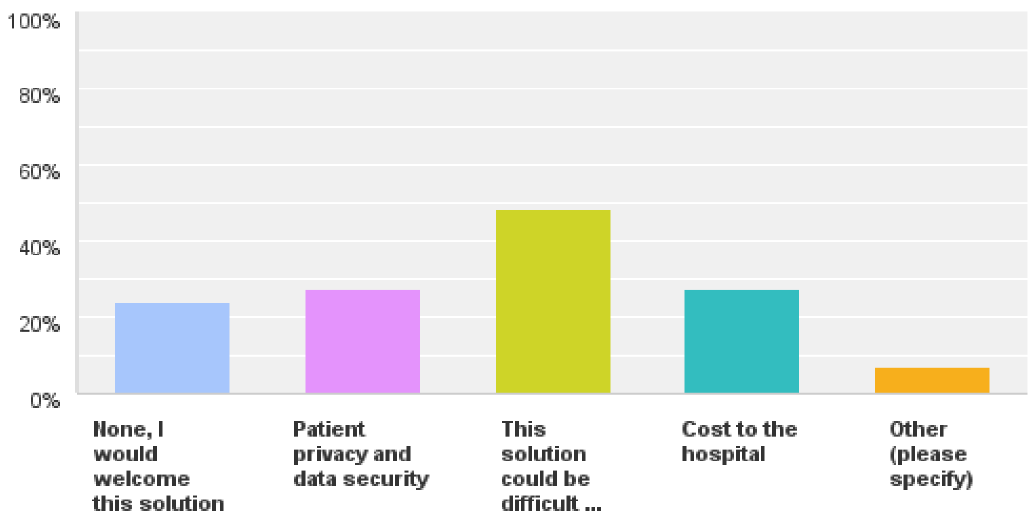


Figure 4. 22 Potential Barriers Of Adoption

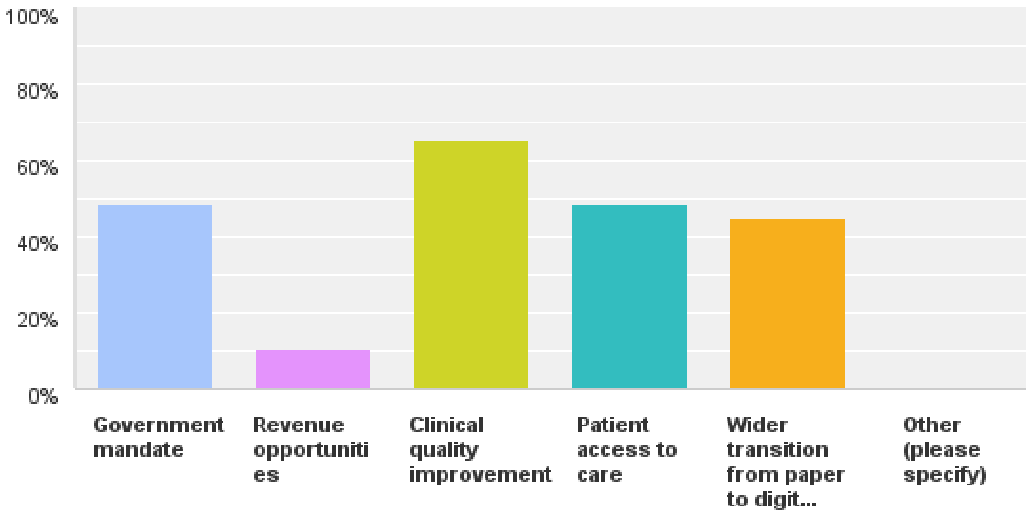


Figure 4.23 Drivers to Widespread Adoption

4.3.2.1.1 Comments in Doctors' Questionnaires

The comments given by doctors in their questionnaires revealed information about:

- The monitoring of patients between appointments [Q5];
- How patients are sent their medical records [Q6];
- Problems with monitoring patients' health [Q9] and
- Factors affecting the decision to introduce an mHealth diabetes solution at the doctor's practice [Q16].

Overall there were far fewer comments made by doctors than by patients, but some of these comments are nevertheless revealing.

Monitoring patients between appointments [Q5]

Just two doctors commented on this, one just putting ‘records’ which suggests that there is no monitoring beyond updating patients’ records (presumably with test results). The other doctor mentioned a visit from a ‘diabetic educator’. It would be interesting to see if these visitors could be used in providing patient training in the use of a diabetes management application.

How patients are sent their medical results [Q6]

Four doctors commented on this; two saying that patients were simply given the results at their next appointment. Given that some patients wait for a long time to get an appointment, this shows that it would be useful to have a simple way of communicating these results, such as through a diabetes management application. The other two doctors said that the results were sent to the patient’s GP. This solution is acceptable if the GP is able to communicate these results easily and speedily, but if they then have to phone the patient or make an appointment, this makes more work for the doctor and delays getting the result to the patient. If the result is good and the patient does not need to see a doctor, giving the patient this information quickly would save unnecessary worry; if the results necessitate the patient seeing a doctor or having a change in their prescription, then it is even more important to communicate this speedily so that the patient can take necessary action.

Problems Monitoring Patients’ Health [Q.9]

Two doctors commented. One said that patient compliance was the problem. At interview doctors said that the doctor-patient relationship was very important, and that it was essential for doctors to take the time to sit with patients and explain carefully how to self-manage their illness. Many survey patients commented that they had no trust in doctors or that they were unhappy with how they were treated by their doctor or that their doctor did not spend enough time with them. Here now is an example of a doctor's frustration with the patient not complying with the doctor's suggestions. Although being given information by a diabetes management application may not be a substitute for a good doctor-patient relationship based on trust, it may well be a solution if this relationship fails. The second comment was that the hospital did not have sufficient IT support to allow electronic contact with patients. If a diabetes management solution is to work as a means of communication, then there would have to be the means of the hospital having the time and the technology to allow for it.

<u>Factors Affecting the Decision to Introduce an mHealth Diabetes Solution[Q.16]</u>

Two doctors commented on this. One said that the Saudi Ministry of Health had an 'old system'. Presumably this means that the doctor felt that there would not be the required infrastructure to support use of the application. This reflects the concern listed above with monitoring patients' health. The other doctor saw the difficulty as being that some patients are illiterate or too poor to have a Smart phone. Clearly, there are serious problems with using a diabetes management application with patients who have computer literacy problems, although training can overcome this. More problematic is patients who cannot read – either through illiteracy or because of eyesight problems. It would be interesting to investigate the possibility of applications that 'speak' and 'listen' for this group. The poverty problem might be solved by patients accessing the application on a computer provided by their community. If this was done, then privacy and data security could be ensured.

4.3.2.2 Bivariate Analysis

The relationship between the socio-demographic variables (gender, experience and number of patients) and the following selected variables were examined:

- Use of text messages for appointment reminders (Q8_4)
- Acceptance of the mHealth solution (Q11)
- Confidence about security of patient data (Q15)
- Belief that the solution could be difficult to use (Q16_3)

Fisher's exact test, which is more appropriate when working with small sample sizes, was used to assess the association between pairs of variables.

Use of Text Messages for Appointment Reminders [Q.8_4]

Looking at the percentages, female doctors seem more likely to use text messages for appointment reminders than male doctors. However, maybe due to the small sample size, the results are not statistically significant so nothing can be concluded. There is an association between years of experience and use of text messaging for appointment reminders. This association is significant at a level of 10%. Doctors with more experience show higher percentages of using text messaging (Chi-square = 7.1952, Fisher's exact p=0.067).

There was no association between number of patients and the use of text messaging.

Acceptance of the mHealth Solution [Q.11]

No significant results, that is, all p-values were larger than 0.05

Confidence about Security of Patient Data [Q.15]

Significant results at a 10% level were obtained when comparing confidence about the security of patient data with the number of years of experience. Doctors with less experience (0-5 years) were the ones more confident about security of patient data. (Chi-square = 5.2055; Fisher's exact p=0.090) This might reflect the fact that younger doctors have more trust in using the new technologies in their practice. It also seems that confidence about safety of patient data is higher among middle size and larger practices. (Chi-square – 5.2055; Fisher's exact p=0.063)

Belief that the Solution could be Difficult to Use [Q.16_3]

A higher percentage of small practices believed that the solution would be difficult to use (83%) compared to middle-size practices (22%) and to larger practices (50%). (Chi-square =5.4164; Fisher's exact p=0.077)

4.4 Comparison between Doctors' and Patients' Views in the Online Surveys

It is interesting to compare the views of doctors and patients surveyed to see to what extent they concur over patients' needs and problems as well as their perceptions of a diabetes management application as a solution.

Patients' Needs

Both doctors and patients agreed that the primary need was information on managing diabetes, followed by information on diet and then exercise. Doctors rated these patient needs more highly than patients themselves.

Patients' Problems

Two thirds of patients said they had problems controlling their illness; with over half mentioning they forgot to take their medication, and 40% saying they forgot to test their blood glucose. There were also problems with getting appointments and going to appointments (60% and 45%). Doctors appeared to underestimate these problems, with 41% believing patients did not see the specialist often enough and 45% saying that they did not see patients for long enough. However, 17% said there were 'no' problems with their patients getting appointments. This may well because different hospitals operate at different levels of efficiency and different doctors allocate different amounts of time for patients. Some patients' comments revealed deep dissatisfaction with doctors and a lack of trust. Both doctors and patients reported problems with female patients not being able to see female doctors, which is important in the Saudi culture.

4.4.1 Perceptions of an mHealth Solution

Patients were generally very positive about using a diabetes management application, with only 4% saying they would not use it. Doctors were also positive and none of them said they would not use it. There were however, reservations from both groups, with doctors being more cautious. For example 92% of patients said they would feel comfortable sharing data this way, but 27% of doctors felt this was a concern. 15% of patients though the application might be 'too complicated', but 48% of doctors raised this issue. Both groups raised technical issues with using the application; a quarter of patients mentioned access to a Smart phone or computer as possibly being a problem and 48% of doctors saying that they did not feel the current IT infrastructure would enable the use of a diabetes management application.

4.5 Research Hypotheses

After reviewing the results of the qualitative and quantitative studies, it is possible to ascertain the extent to which the research hypotheses stated in the introductory chapter (Ha3 – Ha6) have been supported.

Doctors will perceive that a mobile health solution would benefit diabetes patients in Saudi Arabia (Ha3).

Although there were some doubts that a mobile health solution could be easily used by some patients, doctors generally perceived that a mobile health solution would benefit diabetes patients if they had the technology, the ability to use it and could be assured of the confidentiality of their personal medical data.

Diabetes patients will have a favourable response to using a mobile phone application to help manage diabetes (Ha4).

Again, some patients were worried that using a mobile phone application might cause them some difficulty, but the results were generally favourable with many respondents to the online questionnaire saying that they wanted to know how to get access to a diabetes management application immediately. The results of the survey have supported this hypothesis with the proviso that its introduction may have to be accompanied with training for some patients on how to use it.

Diabetes patients will accept the use of mobile phone application to help manage diabetes in Saudi Arabia (Ha5).

This hypothesis is supported as 96% of diabetes patients questioned would consider using the mobile phone application. Of those reporting that they did not wish to use it (4%), some might consider using the application on a PC as reasons given included that the user loved her phone and would not like to use it for a depressing reason like managing her illness. From the comments made by respondents, the application would have to be available in Arabic, as language difficulties seemed to be the main objection. Other comments about not being committed enough to use it regularly, although very few are telling, as is the worry that the specialist might not support its use. Doctors' encouragement to use the application would seem to be an important acceptance factor for some patients.

Diabetes specialists will accept the use of mobile phone application to help manage diabetes in Saudi Arabia (Ha6).

The specialists questioned were generally very welcoming of this technology and the hypothesis has been supported. There were, however, a lot of factors which specialists felt needed to be taken into account if the use of the application was to be effective. These factors were divided into two kinds: Firstly, misgivings about the ability of some patients' ability to use the application, which again points to the need that some diabetics will initially need help. Secondly, concerns about the application giving the specialists more work. It would seem that diabetes specialists may have to be convinced that this would not happen for them to be fully accepting of the application.

Figure 4.24 Summary of Hypotheses and Findings

Doctors believe a mobile health solution would benefit diabetes patients in Saudi Arabia	Doctors agree while the patients expressed apprehensiveness about technology, the ability to use and the confidentiality of data
Diabetes patients will have a favourable response to using a mobile phone application to help manage diabetes	Generally favourable with many wanting to know how to get access to a diabetes management application immediately. However, its introduction may have to be accompanied with training for some patients.
Diabetes patients will accept the use of mobile phone application to help manage diabetes in Saudi Arabia	Most would like to use it but language seems to be a deterrent, requiring the development of the app in Arabic. Doctors' encouragement could go a long way in seeing larger use of this app.
Diabetes specialists will accept the use of mobile phone application to help manage diabetes in Saudi Arabia	Specialists were supportive but have two major concerns – patients requiring support in its use and extra time commitment by specialists

4.5.1 Technology Acceptance Model for a Diabetes Management Application for Diabetics in Saudi Arabia

Moving the focus to modeling the results, Figure 4.24 shows an adaptation of the model developed by Venkatesh et al (2003). It is designed to show the factors involved in the acceptance of a diabetes management application by diabetics in Saudi Arabia, and is based on the results of the primary source investigations conducted by the researcher.

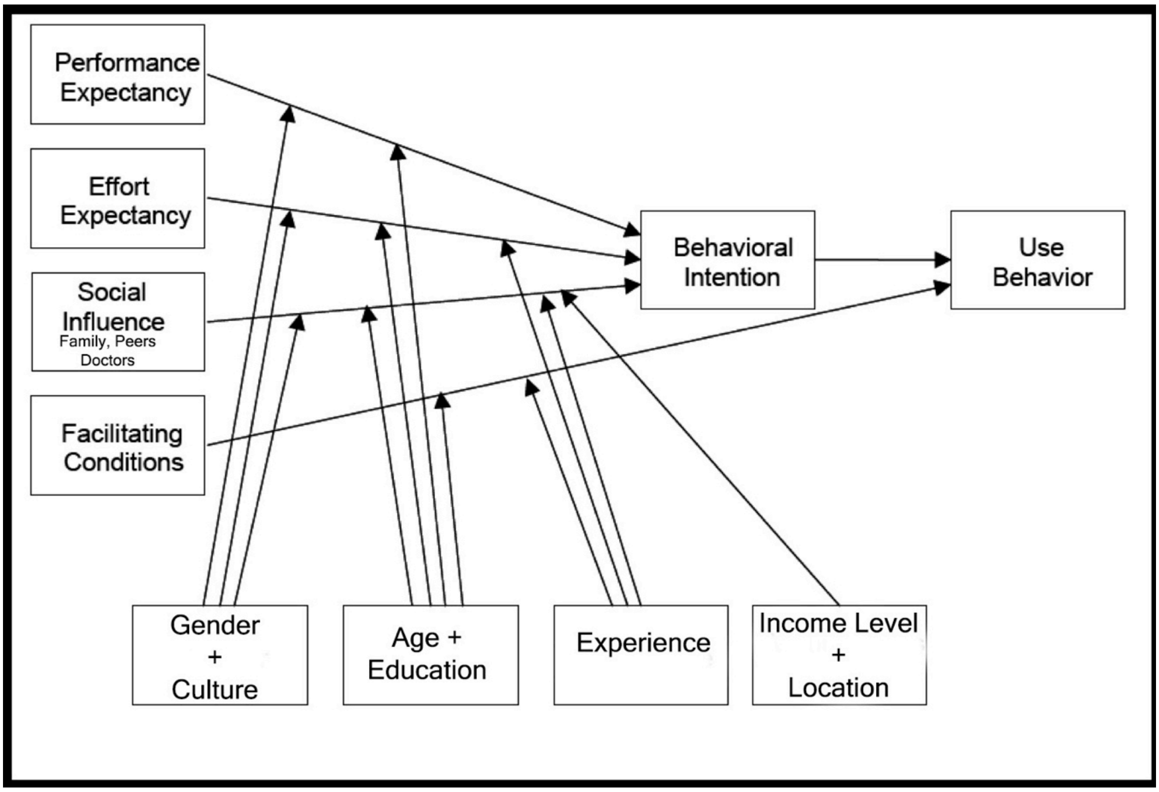


Figure 4.25 Model of Technology Acceptance of an mHealth Solution for SA Diabetes, Adapted from Venkatesh's UTAUT model (2003)

As the original model has already been explored in Chapter One and to some extent in Chapter Three, only the amendments will be further explained:

Social Influence

This has been divided into three categories. It is important to consider the impact of the diabetic's family on their use of the application. At interview, doctors suggested that patients who had difficulties using the Smart Phone app could enlist with the help of relatives who were more adept at using this technology. The peer group is also an important factor. Mention was made in the patients' survey of how information on managing diabetes could be usefully gained from a support group, such as The Diabetes Support Group for Saudi Girls. Such groups could disseminate information about downloading and using the application. Finally, patients could be told about the app by doctors and shown how to use it by them, or by the diabetes education specialists who work at many hospitals.

Gender and Culture

Saudi culture means that many women will not accept to be treated by male doctors, as highlighted by both doctors and patients in the survey; also, they may have problems travelling to appointments (See Chapter 2). Consequently, female diabetics who have difficulty accessing healthcare for these reasons may be more willing to use a diabetes management app if they are confident with using the technology or have someone who can show them what to do.

Age and Education

Doctors in the study were concerned that these would be factors in technology acceptance. One doctor who was interviewed commented that none of his patients would have problems in using the app as they were 'well educated'. Older people who are well educated and have no physical difficulties with using the application are likely to be more accepting of the technology. If the application is only available in Arabic or English this may affect Saudi residents who have not been educated in these languages. Saudi Arabia has a large population of foreign workers, many of whom have difficulties gaining access to specialist healthcare as they do not have their employers' permission to travel to appointments or cannot afford treatment. If these workers are suffering from diabetes they may benefit greatly from the app, but be unable to use it because of language difficulties.

Income Level and Location

Saudi Arabia is a large country and some diabetics are located a long way away from clinics or hospitals that provide specialist care. People on limited incomes may not be able to afford to travel to appointments, or to lose income by taking the time off work necessary to attend. This is further compounded if the patient has to travel with another person because they are female or too ill to travel alone. Such patients would thus find the app most useful.

It is worth noting that these factors interact with each other and with the factor of 'experience' in determining technology acceptance. For example, there may be a link between gender and experience of using mobile apps and also between gender and income. Income and location would be interesting factors to investigate in further work.

Finally, it is worth noting that 'Behavioural Intention' has an emotional dimension. The patient may find the app. useful and easy to use, but still resist actually using it. One patient commented that her mobile phone made her happy and she would not want to use it to communicate about her disease. It is possible that this remark was flippant but it would be useful to know how these emotional and attitudinal factors affect actual behaviour. Figure 4.25 below shows a summary of these findings:

Figure 4.26 Summary of Results relating to added constructs in revised UTAUT model

ADDED CONSTRUCT	**FINDINGS RELATING TO ACCEPTANCE**
SOCIAL INFLUENCE	Family – Younger family members can help older diabetics with app. Peers – Diabetes Support Group could inform and help with app. Use Doctors- Could inform, encourage and even train patients in app use.
GENDER AND CULTURE	Women having problems accessing treatment could use app
AGE AND EDUCATION	Doctors feel education level is crucial. Language issues for non-English/ Arabic -speaking diabetics
INCOME LEVEL AND LOCATION	App. would assist patients unable to travel to appointments because of cost or distance.

4.6 Limitations of methods used

Having conducted both phases of the primary research, it is useful to reflect on the limitations of the methods used by the study. The limitations will serve to highlight areas of future work to be carried out in the area. The qualitative study was limited by having to carry out the semi-structured interviews in the specialists' workplaces, so that there was a sense that the interviewees were 'taking time off work' to do the interview. As noted in the previous chapter, interviews conducted during the specialists' leisure time would have been better. Also, there was only one female specialist interviewed. The sample consisted of specialists who were largely unaware of mHealth. However, this provided a good opportunity to see how a new technologies was first responded to by professionals, and the misgivings they had were very enlightening as they highlighted the barriers to technology acceptance in this case. It was also interesting to note how the specialist with the most knowledge of mHealth had the most positive attitude.

In order to see how familiarity with a new technology such as an mHealth app affects perceived ease of use and usefulness, it would have been useful to conduct interviews with two groups of specialists, one familiar with mHealth and one unfamiliar. Although using a focus group was not feasible for this study (see Chapter 3), doing this would have been so useful, as doctors could have discussed the app and uses and limitations- perhaps with a technical expert to answer any questions they had and explain exactly how it worked. If prototypes on Smart phones that the specialists could have tried for themselves had also been available, this would have given the specialists a more realistic idea of what patients could do than perhaps the video did. A focus group of diabetes patients would also have been useful, especially if they too could have tried using a prototype of the app.

Although there was a good response to the online survey for patients, it did have its limitations. The surveys were distributed online and in Arabic, which means that one underserved group would have been omitted from the survey, namely immigrant workers. This highlights how the final sample obtained was not fully representative of diabetics in the KSA. However, it should be noted that the sample was ‘diagnosed diabetics’ and many diabetics among immigrant workers may well yet be undiagnosed The over 51s were under-represented in the sample (just 16%) which may have been due to the questionnaire being distributed by electronic means rather than as hard copies.

In the doctors' survey the questionnaire omitted to ask whether the doctor served a largely rural or urban area. Given that diabetes management apps are thought to be especially useful for remote populations, this would have been a useful question to ask. This demonstrates how even careful piloting of questionnaires does not always pick up every design fault, and that it is only in retrospect that it is possible to see how further improvements could have been made.

4.7 Conclusions

In general both patients and doctors are ready to accept and implement an mHealth app for diabetes management. The patients' barriers to adoption seem easily addressed with the proper training. The doctors' largest barrier to adoption seemed to be 'additional time needed to dedicate to the app', therefore a successful adoption would have to address this problem, maybe doctors will need to be paid for the time dedicated to communicate with their patients through the app. The hospital's infrastructure, would have to allow integration of the mHealth solution with their medical records otherwise this would seem to be an important barrier to be overcome if there is to be optimal use of the application.

The results of the study found that patients' age and gender can affect their perceptions of the potential usefulness of the app. Respondents were 44% female and it was mentioned by some of them and by doctors that they have difficulty in travelling alone to hospitals and also do not accept to be examined by a male doctor. Using an app may help such patients. There was a concern by doctors in both the survey and the interviews that older patients may be more resistant to using an mHealth app, but in Saudi culture older patients are not usually living alone and they generally are assisted by their relatives.

Smart phones are widely used in Saudi Arabia and their use is increasing and the survey revealed that 61% would like to use mobile phone with this application and 30% both computer and mobile phone. Respondents generally had experience of using mobile phone applications and they are comfortable using the mHealth application. However, there are other aspects of technology acceptance to be considered:

Voluntariness: The mHealth application will need to be trialled and it is essential that any such study only make use of voluntary participants.

Performance expectancy: For example, if a respondent forgets to test blood glucose, then they might find an app that reminded them useful. The study found that participants generally believed this app could assist them and provide benefits in managing their diabetes.

Effort expectancy: Patients use of the mHealth app will more likely if the diabetic perceives the mHealth application to be easy. The study found that there were some doubts about this, highlighting that some patients may need to be shown how to use the app.

Social influence: Participants passed the survey to friends and relatives and many indicated that they had support networks. Diabetics could use these networks to encourage and instruct each other to use the mHealth application. Doctors mentioned that they discussed self-management with patients and these discussions could include introducing patients to the app, to see if it could help.

Facilitating conditions: Saudi Arabia is a rich country and able to introduce technology like this because of the infrastructure and because many people trust the technology and can use it already.

The research hypotheses for this study were designed to ascertain whether there was a general readiness on the part of Saudi diabetics, their doctors and specialists to use a mHealth application to assist in monitoring and the self-management of the disease and to highlight whet barriers might exist to the acceptance of this technology (see fig.4.24 Summary of Hypotheses and Findings). However, the revised UTAUT model (see fig. 4.25 replicated above) generated by the results of this study could be used for further investigation of the use of mHealth in the Saudi context. It suggests a number of hypotheses which could be tested quantitatively through the use of such research tools as questionnaires and further explored qualitatively through the use of tools such as interviews, focus groups, diaries.

Social Influence

The research identified that within the Saudi context, the factor of Social Influence could usefully be divided into 'family, peers and doctors'. Possible hypotheses to be tested are as follows:

Family	The diabetic's family will impact on their acceptance of a diabetes management application
Peers	The diabetic's peers will impact on their acceptance of a diabetes management application.
Doctors	The diabetic's doctors will impact on their acceptance of a diabetes management application

Whether that impact is positive or negative and the strength of that impact can be ascertained through a series of questions on each area of social influence. This would be useful way to explore potential areas of support that could be given to diabetics in encouraging and assisting them in the effective use of mHealth.

Gender and Culture

The revised model shows this factor as moderating Performance Expectancy, Effort Expectancy and Social Influence. The 'gender and culture' factor in the Saudi context refers specifically to women unable to effectively access healthcare for cultural reasons. Hypotheses suggested by this are as follows:

Performance Expectancy	Gender and culture will impact on performance expectancy
Effort Expectancy	Gender and culture will impact on effort expectancy.
Social Influence	Gender and culture will impact on social influence

In order to establish how, and the extent to which gender and culture impact on each of these constructs can be ascertained through gaining further understanding of the nature of this impact. For example, the extent to which women unable to access healthcare effectively see mHealth as a solution which provides what they need (performance expectancy) and is easy to use (effort expectancy).

Age and Education

The revised model shows age and education as a moderating influence on all four major constructs

Hypotheses related to this area are as follows:

Performance Expectancy	Age and education will impact on performance expectancy
Effort Expectancy	Age and education will impact on effort expectancy.
Social Influence	Age and education will impact on social influence.
Facilitating conditions	Age and education will impact on facilitating conditions.

Testing these hypotheses involve identifying specific groups of diabetics whose age and education may impact on their acceptance of mHealth technology. Barriers to the acceptance and effective use of mHealth can be identified with a view to removing them so that mHealth can be effectively used by those individuals.

Income Level and Location

The revised model indicates that income level and experience impact on the constructs of performance expectancy, effort expectancy and social influence. The moderating factor 'income level and location' refer to those diabetics whose location would make accessing effective healthcare very expensive.

Performance Expectancy	Income level and location will impact on performance expectancy
Effort Expectancy	Income level and location will impact on effort expectancy.
Social Influence	Income level and location will impact on social influence

As with the factor of age and education, income level and location, suggest the testing of these hypotheses within particular groups of diabetics whose income and distance from centres of treatment make it difficult for them to access adequate healthcare. This study has identified some of these groups, for example, the Bedouin who are one of the underserved and remote populations in Saudi Arabia.

The assumptions relating to each of the four main constructs of the UTAUT (See Section 1.3) can themselves usefully be turned into hypotheses that can be tested quantitatively and further explored qualitatively.

Performance Expectancy	mHealth will be adopted if it is seen to perform well by the intended users
Effort Expectancy	mHealth will be adopted if it is perceived as easy to use by the intended users.
Social Influence	mHealth will be adopted if significant groups encourage and support the use of mHealth
Facilitating Conditions	mHealth will be adopted if the facilitating conditions are made available.

Limitations of the Model

As has been stated before, the model suggests that acceptance of technology is directly connected to use behaviour, as long as the facilitating conditions are in place. However, more needs to be known about the gap between acceptance and use, as acceptance is far from being a perfect predictor of use behaviour.

Chapter V: Discussions and Implications

5.1 Discussion

The findings from the primary data gathered have been enumerated in the previous chapter. In this chapter, analysis is carried out in alignment with the research questions and hypotheses.

5.1.2 Mobile Technological Solutions to Health Issues

Various mobile technological solutions to health issues have been discussed in Chapter 2. The study identifies both benefits and challenges. For instance, mHealth can enhance communication and interaction at a reduced cost, which in turn facilitates assessment of patients' conditions. MHealth can facilitate constant patient guidance by doctors as well as enabling a customized service provision for each patient through personalization. Other benefits include identification and monitoring of health concerns, as it also provides health professionals with access to patient information. MHealth promotes patient engagement while enhancing service efficiency in disease management. It also serves to provide education about communicable diseases, remind patients to take their medication, monitor disease outbreaks, and extend healthcare services to rural areas.

Despite the above benefits, the technology also comes with challenges because a single mHealth app may not offer all the various functions that are needed to cover all relevant medical needs. Costs of monitoring may be high if a dedicated team is required to monitor and communication with patients through the app. This is also endorsed by the primary research wherein doctors have expressed that they would not be able to devote time to attend to app queries. Lack of regulations in KSA could also impact the successful implementation of mHealth as it could lead to violation of privacy rights.

5.1.3 Current Infrastructure in Saudi Arabia

The key finding of the study indicated that the healthcare system of the Kingdom of Saudi Arabia offered optimum design and infrastructure for an mHealth system for the management of chronic diseases in accordance with the definition of mHealth outlined by Istepanian (2011). Hospitals have established electronic systems that included patient information databases and electronic recording systems. In addition, 80% of the hospitals had automated the recording of patient medical tests, patient appointments, imaging systems and dissemination of medical information through official websites of the hospitals. From the findings, it can be deduced that healthcare facilities in the KSA are optimally suited for the development of the mHealth system for the management of the chronic based on the already existing state of the art IT infrastructure. Subsequently, significant discussions from the literature review identified the KSA as the leading cell phone market in the Middle East with the latest 4G technology. The synergy of these technological dispositions in the KSA highly promotes the introduction of comprehensive mHealth programmes that will address the multidimensional challenges resulting from the chronic diseases in the country. Similarly, studies by Maisel & Shoup (2009) also reiterated the suitability of the KSA's healthcare systems and technological level to be a potential leader in the campaign for mHealth apps.

The issue of data security, confidentiality and privacy elicited varied perceptions and attitudes from the Saudi doctors and patients. The emergence of Saudi doctors as more sensitive to the sharing of patient information was a positive indicator for the mHealth programmes. Moreover, the majority of the patients seemed ready to reveal their personal information for the chance to manage their diabetes effectively. It could be argued that as highly educated members of the society, diabetes specialists were more cautious in comparison to the patients who were generally satisfied with the security framework of the proposed mHealth applications. By being cautious, Saudi doctors could thus play a crucial role in safeguarding inappropriate access and sharing of patient's medical information. In addition, mHealth applications further enhance individual privacy, since patients could directly engage with doctors without the inclusion of other parties. Women would no longer be forced to disclose their private information to their husbands or other male relatives as when they attend appointments appropriately chaperoned.

5.1.4 Requirements of Diabetes patients in the KSA

Saudi Arabia undoubtedly has an ever-growing number of diabetics, with 28% of the population having been diagnosed with the disease. There are also many deaths from this disease, with 15,339 deaths registered in 2014 due to diabetes. Saudi Arabia currently occupies the seventh position in the global incidence of diabetes among individuals (Ministry of SA Health, 2014).

However, with proper management, diabetics can maintain their health and enjoy a good quality of life. As one of the doctors interviewed pointed out, diabetes is a disease that is unique in that it requires a very high level of patient self-management. This echoes the findings by Iakovadis et al (2004) who suggest that chronic illnesses do need constant monitoring. However, the study reveals that patients lack the necessary education; they need to be coached into understanding exactly how their diet affects their diabetes. Through the mHealth app, they can be educated about the sugar and carbohydrates contained in the food they consume. Patients need to be trained to monitor blood glucose and administer insulin correctly.

Many patients lack transport facility, the required understanding of the disease itself and also communication abilities in certain cases, where foreign language issues arise. Lack of time (for students) and no permission granted by employers (for overseas workers) forces patients to skip appointments. Female patients need to be attended by female diabetes specialists, which may not always be feasible, given that male doctors far outnumber female doctors. Furthermore, patients tend to forget their appointments, find that they are not given appointments when needed, and that doctors are too busy to take calls when the patients need them. These are serious problems and clearly patients must get the care and attention they need from specialists, but the implementation of a diabetes management application can go some way to mitigating the problems; in particular when visits are to gather information, a task which can easily be fulfilled through the app. It is also important to take economic factors into account, both in terms of the cost to the patient and to the healthcare system. Iakovadis et al (2004) point out that mHealth does allow for monitoring and communication at a much reduced cost to both parties.

The results gathered from this study have indicated that the political, cultural and religious context of the KSA plays a crucial role in the development and implementation of mHealth programmes in the country. In particular, the cultural and religious doctrines have impacted on related spheres of the initiative such as communication and freedom of movement. These challenges were observed to be mostly affecting female members of the society, who are at present prohibited from driving cars. The introduction of mHealth apps could facilitate communication between the female patients and their doctors without physically attending the appointments. These findings corroborate with earlier studies by Kelly and Breslin

(2010) who noted that women in the KSA either missed medical appointment due to prohibition on their driving to hospitals or fear of being examined by male doctors.

5.1.5 Requirements of Medical Professionals for an mHealth Solution

The medical professionals have expressed their own concerns regarding the use of technology and have expressed doubt of its acceptance by patients as well as medical professionals. One of the main concerns expressed is that both doctors and patients require training in technology to be able to effectively use the apps for self-management. Training should be given to doctors, patients, family members and primary care givers. Furthermore, many hospitals are ill-equipped with IT systems and hence there could be difficulties in maintaining electronic records or having a system through which mHealth could be implemented. They have also expressed that time is a critical factor and since they are unable to attend to calls of patients, attending to app queries could only add to their responsibilities. As such, dedicated doctors should be given the time required to handle the app and its implementation.

Although the diabetes management application cannot replace treatment by a good specialist, it could be a partial solution to this problem in making self-management more effective, and this was seen in responses by both the patients and doctors questioned.

An examination of the survey data from patients and doctors revealed little about the needs of physically impaired and language illiterate patients. The programme of mHealth application for diabetes is a relatively new concept in the country. In view of this, it is not surprising that there does not seem to be a focus on the relevant technological advances and the willingness of the stakeholders to implement special consideration to the visually impaired and illiterate patients. The majority of the KSA population demonstrates fluency in Arabic; hence the availability of mHealth services in local language was highly anticipated.

5.1.6 The IVR System – A Possible Solution

Based on an evaluation of the different mHealth apps in practice for self management of diabetes (Chapter 2), the IVR system appears to be the most appropriate for the Saudis, given the constraints in technology acceptance. Other apps have features such as engagement with technology or text messages to be read, which would be difficult for the Saudis to implement and derive benefits from. Reading text messages can be challenging for diabetic patients, as advanced cases may be suffering from glaucoma.

IVR has been chosen because of its successful applications in several countries for the management of non-communicable diseases such as diabetes. Since patients may be reluctant to share their phone numbers or interact with others over the phone, Heisler (2007) endorses IVR as a workable and safe option in which patients have the option to block calls during certain hours. The IVR system can generate automatic reminder calls and give patients more support without additional workers. In fact, such systems can extend the reach of ongoing face-to-face self-management programmes while protecting the anonymity of patients. Heisler also supports the peer support model but this may not be workable for all diabetics in Saudi Arabia, as patients may not be willing to communicate with their peers.

Another study conducted by Piette et al (2011) evaluated the effectiveness of IVR in four countries in self-management of diabetes, among other non-communicable diseases. In a trial of low-income diabetes patients in the United States, the study found that participants receiving IVR calls reported significantly better self-care than control patients when followed up after twelve months. Intervention patients also had better glycemic controls after 12 months and fewer symptoms of diabetes and depression.

While a majority of doctors and patients readily accepted mHealth technology, based on the assessment of the appropriate platform of implementation, statistics indicated that the Smart phone offers optimum suitability for the project. Although the KSA leads in mobile technology penetration in the Middle East, there still exist concerns over access to a Smart phone. Smart phones are relatively expensive for vulnerable groups in the KSA. The majority of the women and the elderly who live in the rural areas are less likely to have access to modern models of Smart phones. Because of this, the implementation of any mHealth project on Smart phones will result in the alienation of specific groups in the society. Despite the infrastructural suitability of the Smart phone, the findings highlighted that it further presented unprecedented drawbacks to the primary aim of the mHealth project. According to patients, not all had access to Smart phones. It is therefore possible that the medical benefits of mHealth services could turn into the preserve of the wealthy members of the KSA society. Furthermore, the lack of electricity and network coverage in rural areas further deters rural dwellers from owning a Smart phone that is highly dependent on electricity. The IVR system thus eliminates the challenges that the government and the patients face particularly in the rural areas.

5.1.7 Feasibility of the proposed solution – the IVR system

Saudi Arabia has high density network in telecommunication and hence setting up an automated system would be the most cost-effective method in mHealth.

The COSMOS Model

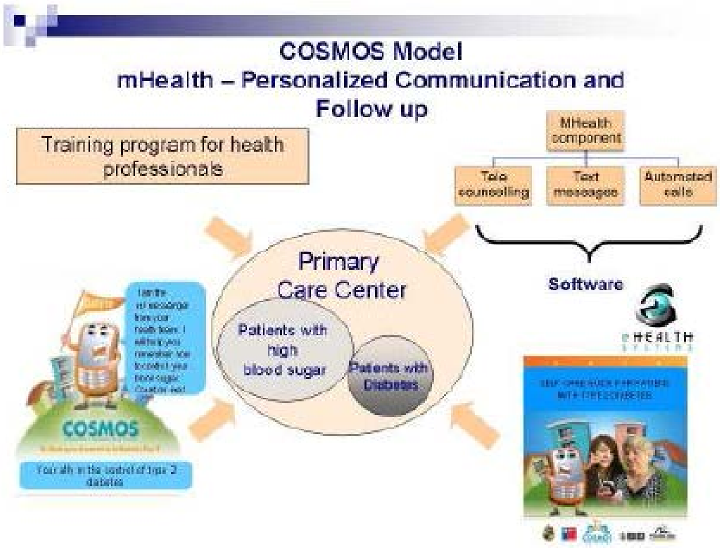


Figure5.1 The COSMOS Model Source: Piette et al (2011)

The software platform required for this system comprises of a web-based, open-sourceElectronic Medical Record (EMR) (Piette et al, 2011); which many hospitals in the KSA already use. This model, known as the COSMOS model (see Fig.5.1) is built on Open MRS architecture which generates the rules when an automated call or an SMS should be sent to the patient. The automated calls are similar to forms filled by the clinical staff. The COSMOS model is scalable as the organization grows. It is possible to configure the automated calls and text messages depending upon requirement of individual clinics. No technical challenges are foreseen in the KSA, as they already have gateways and networks to handle SMS and calls to patients with different service providers. The only concern in implementing IVR could be the limited literacy of patients which can be overcome through the support of family members and care givers.

The IVR system could go some way to solving the following issues identified in the primary research:

Doctors' Fears: Implementation of IVR system could alleviate doctors' fear of increase in workload and insufficient patient information on app leading to wrong prescription through the app.

Performance Expectancy: instructions about exercise and how to self-administer insulin, recording diet, being able to receive data such as blood glucose level, could enhance performance. Major concerns of doctors were regular reminders about monitoring heart rate, blood sugar and blood pressure required; information on diet and exercise. All of these could be managed through IVR.

Patients' Perceptions: The patients' survey revealed that some participants were not sure of the benefits they could derive from such apps. With training they could understand the benefits and possibly accept technology as the majority of participants said that there would be no barriers to accepting the Diabetes Management Application. This is confirmed by the findings that diabetes patients have been searching for information on the social media, internet, through doctors and other online sources. Willingness to acquire knowledge has been observed as patients have expressed their engagement with deep research and studies on diabetes. However, since use of Smart phones is a challenge, IVR could be an effective mHealth solution for patients.

It needs to be noted however, that the IVR system alone would not be sufficient and this has to be supported by local care givers. The system can serve as a support system between appointments or visits to physicians and enhance patient engagement and involvement in personal care. The IVR system also provides access to health information and health education without any additional work load on the existing staff, as the entire system is automated.

The findings on the relationship between doctors and patients in the KSA further conflicted with the literature on the healthcare system of the KSA. Many of the patients underscored the fundamental role of the medical practitioner and additionally commended their support and medical interventions. The findings did not highlight any negative attitudes of the medical professionals towards the patients in the healthcare facilities. Cases of victimization within the context of the KSA healthcare system were predominantly driven by the cultural traditions and Islamic doctrines that contradicted with pertinent human rights. This notwithstanding, diabetic patients overwhelmingly recognized the concerted efforts by the medical community to improve their medical status. Although there may have been incidence of unprofessionalism among the medical profession in the delivery of their services, none of the respondents supported these claims. Nevertheless, the management of diabetic patients and the success rate of the mHealth management project highly depend on the harmonious interaction between the patient and medical practitioners. The professionalism of healthcare workers should thus occupy centre stage in the structuring of the entire project. It is paramount the doctors, and nurses and patients overcome their religious biases, cultural differences and personal affiliations that either directly or indirectly hampers optimum service delivery.

The study demonstrated an information gap between doctors and diabetic patients regarding their medical states. A comparison of doctors' and patients' views based on the online survey indicated some disparity of information. The findings showed that due to the information gap, doctors sometimes misinterpreted the needs and problems facing diabetic patients. However, both patients and doctors agreed on the primary needs of the patients that were indicated as access to information on managing the diabetes. On the other hand, doctors underestimated the problems that faced patients in managing the diabetic conditions. The introduction of an mHealth application will act as a channel of communication between the diabetic patients and their medical specialist. While 17 % of the doctors presumed that there were no problems with their patients, 40 % of the patients acknowledged forgetting to take their medicines. This scenario calls for a two-way communication channel between the patients and health worker whereby the patient freely relays feedback to their specialist while at the same time accessing instructions. The information gap also led to misunderstanding and mistrust between some patients and their medical specialist. These information gaps could be interpreted as opportunities for development of a diabetic management application. This information gap can be bridged through the implementation of the IVR system.

In line with the literature's discussions of the management of chronic diseases in developing countries, the findings underlined the role of public awareness and change of behaviour in addressing the epidemic of diabetes in the KSA. Respondents demonstrated a basic knowledge concerning diabetes. The Internet and social networks were identified as the immediate sources of information accessed by them. Apart from Face book and Twitter, some diabetic patients also interacted with doctors and nurses online. With over 50 % broadband penetration in the country and access to 4G network, diabetic patients could freely communicate with a medical professional from anywhere in the world. Furthermore, some understanding of technology is already prevalent among diabetic patients in the country. With the existence of this background knowledge, the concept of mHealth could easily be expounded to the Saudi public. Doctors and other patients were also listed as sources of information on diabetes. The role of Saudi doctors and nurses as sources of information further provides an opportunity for using the medical fraternity as a public awareness medium since diabetic patients may readily trust their own advisor. Similarly, one of the female diabetics mentioned her diabetic girls' group as her source of information. The existence of such diabetic management groups in the KSA further offers a potential platform for disseminating information about diabetes management applications. From the highlighted sources of patient information, it is evident that the healthcare system of the KSA offers ample channels of communicating the presence of diabetic management applications at minimum costs. Furthermore, unlike computer-related applications, mHealth applications only require familiarity with Smart phone functionality to access medical services. The ease of texting and voice calls offers far-reaching advantages over computer functionalities such as emails that require formal skills to operate. The mHealth application also offers increased work efficiency, saves time and reduces workload. The application presents minimal disruption of the routine activities of the medical professional hence is likely to face less resistance when this is realised. The doctors further exhibited high expectations over the performance of the application. Besides managing the diabetes condition, mHealth application enables real time transmission of patient information, recording of patient's data, acting as an alert system and educative capabilities on health living and fitness. The only limitation identified in the technology acceptance model was the level of effort needed to learn the specifics of the application. Nevertheless, professional gain and clinical benefits derived from the mHealth highly outweighed the effort expectancy. The following section looks at the feasibility of implementing one existing application as a mobile health solution for the KSA.

5.1.8 The Glucose Buddy- a possible solution for the KSA

Based on the evaluation of the different available mHealth apps and the findings from the previous chapter, analysis is being conducted in this section on the feasibility of using the Glucose Buddy and one-way video messages. As this study progressed, the Glucose Buddy was made available across all Operating Systems, which means that it is compatible with all mobile phones, and not limited to iPhones and iPods.

The main features of Glucose Buddy are as follows:

The app saves multiple logs with just one click which makes it easy to operate and use.

It has its own custom keypad which is much larger than the phone keypads, thus making it easier for diabetes patients to use.

Figure 5.2 Keypad of the app.

Source: Glucosebuddy.com (2015)

As in most apps, this app to sends PUSH NOTIFICATIONS which in simple terms means REMINDERS even when the app is closed. These reminders can be to take medicine, check blood glucose periodically once medicine has been taken. Logs can be maintained of food consumed, medicines, as well as of exercise done. This could differ from patient to patient and this setting may have to be done by a medical professional.

The app also offers support in operating the app. Contact details are listed and can be used by patients that are younger and have knowledge of technology. This can eliminate the need to approach a medical professional. There is also an online Forum that can help users to derive benefits from the app.

Challenges for the KSA in using the Glucose Buddy are as follows:

The app has to be downloaded on the patients' phone and this can be challenging for those not very technically-minded. However, this can be done by any assistant with minimum knowledge of apps downloads.

The survey findings suggest patients are keen to better manage their diabetes; and the IT infrastructure in KSA is congenial to such apps. However, the Glucose Buddy would have to be available in Arabic if it was to be widely used in the KSA; language being the biggest impediment to the success of such apps.

The diabetes specialists that were interviewed expressed concern whether having to use mHealth apps would increase their commitment and workload. If all logs are maintained and there is a system through which all information reaches the medical data of the patient, then it may reduce the work load of doctors. The specialist would know when their patient needs personal attention or whether remote monitoring would be sufficient.

Using such an app reduces doctor-patient face-to-face interaction which may psychologically affect the patient; and this needs to be investigated in further studies. However, this disadvantage is common to all mHealth solutions.

Figure 5.3 Evaluation of the Glucose Buddy for the KSA environment

Functionality	Has tremendous potential as patients express the need for better management of their diabetes condition; it helps in reminders for medicine intake as well as reading of blood glucose levels, which patients tend to forget
Requirements – for doctors	Some form of motivation or incentives to help them enable patients to adopt technology in managing diabetes. The advantage of the Glucose Buddy is that it has the potential to reduce workload.
Requirements – for patients	Training in downloading the app, in setting it up initially and encouragement in using it regularly. Such training means that face-to-face interaction is initially part of adopting the Glucose Buddy for self-management.

Table 5.4 Alignment of the UTAUT Model constructs with the Glucose Buddy App

Performance Expectancy	The Glucose Buddy serves as a personal assistant and can remind the patients to check their BG or take medicines. Results show they forget to take medicines and hence the usefulness of the app
Effort Expectancy	This requires technical know-how which appears to be low at the moment among the KSA population. This could be addressed through training
Social Influence	Findings suggest that patients feel more comfortable in supported networks. The app has its forum of users as well as the

	app management provides support to its users.
Facilitating Conditions	Government support is forthcoming; the country has the infrastructure and technology to expand smart phones reach to remotest areas.

a. Research Questions

The study began by identifying seven research questions (see Chapter 1), which are now revisited with a view to summarizing the answers to them, along with comments about the extent to which the questions were answered.

The first two research questions were addressed in the Literature Review, which revealed that there was a significant relationship between the application of mobile health services and improvement in the management of chronic diseases such as diabetes (RQ1). It also showed that Saudi Arabia can offer an optimum design and infrastructure for an mHealth system for the management of chronic disease such as diabetes (RQ2). This question was also addressed in the primary research and both doctors and patients were questioned about the technology at their disposal. All the patients questioned could use the application on a PC (as they were using one to answer the questionnaire) and most had access to a Smart phone. However, using an online questionnaire meant that sections of the population who could benefit from the app will have been omitted. The doctors and specialists varied in their reports of the digital infrastructure at their workplace, but many saw the increasing use of mHealth as inevitable.

The next six research questions were answered by conducting the semi-structured interviews with Saudi diabetes specialists and the two online questionnaires. Socio-cultural factors were explored to identify those which would have an impact on acceptance of an MHealth solution, and found that the influencing factors of age, gender and experience were indeed important, but that it was necessary to refine the theoretical UTAUT model but adding the factors of culture (to gender)education (to age) and income level and location. The study did reveal some interesting data about social factors, such as the close extended family and community, which would help or impede people who need access to mobiles, and the help they need with using them. The attitude of a patient's GP towards mHealth appears significant and the diabetic support groups that exist in Saudi Arabia could also play a part. More work would need to be carried out as to exactly how mobiles are or are not shared in families and communities and the extent to which diabetics get support and encouragement to use mHealth (RQ3).This study also found that, there were several challenges to successful adoption of an mHealth solution identified in both the qualitative and quantitative studies. Specialists were mainly concerned with how such a solution would impact on their role and time and, along with the doctors surveyed were concerned about how easy patients would find the app to use. For example, several doctors were concerned that poor literacy would impede the successful use of mHealth Patients were generally enthusiastic, but there were concerns about how easy it would be to use the application and how much time it would take up (RQ4). The UTAUT model was used to explore technology acceptance issues related to a mobile solution to diabetes in the KSA and the model was adapted to the Saudi context in light of the findings from the field studies. If the revised model is to be used for exploring technology acceptance of mHealth in similar contexts, each of the added factors in the adapted model (culture, education, income and location) could be further refined to suit the context it addresses (RQ5). This chapter has discussed which mHealth solution would be the best solution for both diabetic patients and doctors in the KSA. The IVR system was explored and found to be capable of providing a partial solution to diabetes self-management and the Glucose Buddy was identified as a specific application that would both provide the services identified as important for Saudi diabetics and go some way to overcoming some of the barriers to acceptance and use of a mobile solution. With provisos such as the application being available in Arabic, it was estimated that most of the Saudi diabetics questioned would accept the use of this mobile phone application to help manage diabetes. However, as the sample probably excluded blind and severely arthritic patients, this would be a useful area to look into (RQ6). In the matter of security, privacy and confidentiality issues related to implementation of mHealth system (RQ7), doctors appeared to have more reservations than patients, although some of the latter also expressed concerns, and careful exploration of this area needs to be made.

Addressing the research questions has answered some important points about the extent to which a diabetes management application could successfully be introduced into the healthcare system of Saudi Arabia; and what those applications should be. It has also highlighted particular areas that could usefully be looked into further and it is these which are considered next.

The New Constructs

The introduction of the four new constructs was the result of identifying factors of technology acceptance that were specific to the Saudi context as the research aimed to identify any hindrance to the adoption of the technology. The main UTAUT constructs informed the design of the questionnaire ensure that the mHealth technology met the users' expectations in terms of its performance and ease of use as well as exploring the social influence of doctors and the facilitating conditions, otherwise without considering these factors; it would be hard to predict if the technology would be accepted by potential users. The new constructs however suggest further areas of investigation into the technology acceptance of mHealth in contexts similar to that of this study (See Section 4.7). Each of these constructs could be explored in much greater depth in order to see exactly how they influenced technology acceptance.

5.3 Testing the application on voluntary participants, with a view to re-designing the app. for more relevant use in Saudi Arabia

This study has begun an exploration of the acceptance of mHealth technology as a possible solution to the problems of Saudi diabetics in managing their illness. However, participants were only shown a video about how such an application would work. Although results were encouraging in terms of patient reaction to the application, this is not the same as actually conducting trials using voluntary participants. Furthermore, comparative experiments could be done using different models of diabetes management applications in order to test which versions were more acceptable to users. Using trials, the requirements and reaction of very specific groups of diabetics could be monitored. Each group may have very particular needs, skills, experience, social environment and attitudes, which may result in having to create a technology acceptance model that was very specific to that group.

Given that the attitudes of patients were collected by means of an online questionnaire, this means that diabetics who would find answering such a questionnaire difficult could not participate. As stated previously, diabetics who are blind or have arthritis in their hands would need specialised voice-activated mobile technology in order to make use of an mHealth application. Field studies would need to be carried out on these groups to see how this technology was accepted as well as looking into the cost of introducing such a scheme.

Before a more general consideration about how the work of this study might be usefully extended in future, it is important to examine the implications of introducing a diabetes management application into the Saudi healthcare system.

5.4 Implications for the introduction of an MHealth Diabetes Management Application into the Saudi Healthcare System

The results from the patient survey underpin the importance of chronic disease management to diabetic patients. Over half of the respondents 53%, monitored their blood glucose at home, while only 17 % physically visited a doctor. Alarmingly, only 6% of the diabetic patients interviewed checked their blood glucose five times a day. These findings reiterated those of Guthrie and Guthrie (2009) who argue that the monitoring of diabetic patients is core to the management of diabetic disease. The figures indicated that the majority of the diabetic patients only checked their blood glucose level once a day. The development of a monitoring mHealth application that would regularly remind patients to assess their blood glucose through SMS could increase the average number of daily blood glucose levels checks. Only a fifth of the interviewees confirmed that they never failed to test their glucose levels.

The need for constant monitoring of the blood glucose levels was further emphasized by the large number respondents who reported that they needed more information on the management of the diabetes. While 61 % indicated the need for more information on the management of the disease, many of the patients had already heard of the clinical benefits of mHealth programmes. These findings parallel earlier reports that the KSA is already awash with numerous types of mHealth applications, which could be accessed by Smart phones. The call for additional information on the management of the diabetic disease by the respondents is significant and highlights the timeliness of mHealth diabetes management apps for the country. The implementation of a comprehensive mHealth app for the diabetic patients in the KSA will first serve to impart knowledge on the effective means for the management of this chronic disease. Kvedar (2014) noted that the access to knowledge and education on the management of the chronic could further inform members of the public on the benefits of healthy living.

The introduction of monitoring and healthy living forms of mHealth apps for KSA should aid the behavioural change of diabetic patients. Only one tenth of the patient surveyed believed that they could successfully control diabetes. The majority of the patients lacked the pertinent motivation and personal drive to improve their health status. The implementation of an mHealth app in the country will enable diabetic patients to monitor their blood levels individually, correctly supervise their dietary composition and undertake requisite exercises for the betterment of their health conditions. Research by Malvey & Slovensky (2014) and Hanauer (2009) suggests that direct engagement of the patients in managing their diabetic conditions will trigger behavioural change based on the daily evaluation progress from the mHealth texts feedback and this could also be the case in the KSA.

The extent of the doctors' engagement in the treatment of the diabetic patients further elicited calls for mHealth programmes in the KSA. Sixty percent of the patients noted that they had difficulty accessing doctors when they need them. Similarly, a third of the respondents reported personal difficulty in going for a clinical appointment while 12 % could not afford the travel. These data appropriately fitted with the literature review assertion that KSA present ample condition for mHealth application (Donner & Mechael, 2012). The introduction of mHealth will ultimately provide a comprehensive solution to major challenges as indicated by the respondents. MHealth will easily enhance communication between the physicians and patients remotely thereby enabling those with difficulties in accessing medical professionals to continue obtaining clinical services through texts and furthermore transmit back medical records such as daily blood glucose levels. Access to the medical appointment has predominantly been an issue for female members of the community and immigrant workers who have been subjected to constrained movement by unscrupulous employers. Schwenken (2011) and Al-Mohamed (2008) argued that women and immigrant workers in KSA were the direct victims of substandard medical services. The availability of a medical platform on mobile cells will significantly aid women and children who cannot drive to hospitals, labourers who are unable to access medical services and remotely located citizens from the country's rural areas.

The patients' survey showed a preference for services on the mHealth platforms that paralleled the global forms of services from medical apps. 57 % of the respondent preferred the utility of recording blood glucose levels and 50% opted for advice and information on diet and related feedback from the doctors while alerts for taking the medication accounted for 42 %. The interpretation of the results demonstrated the heightened need by the patients for a myriad of services from mHealth. Since the nature of the questionnaire provided the options for the respondents to ticks as many services they liked, it emerges that diabetic patients are not satisfied with a single form of mHealth utility. This has been observed as a consensus view as was also noted by Hanauer (2009), who stressed that the versatility of the app was a key challenge hindering the successful implementation and sustainability of mHealth apps in the mid and lower income countries.

Diabetic patients are more likely to suffer from multiple medical conditions. The development of a comprehensive mHealth programme should therefore be designed to accommodate a myriad of medical issues that transcends diabetes. From the ticked choices by the respondents, mHealth apps for the diabetic patients in the KSA should incorporate the following medical features: a record of blood glucose results, dietary information, medical alerts, appointment capabilities and a communication channel to medical professionals. Half of the respondents recommended that the diabetic management application should be both a tool to aid in the management of their diabetes and as a means for the effective delivery of medical information to physicians.

Another key finding from the survey of patients was the results on the most preferred platform for the diabetes management application in the KSA. The majority of the respondents identified the Smart phone as the preferred platform, accounting for 61 % while 30 % would use the application on both Smart phone and computer. As the country with the leading mobile penetration rate, the observation was related to arguments by Iakovidis (2004) that the extensive mobile phone infrastructure in the country and users provided feasible grounds for the establishment of mHealth services. Unlike computers, embedding a diabetic management application on mobile phones will ensure reach of the services to the most vulnerable groups of diabetic patients, women and children. The utilization of computers as a platform for diabetic management applications faces both financial and skills constraints. Smart phones are relatively cheap compared to computers, therefore, as a project to enhance healthcare delivery to the already discriminated segment of the population; mobile phone communication technology would offer extensive area coverage, reduced operational charges and increase the ease of operability. Consequently, the majority of the barriers that seemed to emanate from the mobile platform could be addressed by an awareness campaign and education on the specification of the applications. Some of the core drawbacks listed by the diabetic patients included complexity of the application, that it was time-consuming and a limited access to Smart phones. To spur the optimum results from the mHealth application, an awareness campaign and education on the benefits and application of the diabetic management programme could be spearheaded by the Ministry of Health. Additionally, selected healthcare facilities could register diabetic patients without an access to Smart phones and purchase some for the primary purposes of medical service delivery only, since a quarter of the patients lacked access. Unlike computers, Smart phones further promoted emergency response compared to computers as patients and doctors would constantly be in possession of cell phones.

The bivariate analysis on the patient's confidence in managing diabetic disease, difficulty in accessing specialist care and the willingness to share medical data via Smart phones demonstrated interesting findings with regards to gender, age and number of years with diabetes. Firstly, confidence in managing diabetes was not significantly related to gender. Therefore, Saudi men and women equally needed access to medical services that aid in the management of diabetes. The findings implied that mHealth applications in the KSA would be both suitable for male and female patients in the country. Secondly, the results indicated that confidence in managing diabetes was not affected by the age of patients. Younger diabetic patients suffered low confidence as much as the older patients did. It is hence paramount that the design and development of mHealth specification accommodate a wide range of patient age- groups. Again, the relationship between the numbers of years patients have had diabetes, and their confidence in managing it was insignificant. These findings demonstrated that every category of diabetic patients appeared in need of the management programme irrespective of the age, gender or duration of diagnosis.

In relation to the chi-square tests, the results showed a significant relationship between the patient's confidence and the daily frequency of checking the blood glucose levels. In other words, diabetic patients who regularly check their blood glucose levels are more likely to attain confidence in managing their conditions. As was noted by Guthrie and Guthrie (2009) and further corroborated by Defronzo (2004), mHealth applications are instrumental in reminding patients to monitor their blood glucose levels. The diabetes management program will serve to improve on patients' confidence through texting alerts to diabetic patients to monitor themselves. At this stage, it is also prudent to consider patients who are likely to forget to take their medications. From the multivariate analysis, 55% of the forgetful patients acknowledged their weak confidence in managing their diabetes. Implementation of the diabetes management programme may well bolster confidence in forgetful patients and improve on their uptake of the medications. Since the mHealth application facilitates constant interaction between the patients and doctors, the programme could further improve the confidence of the patient as was indicated by the strong correlation between doctor engagement and the level of patient confidence. It could be argued that patient–doctor interactions enhance confidence through medical guidance on the dietary needs, follow-ups on the medications and interpretation of the clinical records. Similarly, a comprehensive diabetes management programme should have the operability to provide diabetic patients with the same set of services hence culminating in the development of patients' confidence.

Consistent with Centre for Disease Control (2014) findings, the study showed that there was a correlation between age and access problems. Patient aged 31-50 had the lowest rate of visiting specialists compared to those above 50. The age bracket of 31-50 includes working citizens who may be constantly busy in their daily undertakings and thus not able to attend medical appointments. Nevertheless, the introduction of availing medical services to the patients at their convenience may be in part a solution to such difficulties. Such arrangement also promotes saving on time and money.

Using the UTAUT model, the study determined the acceptability of the diabetes management programme based on the assessment of patients' and doctors' performance expectancy, effort expectancy, social influence and facilitating conditions. In addition, gender, age and experience were chosen as moderators of the identified factors. The study sought to identify whether diabetic patients and doctors would accept the use of the mobile phone application in managing diabetes. The survey showed that many doctors in the KSA would welcome the introduction of diabetes management applications as 48 % asserted that the apps offered a medical solution. There is, however, the need to educate KSA medical professionals on the management strengths of the programme as 21 % of the doctors indicated reservations in utilizing the mHealth app. The medical fraternity of the KSA was indeed optimistic towards the introduction of the programme since 83% of the doctors agreed that the application would aid in the monitoring and management of diabetic patients while 72 % approved of the app. for its communication and engagement capabilities. The KSA doctors believed the programme would evidently contribute to performance improvement through increased access to patients in rural areas, alleviate appointments and prescription services. The significant barrier that may hinder KSA doctors from accepting the mHealth application was the difficulty in using the application. The majority of the medical practitioners questioned had not been exposed to mHealth applications. Furthermore, some of the doctors raised concerns over the privacy and security of the patient's data. In view of these concerns, it would be paramount that the diabetic management programme extended training of the patients to include medical professionals on the applicability of the mHealth programme. The institution of stringent government policies on data management and robust IT infrastructure should be implemented to mitigate the violation of privacy rights. In a study by Holtz (2008) patient data privacy and security presented a significant barrier to the introduction of mHealth programmes in developing countries and hence the deterioration of the healthcare services.

The bivariate analyses of the doctors' survey results were broadly consistent with major trends in the literature review. Although the sample was very small it could be seen that female doctors were more likely to use text messages for appointment reminders than men. It could be argued that women doctors in KSA would thus be the driving force in implanting the mHealth programme in the country based on their preference for the Smart phone platform, but further research would need to be carried out to test this hypothesis.

A comparison of the level of acceptance between doctors and patients indicated that doctors were more reserved towards mHealth with regards to sharing of information, increased workload and the complexity of the system. The success implementation of the diabetes management programme should be focused on bringing the KSA medical fraternity on board by assuring synergy of patient- doctor privacy, simplicity of the system and performance effectiveness.

A synthesis of the study's findings revealed that the KSA offers an optimum design infrastructure for an mHealth system for the management of diabetes. The country has the highest mobile penetration rate in the Middle East with the most advanced 4G technology. The healthcare system has also, to some extent, integrated core medical services with IT thereby easing incorporation of mHealth application into the systems. The evaluation of the acceptance of the application showed that diabetic patients in the KSA reported that they needed additional information on how to manage diabetes, and this was borne out by doctors in both the survey and the interviews. Similarly, the diabetic specialists acknowledged that the mHealth application programme could significantly aid in the daily management of diabetes through monitoring services, alerts, facilitation of appointments and provisions of feedback through text messages. The research noted that the cultural and religious context of the KSA were significant impediments to the effective management of diabetes and subsequently the success of the mHealth diabetes management application programme was one way to overcome some of these problems. It may therefore be imperative that a nationwide education and awareness campaign on the benefits of the mHealth app be undertaken in KSA before the introduction of the diabetes management mobile application.

The findings from the study suggest profound implications for the healthcare system of KSA and developing countries. In light of the heightened proliferation of mobile communication in the mid and low-income countries, the healthcare system could utilize mobile platforms to provide services to vulnerable groups. Through the implementation of mHealth applications, the healthcare system of KSA will expand its outreach to rural areas where medical care access is highly limited. Furthermore, in view of the versatility of the text-oriented platform, mHealth could be designed to provide medical support to some of the most vulnerable groups in the country, i.e.

women and children. Similarly, the study highlighted on the plight of women and immigrant labourers in relation to substandard access to services (Al-Mohamed, 2008). By facilitating medical information access without physically visiting doctors, Saudi women who had been hindered by cultural biases and financial constraints would be better able to start managing their diabetes while at home. The introduction of the diabetes management application would indirectly promote maternity care in KSA since diabetic pregnant women would continue to access medical care remotely through their phones. However, in the long term, it is paramount that the society of the KSA identifies discriminatory cultural and religious beliefs that promote the violation of human rights and subordination of individuals on the basis of their race and gender.

The survey data indicated that patients' confidence to manage diabetes was hugely dependent on their interaction with doctors and access to information on the management of the disease. Therefore, the prevalence of chronic diseases in the country could be significantly addressed through the provisions of disease management information. In particular, a majority of diabetic patients in KSA believe they need additional information on the management of diabetes (Guthrie & Guthrie, 2009). In addition, the study showed that a diabetes management programme on a mobile communication platform could impact positively on diabetic patients by raising their management confidence. Through the implementation of diabetes management programmes, the majority of the diabetic patients in KSA would have access to information on education and awareness on the management of diabetes. The programme may also significantly increase the level of diabetic patients attending medical appointments especially the country's working class.

A far-reaching implication of the introduction of a diabetic management application would be the generation and subsequent storage of a vast amount of information on diabetic patients in this electronic format. The availability of such data in highly portable and secure databases could enhance policy formulation and health programme development by the Ministry of Health. Furthermore, automating patients' medical data would ease consultation in emergency cases involving diabetic patients, since the information could be transferred through phone texts, electronic mail and fax.

Data from the study showed that both diabetic patients and doctors underlined the need for the monitoring of blood glucose levels. Successful implementation of the diabetic management programme in the KSA will improve the blood glucose checks, monitoring and subsequent transmission of the results to the doctors. Through text reminders, diabetic patients will be less likely to forget to check their blood glucose levels and report the recordings to their specialists. Apart from the consistent monitoring of the blood glucose levels, the execution of the programme would address the primary concerns of those diabetic patients who complained of limited access to a medical professional. Widespread introduction of mHealth applications in the country could strengthen the doctor-patient relationship by promoting daily interactions through text message and voice calls.

It needs to be said, however, that the deployment of a diabetes management programme in the KSA could also result in the violation of patient privacy in case of a database breach or wrongful access to the patient data. Donner & Mechael (2012) noted that the automation of patient medical data made it highly prone to security and privacy violations; hence the KSA's policies on patient information protection should incorporate protective measures for electronic forms of data. Patient information will be subjected to predominant scrutiny by medical staff and patients' relatives, hence leading to the possible violation of an individual's privacy. The issues of patient privacy would further extend beyond the healthcare system to include the mobile service provider who may have unlimited access to a patient's cell phone data. With regard to the issue of patient information, protection may elicit fierce debate from the stakeholders in the mHealth management programme and possibly from civil rights protection groups in the KSA. According to Practical Law (2012), at present, there is no specific data protection legislation in Saudi Arabia. However, the Basic Law of Governance A/90 (1992) does protect the privacy of the individual and all data communicated must be safeguarded. Individuals have a right to be compensated if they suffer loss as a result of disclosure. The Electronic Transactions Law (Royal Decree M/8) does not directly address the exchange of personal data, but sets out some breaches of security; and the Telecommunications Act (2001) does too. It is of note that there are no regulations regarding the sending of unsolicited electronic commercial communications in Saudi law. This could be problematic in terms of diabetic patients being targeted for this.

However, on balance, the development of diabetes management applications in the KSA will positively impact on the diabetic patients and healthcare services delivery. Although the mHealth application has been observed also to present its equal share of drawbacks to the country's healthcare system, medical benefits from the programme highly outweigh financial and privacy issues associated with the implementation. The entire healthcare system of the KSA could experience a lessening of the chronic burden as a majority of diabetic patients will eventually gain the confidence and behavioural changes that occurs with better self –management of the disease. The sector will further be in a position to save funds and resources that could be diverted to address other chronic disease-related challenges affecting the country. Moreover, mHealth applications that are aimed at educating and informing patients about the right lifestyles and dietary needs could prove instrumental in preventing the prevalence of both Type I and Type II diabetes in the KSA**.**

Analysis of the most suitable platform for the diabetic management application indicates the Smart phone as the best-suited infrastructure. However, as a project dedicated to providing health services to the most discriminated groups in KSA, the Smart phone presented a significant drawback. This implies that a comprehensive strategy should be developed to ensure availability of Smart phones to rural residents, Saudi women and foreign workers. This could be achieved through the collaboration of state agencies and Smart phone manufacturing companies to develop economical cell phones that could be afforded by majority of the Saudis while still having the inherent functionalities of Smart phones.

The study also underscored the relevance of a close patient – doctor relationship.

The identification of an information gap between doctors and their patients was a leading cause of concern for diabetic patients. With the consideration of the eminent chronic disease epidemic in the country, additional research should be conducted to investigate the extent of the information gap between the entire healthcare sector and the public in general. Furthermore, the Ministry of Health should integrate the dissemination of public health education through the identified sources of patient information. The prevalence of network mobile network coverage and modern Internet broadband places the Internet as a strategic platform for publicizing the advantages of mHealth and health benefits of responsible lifestyle to mitigate the national burden of chronic diseases.

5.5 Future Work

The diabetes management application has great potential. As one doctor said, 'It is the future'. The problem is how to have this technology accepted. There needs to be further work done to see exactly what such an application needs to contain and to examine the patients' experience of using the application and its effects on the management of their diabetes. Thus, initially if the IVR is implemented, patients would get started on mHealth and gradually become keen for more sophisticated apps. For example, this study has already highlighted that the application would need to be available in Arabic and that information about how to monitor blood glucose is crucially important.

Thus,

1. Trials need to be conducted to evaluate user experience, the limitations and requirements
2. Doctors' problems and limitations regarding time and commitment need to be explored

This study has excluded users who were too ill to answer the questionnaire and this group may well benefit from related mHealth devices such as blood glucose monitors that send data automatically without the patient having to record it and send it. As has been suggested, trials on groups of such patients would be invaluable to see the extent to which diabetes management applications could be a solution for these diabetics. Support networks need to be investigated to discover effective means to disseminate information about using mHealth to self-manage diabetes. The research uncovered that some patients already belong to Diabetes Support Groups and such groups could be used, as well as the diabetes education specialists that doctors mentioned. Feasibility studies on the use of these people and organisations as disseminators of information would also help to find out how best to enhance the spread of effective use of mHealth in self-managing diabetes. Another model that could be researched is the peer-to-peer support model as suggested by Heisler (2007) wherein patients offer support to each other and overcome the stigma and resistance to acceptance of the disease.

This research could usefully link to other fields such as Gender Studies, where the use of a diabetes management application could be studied in populations of female patients who have difficulties accessing female specialists, or who have problems with getting transportation to hospital appointments. In the context of Saudi Arabia, such research would be best carried out by female researchers or research assistants, as there are cultural restrictions on face-to-face (or even telephone) communications between unrelated men and women.

Researchers studying the problems of foreign workers in Saudi Arabia could look at the diabetes management application as a solution for foreign workers who cannot get permission to travel to appointments or who cannot afford specialist healthcare. Given that these groups are from different cultural backgrounds and speak languages different from Arabic, it would be of interest to see how the technology acceptance model applies to this underserved group.

Additionally, future studies could be designed to incorporate family members of the diabetic patients. This present study only used feedback obtained from the sample patients and doctor participants. However, as highlighted by the UTAUT model, social influence is a crucial factor in the analysis of the acceptance of the technology. Moreover, close relatives play a crucial role in the management of diabetic patients, especially teenagers and the elderly. More credible and comprehensive results for analysing this aspect of technology acceptance could be obtained from a study of diabetic patients' peers and relatives.

Given the apparent lack of effective legal redress in the KSA's legislation on data protection; studies could usefully be done to see what amendments to the current regulations could be made in order to effectively protect patient data harboured by any mHealth applications as well as investigating what redress patients could have if security was breached.

Furthermore, the study identified the closed standards forms of mHealth applications as a hindrance to development of mHealth apps and the sharing of knowledge. Future studies should be designed to evaluate the level of intervention for both open standard and closed standard applications for the management of diabetes in the KSA.

This research has uncovered many key issues that need to be addressed for the successful introduction of an mHealth diabetes management application in Saudi Arabia. The studies carried out have indicated what factors could be further investigated to ensure that barriers that exist to technology acceptance can be properly addressed, such that mHealth can provide some solution to the increasing problem of diabetes that currently exists in Saudi Arabia.

5.6 Conclusion

Diabetes has reached chronic levels in Saudi Arabia and no research could be found that examined the possibilities and benefits of using mHealth in patient treatment and self-management of diabetes in the country. Diabetes as a disease requires high level of self-management, and several factors hinder self-management of diabetes in the KSA. Inability to take time off work, cultural attitudes that prevent women from consulting male diabetes specialists, lack of pay, mistrust of doctors, long distances required to reach any hospital or consultant, and other practical difficulties have been impediments to self-management of diabetes in KSA. While the literature review demonstrated the use of apps in managing health in several countries, no such studies in the KSA could be identified. With the aim of investigating the challenges and benefits of implementing the use of mHealth application for diabetes management in the KSA, seven research objectives were set in Chapter I. Based on the literature reviewed in Chapter II, the research hypotheses and research questions were identified. The key findings and contribution to knowledge through this study have been enumerated in this chapter.

5.7 Key findings

The findings position the KSA as potentially having a highly suitable healthcare sector for the development of a diabetic management application programme. This ranged from the extensive healthcare sector reforms, technology acceptance by patients and doctors, modern mobile network infrastructure, the urgent need for information on diabetes management and the overwhelming national burden of chronic diseases.

Based on the UTAUT technology acceptance model, the medical fraternity indicated a high rate of acceptance for the mHealth application. The fieldwork also indicated that the model could be further refined to suit the Saudi context. MHealth has demonstrated remarkable functionalities that encompassed the bridging of the information gap between the doctors and patients. Based on the technological nature of the application, it emerged that younger diabetic patients were better placed to accrue more value from the services of the application compared to other age groups suffering from diabetes. Additionally, the majority of the Saudis had preliminary knowledge of diabetic conditions with some patients already exposed to the online medical communities. Nevertheless, healthcare facilities remain the primary source of information for the majority of diabetic patients.

Challenges do exist in the KSA but these can be overcome with a planned approach to mHealth. The medical fraternity and the patients demonstrate some degree of resistance to technology but that is due to lack of adequate information. Proper training could help alleviate these fears and lead to better adoption of technology in healthcare. The findings confirm a significant relationship between application of mobile health services and improvement in the management of chronic diseases. The KSA's healthcare facilities are optimally suited for implementing mHealth system for the management of the chronic diseases based on the already existing state-of-the art IT infrastructure. Cultural identity, degree of education and gender do impact the extent to which technology in mHealth services would be accepted in the given environment.

Evaluation of the recommended app for mHealth suggests that both the medical professionals and patients need some sort of incentives or motivation to start using the app. Apps may also need to be customized to suit patients' needs as diabetes is a special condition. However, once this app is implemented across KSA, its potential and benefits are immense. The apps would serve as a reminder service to patients to take medications, to check their blood glucose levels, facilitate immediate action by the medical professionals when necessary, reduce the time between two visits of patients leading to improved doctor-patient communication and save on costs and time in traveling long distances. The doctor-patient ratio being 1:1000 in the KSA, there is a clear need of developing remote consulting facility connecting patients with centralized medical staff. Most importantly, it would help women and the migrant population in getting the services while maintaining privacy.

5.8 Contribution to Knowledge

No previous study has been found that investigated the problems and concerns of the medical professionals in the acceptance of technology for healthcare of patients of type II diabetes in the KSA. Thus, this study has contributed significantly to the medical literature as it highlights the concerns of medical professionals in Saudi Arabia. In fact, it has also brought to light that, in the KSA, some doctors are not even aware of such technology; others are somewhat aware but have never got the opportunity to know more. The 'perceived ease of use' factor in technology acceptance needs highlighting when the apps are released. These need to be demonstrated through the mainstream media to enhance awareness and its benefits. Thus, if doctors too are unaware, patients' lack of awareness is not surprising. The responsibility then rests jointly in the hands of the medical professionals and the technology professionals to create awareness in countries such as Saudi Arabia.

While the study finds support in the literature of the apps available for managing type II diabetes and in use in other countries of the world, no such support could be found existing in Saudi Arabia. Another important finding that needs attention is the discrimination that women face in reaching out for medical help. Women face a cultural barrier in consulting with male diabetes doctors while they are also restricted from travelling far distances alone. Other cultural factors such as lack of trust in doctors are a deterrent for patients to maintain regularity in management of diabetes.

Resistance to change is a known factor in any environment because people are reluctant to leave their comfort zones. However, in order to progress in supporting good healthcare, the Ministry of Health needs address this resistance.

The study contributes to the academic and medical literature that even in countries where culture and religion are considered as deterrent, changes are taking place and the challenges can be overcome through a planned approach. The developing nations need a larger focus on mHealth given the large number of geographically distanced rural populations, the high number of immigrant populations and the taboo on women consulting male doctors or travelling alone to appointments.

The UTAUT model of technology acceptance has usefully been adapted four by the addition of four constructs identified as important in explaining technology acceptance in this context. The revised model demonstrates how the use of an exploratory sequential mixed methods approach has generated a research design that has generated data that contributes to new understanding in this field. It is hoped that this provides a theoretical basis for further research.

5.9.1 Recommendations

In light of the pertinent role of the government, public health sector, private sector and mobile network operators, the development of the mHealth application project should be implemented through a multiagency approach where every stakeholder in the market will contribute towards the success of the programme.

Based on the technology acceptance model, the medical fraternity indicated a high rate of acceptance for the mHealth application. Nevertheless, the diabetic management programme based on the UTAUT model should first identify the existing shortcomings such as extreme effort expectancy among the users, lack of electricity in rural areas and the need for customizing of the application for the elderly. Besides, since women face difficulties in reaching out for medical help, applications should focus on reaching out to this segment of the society so that they can access medical help without reluctance and hesitation, while also maintaining privacy.

MHealth has demonstrated remarkable functionalities that encompassed the bridging of the information gap between the doctors and patients. Based on the technological nature of the application, it emerged that younger diabetic patients were better placed to accrue more value from the services of the application compared to other age groups suffering from diabetes. Additionally, the majority of the Saudis had preliminary knowledge of diabetic conditions with some patients already exposed to the online medical communities. Nevertheless, healthcare facilities remain the primary source of information for the majority of diabetic patients.

5.9.2 Recommendations for Further Research

Further investigation can be done on issues such as the psychological impact on diabetes patients if doctor-patient face-to-face interaction is reduced with the introduction of mHealth apps. This could be conducted after at least one year of the implementation of apps.

Another study could be conducted to examine if there is any difference in adoption of mHealth among rural and urban population once proper training and motivation has been provided to the people in the KSA.

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APPENDIX A: Cover Letters

Faculty of Science and Engineering

University of Brighton

School of Computing, Engineering and Mathematics research

Watts Building
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Brighton BN2 4GL
United Kingdom
Telphone 01273 642455
Fax 01273 642405

Dear Doctor,

My Name is Bander Alkhudairi and I am a PhD student at Brighton University. I am currently conducting research into the use of a mobile Health Application, which would allow patients to both monitor their own health and to send and receive information about their health with their health care provider. The application aims also to educate the patient to help them manage their illness, providing information about important aspects of diabetes such as diet and exercise. Users can be sent reminders of appointments and medication times and allows the patient to keep in touch with their health care provider remotely.

I would like to interview you in order to acquire information about the sort of experience your diabetic patients have in accessing healthcare and managing their health and if they can accept it. I would also be interested in your reactions to the mHealth application for diabetes.

The interview will not take more than one hour and will be audiotape recorded. I will also give a short presentation to demonstrate the mHealth application. This demonstration will take no more than 5 minutes. The recording will remain confidential and will only be heard by me. All the information you give me will be confidential and only appear in my final report completely anonymously.

If you are willing to participate in this informal interview, then please complete and return the attached consent form below. We will need to arrange a mutually convenient time and place for interview.

Please can you let me know when and where the interview can take place.

Please do not hesitate to contact me if you have any questions

Thank you

Bander Alkhudairi
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Supervisor: Dr Lyn Pemberton
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Dear Patients,

I am a PhD student in UK at Brighton University. I am currently conducting research into the use of a mobile Health Application, which would allow diabetes patients to both monitor their own health and to send and receive information about their health with their health care provider. The application aims also to educate the patient to help them manage their illness, providing information about important aspects of diabetes such as diet and exercise. Users can be sent reminders of appointments and medication times and allows the patient to keep in touch with their health care provider remotely. I am interested to know how useful such devices would be for Saudi patients. All information you give me in the questionnaires you complete would be confidential and anonymous. The questionnaires may be looked at by the researcher and the research supervisor at the University of Brighton.

The questionnaire consists of 18 short questions, the questions ewill be about how you manage your diabetes and you will also be asked to watch a three-minute video about the diabetes management app.

If you are under 18 years old, stop now and don't continue. If you agree to answer the questionnaires, please put your name on the consent form and start the questionnaire.

Bander Alkhudairi
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Thank you

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APPENDIX D: Semi-structured-Interview Questions

1. Is the doctor male/female

2. How long have you been practicing as a doctor?

3. How long have you been a diabetes specialist?

4. How many diabetes patients do you currently have?

5. Where did you train?

6. What area do you cover?

7. On average, how many patients do you see each day?

8. Do you have any problems with patients missing appointments?

If yes, what reasons do they give for missing appointments?

9. Are you ever too busy to see every patient that makes an appointment?

   If yes, please tell me more about that.

10. In your experience, do your patients have problems with any of the following?

1 Self-managing their illness

2 Lack of information about diet/exercise

3 Remembering appointments

4 Communicating with you and the hospital

5 Are there any other problems

11. Does your hospital use any of the following?

1 Electronic patient records

2 Emails to patients

3 Electronic medical information

4 Patient appointment system

5 Electronic results of medical tests

6 Does the hospital use a computer system for any other use? If so, what?

12. What do you know about mHealth?

13. Have you seen any diabetes management applications?

The doctor will be given a demonstration of the diabetes management application

There is an application that your patients could use on a Smart phone or computer which will allow you to send and receive information to and from the patients, gives them information about diabetes, diet and exercise and can remind them to take medication, do glucose tests and go to appointments. This application is to help them manage their diabetes more effectively.

To access a three minute video which explains the application, please click on:

https://www.youtube.com/watch?v=mePnFcEihDI

14. How do you feel about this diabetes management application as a tool for diabetes doctors to use with their patients?

1 Do you think it would be easy to use?

2 Do you think it will be useful for you?

3 Do you have any other comments

15. How do you feel about this diabetes management application as a tool for your patients to use?

- Do you think it will be useful to your patients
- How easy do you think it will be for your patients to use?
- What features would you, as a physician find most beneficial?
- What features would be most beneficial to your patients as a self-management solution?

16. Are there any other functions that you feel the application should have?

17. Are there any obstacles to using this type of solution in your practice and with your staff?

18. Do you have any questions about the application?

19. Would you consider using this application? If so, what would convince you that it would be a solution that you would like to implement?