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MOBILE HEALTH TECHNOLOGY TO ENHANCE HEALTHCARE SERVICE
DELIVERY IN DEVELOPING NATIONS (SAUDI ARABIA)

by

NAWAF IBRAHIM KHAN

B.S. Umm Al-Qura University, Saudi Arabia, 2003

M.S. University of Central Florida, USA, 2013

A dissertation submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy
in the Department of Industrial Engineering and Management Systems
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Major Professor: Pamela McCauley

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ABSTRACT

Saudi Arabia is among the countries that have very high prevalence rates of diabetes and hypertension, with prevalence rates of almost 18% and 25%, respectively. The majority of patients with diabetes and hypertension fail to manage their diseases and to show up for their follow up appointments. Mhealth technology is among the interventions that have been recently adopted to overcome these issues and improve the quality of healthcare services. This study aims to evaluate the effectiveness of a mobile phone application named diabetes and hypertension application (DHA Tracking) to promote adherence for patients with diabetes and hypertension in Mecca, Saudi Arabia. The proposed intervention was designed to promote adherence via two features, namely, refill medication reminder (RMR) and doctor appointment reminder (DAR). The third feature, which is managing the number of unnecessary visits, was covered by the cumulative blood sugar test (Hemoglobin A1c) for patients with their doctors. The study examined the difference in adherence level before the intervention and after the intervention with samples of $n = 199$ and $n = 165$ for diabetes and hypertension, respectively. The mhealth intervention was found to have significant effects on both the refill medication reminder and the doctor's appointment reminder. Also, it was found that the intervention was efficient in reducing the number of unnecessary follow-up visits to around 20%. This study supports the evidence in the literature on the effectiveness of mhealth in promoting adherence to medication for patients with chronic diseases in the developing countries and specifically in Saudi Arabia. Positive social change that may result from this study is for better management of chronic disease symptoms and increase the awareness of using mhealth applications. This would improve the quality of life for patients, their families, and the community.

This dissertation is dedicated to my parents, my siblings, my daughters, and my lovely wife who was extremely patient and supportive with me during all these years.

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NOMENCLATURE

Acronyms

DAR

Doctor Appointment Reminder

DHA Tracking

Diabetes and Hypertension Application

RMR

Refill Medication Reminder

CHAPTER ONE: INTRODUCTION

1.1 Introduction to Topic

Chronic diseases, such as diabetes and hypertension, have reached epidemic rates worldwide. According to the International Diabetes Federation (IDF) DIABETES ATLAS 2017, around half a billion people worldwide live with diabetes. Also, the majority of those diagnosed with diabetes live in medium to low-income countries. Similarly, hypertension affects more than one billion people globally (World Health Organization, 2013).

The diagnosis and treatment of chronic diseases require prolonged care and management from both patients and the healthcare facilities where patients receive health services. Such diseases increased the burden on the healthcare systems in developing countries where medical, financial, and human resources are limited (Allegranzi et al., 2011). Subsequently, in such a situation, providing high-quality healthcare services to patients with chronic diseases such as diabetes and hypertension became very challenging.

In an effort to deal with past challenges, many scholars and healthcare providers have initiated several health interventions to provide high-quality services to patients with a variety of diseases. Among those interventions that have widely been adopted recently is mobile health “mhealth.” The mhealth is defined as the use of cell phone and wireless technologies to provide medical care services (Agarwal et al., 2016). Mobile technologies include devices such as “mobile phones; personal digital assistants (PDA) and PDA phones (e.g., BlackBerry, Palm Pilot); Smartphones (e.g., iPhone); enterprise digital assistants (EDA); portable media players (i.e., MP3-players and MP4-players, e.g., iPod); handheld video-game consoles (e.g., PlayStation

Portable (PSP), Nintendo DS); and handheld and ultra-portable computers such as tablet PCs (e.g., iPad and Smartbooks)” (Free et al., 2013, p. 2).

Mhealth technology has been adopted in several areas of healthcare, including but not limited to adherence to medication (Park, Howie-Esquivel, Chung, & Dracup, 2014), disease prevention (Cole-Lewis & Kershaw, 2010), appointment reminders (Prasad & Anand, 2012), data collection (Tomlinson et al., 2009), and diagnosis of diseases (Breslauer, Maamari, Switz, Lam, & Fletcher, 2009). Figure 1 shows some of the applications of mhealth technology in healthcare.

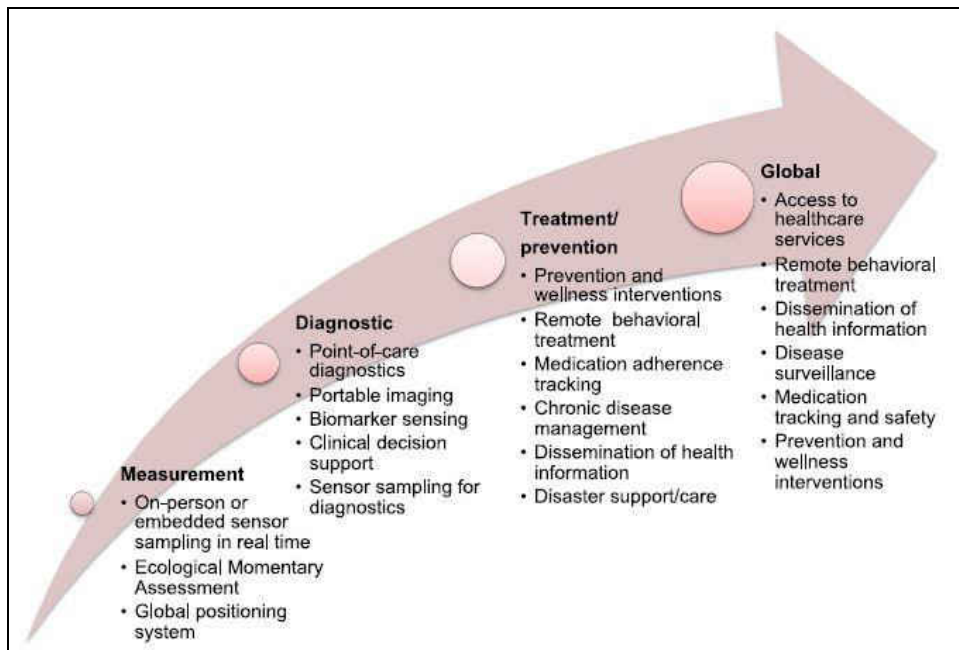


Figure 1 Applications of mhealth technology (Kumar et al., 2013)

Most of the mhealth implementations were carried out in developed countries. However, in developing countries where healthcare systems lack the resources and efficiency to provide high-quality services, patients, and the community, the adoption of mhealth has not been widely explored. Therefore, this study aimed to enhance the quality of healthcare services for diabetes and hypertension patients with mobile health technology in Saudi Arabia.

1.2 Significance of Research

Chronic diseases patients such as hypertension and diabetes are susceptible to some health complications if they failed to manage their diseases regularly. This situation is more prominent in developing countries where limited resources are available, and access to healthcare services is very challenging. Therefore, encouraging diabetic and hypertensive patients to manage their diseases and adhere to medications are very crucial. This can be accomplished, for instance, using mhealth technology.

This study aims to enhance the effectiveness of mhealth platforms in developing nations for diabetes and hypertension diseases. This goal is achieved by redesigning a mobile application that fits the requirements of diabetic and hypertensive patients and used the blood sugar level test (Hemoglobin A1c). The proposed mobile application is intended to perform two tasks, which are: managing patients' adherence to medication refill timing and managing patients reminders of physicians' appointments. The blood sugar level test will help to manage the number of unnecessary follow-up appointments. Based on the results, patients who show improved or stable health conditions may be temporarily dismissed from the follow-up appointments' list, which will allow the healthcare center to provide health services to more patients with a given time frame.

Accordingly, the developed mobile phone application and the blood sugar level test will improve access to health care services through decreasing the physical contact between patients and healthcare workers and investing the saved clinic-time to serve new patients. It will also lead to improving healthcare service cost-effectiveness for both healthcare providers and patients, which will positively impact the developing nations' economy. Finally, the developed mobile

application will assist in encouraging diabetic and hypertensive patients to manage their diseases and adhere to medications and doctor appointments.

1.3 Theoretical Foundation of Work

Many studies have investigated the factors that may contribute to adherence to medications of patients with chronic diseases such as diabetes and hypertension. In one study, the influence of health beliefs on medication adherence among patients with type 2 diabetes was investigated (Alatawi, Kavookjian, Ekong, & Alrayees, 2016). The Health Belief Model (HBM) was used in this study to explore the medication-taking behavior of diabetic patients in Tabuk, Saudi Arabia. A convenience sample of size 217 diabetic patients of both genders and were over 18 years old were included in the study. A questionnaire containing demographic, medical history, medication adherence, and health beliefs information regarding diabetes was used in this study. The results revealed that almost 43% of the participants did not comply with their medication for at least one day in the past week.

In another study, adherence of patients with type 2 diabetes to the standards set by the American Diabetes Association (ADA) was investigated in the city of Riyadh, Saudi Arabia (Al Harbi et al., 2015). In specific, adherence of diabetic patients to 11 ADA standards, including glycemic control, blood pressure control, and lipid management, were studied. A sample of 450 diabetic patients, who were at least 18 years old, and who visited the health center more than once during six months, was selected to participate in the study. The results showed that the majority of the patients were between 50 and 69, with less than half of which being male. Also, about 85% of the patients were either overweight or obese. The results also showed that compliance with the ADA standards ranged from 35.6% for Nephropathy screening to 92.9% for Blood pressure measurement.

The effects of some socio-demographic factors on the compliance to the medication of diabetic patients have also been investigated in Abha, Saudi Arabia (Salam & Siddiqui, 2013). A total of 406 patients with type 2 diabetes were randomly selected to participate in the study. The data were collected from the participants through a questionnaire, which included items on diet, exercise, medication, and follow up. The results showed that patients who were 40 years or younger showed significantly higher levels of adherence to appointment and diet compared to older patients. On the other hand, older patients showed significantly higher levels of compliance with medication. Moreover, the study also reported that most of the patients were compliant with medication and follow up regardless of their personal characteristics.

Similarly, a study examined the factors that may have potential effects on the level of non-compliance of diabetic patients in three chronic disease clinics in Al Hasa, Saudi Arabia (A. R. Khan et al., 2012). The study used a survey to measure the non-compliance of a total of 353 randomly selected patients with diabetes, 468 of which completed the study. The questionnaire included demographic items such as gender, age, marital status, and level of education. It also included other medical items such as the presence of other chronic diseases, the number of medications taken, the frequency of taking medication, and the frequency of follow up visits. The results revealed that the overall non-compliance rate was found to be 67.9%, with male patients have significantly higher non-compliance rates than female patients. Also, the non-compliance rate of patients taking oral and insulin treatment was found to be more than 79%, while the patients taking only one medication showed a non-compliance rate of 48%.

In the same context, medication adherence among patients with chronic diseases visiting an outpatient clinic in Riyadh, Saudi Arabia, was also evaluated (Tourkmani et al., 2012). The study evaluated the potential relationship between motivation and knowledge on the intention to

comply with the medication of chronic diseases such as diabetes and hypertension. A questionnaire was used, and a sample of 347 patients was included in the study. The questionnaire was designed to elicit specific information for the participants including demographic characteristics, medical history, and medication history. The results noted that more than 75% of the participants had at least two chronic diseases and taking on average more than six medications. The results also reported that more than 58% of the participants had a high rate of intention to comply with medication. Furthermore, the study reported that no relationship between motivation and knowledge of medication regarding adherence to medication was found.

Moreover, a review was conducted on patients' adherence to medications of chronic diseases, such as hypertension, in the middle eastern countries, including Saudi Arabia (Al Qasem, Smith, & Clifford, 2011). The study reported that patients' self-reporting, pill counts, and blood pressure measurements were used to determine the adherence to the medication of hypertensive patients. The study also reported the reasons for patients' nonadherence to medication and indicated that the nonadherence rate of patients with high blood pressure was higher than those with diabetes. Thus, there is a need to adopt a healthcare intervention such as mhealth to promote self-management for patients with hypertension to reduce the rate of nonadherence to medication that is reported in the literature.

In another study, the factors that may influence the compliance diet, medication, and appointments of patients with diabetes have been explored in Abha, Saudi Arabia (Khattab, 1999). A total of 294 diabetic patients were involved in the study. The compliance was measured based on the number of visits of diabetic patients during a 6-month period. In specific, patients who visited the health center at least one-two occasions during six months were considered to have good compliance. Also, patients who visited the health center on one occasion during the

six months were classified to have poor compliance. In addition, poor compliance was defined as the patients who failed to visit the health center during the six-month period. The results revealed that more than 61% of the participants were good compliant with appointments. Regarding compliance with drugs, the majority (84.2%) of the participants showed good compliance, while less than 2% showed poor compliance. The study also reported a significant difference between males and females in terms of good compliance, with male patients being more compliant than female patients.

In addition, to identifying the factors influencing patients' adherence to medication, other studies were exploring the reasons that led patients to miss prescheduled appointments. For example, the reasons for missing appointments were investigated in a military hospital in Riyadh, Saudi Arabia (Alhamad, 2013a). The study included two groups of randomly selected patients for each sample of 380. The first group included the patients who missed their appointments, and the second group was set to be the control group, which included the patients who showed up for their appointments. The study defined the missing appointments as either the patients who didn't attend at least one prescheduled with the clinic or the patients who showed up later than their prescheduled appointment time. The results indicated that the difficulty in booking an appointment, long-distance travel, work commitment, lack of transportation, and visiting another hospital were the most frequently reported factors that contributed to missing appointments. Moreover, no significant difference between the experimental group and the control group in regard to the reasons cited for missing appointments.

The use of mhealth interventions may promote medication adherence and hence improve healthcare service delivery for patients with chronic diseases. However, the acceptability of such interventions should be evaluated prior to their implementation to ensure feasible results. In fact,

Alkhudairi evaluated the acceptability of a mobile phone diabetes management application by diabetes specialists in Saudi Arabia (Alkhudairi, 2016). Specifically, the study examined whether the use of mhealth applications would improve the management of diabetes. The study examined the feasibility and challenges of using a mobile phone application called Glucose Buddy within the context of Saudi Arabia through conducting interviews and questionnaires of selected participants and medical professionals. The study indicated that mobile phone applications such as Glucose Buddy could be successfully implemented within the Saudi context giving appropriate training and incentives.

Electronic health record (EHR) applications have also been used to improve healthcare service delivery in three public hospitals in eastern Saudi Arabia (El Mahalli, 2015). Specifically, the study evaluated the barriers using HER by physicians as well as its utilization. The study used a self-administered survey to gather data from a total of 555 physicians, 357 of which who completed the questionnaire giving an average response rate of nearly 56%. The questionnaire contained items of demographic information, the functionality of HER, and barriers to use HER. The results showed that most of the respondents had access to a computer at work. For chart review, the study showed the highest frequency of utilization was found to 'Obtain and review lab results' (94.4%). However, the study also reported a lack of utilization of communication tools such as email and SMS text messaging. Regarding the barriers to use HER, the study reported that 'system hanging up problem' and 'loss of entree to medical records transiently if the computer crashes or power fails' were the two most cited barriers.

Some studies evaluated the effectiveness of mobile health applications in Saudi Arabia. In one study, a randomized control trial was conducted over a six-month period to evaluate the effectiveness of SAED to manage and educate diabetic patients in Tabuk, Saudi Arabia

(Alotaibi, Istepanian, & Philip, 2016). A total of 20 patients aged from 20 to 65 years were aimlessly nominated to contribute to the study, and they were separated into two groups, with ten patients allocated to the nonintervention group and ten patients allocated to the intervention group. Patients' information, such as blood glucose levels were recorded two to three times a day on two to three different days a week. Moreover, patients in the control group received weekly SMS text messages to promote their knowledge of diabetes and related risk factors. To measure the effectiveness of SAED, patients' Hemoglobin levels, as well as a test of knowledge about diabetes, were used before and after the intervention. The results revealed a significant reduction in hemoglobin levels of patients in the intervention group compared to the control group. Furthermore, patients' knowledge about diabetes was higher in the intervention group comparing to the control group, although both groups showed a significant improvement in their knowledge before and after the intervention.

In another study, Abbas and his colleagues evaluated the effectiveness of using SMS text messaging to control glycemic of diabetes patients within Riyadh (B. B. Abbas, Al Fares, Jabbari, El Dali, & Al Orifi, 2015). A sum of 100 patients with diabetes type 2 was chosen to participate in the study. Variables such as glycosylated hemoglobin (HbA1c), blood glucose levels, and average fasting blood sugar were assessed before and after the SMS intervention. During the intervention, patients received from five to seven messages every week, including educational information about diabetic care and management in the Arabic language. The text messages were also designed to remind patients of taking their medications and checking their blood glucose levels. The results indicated that a significant decline in patients' blood glucose levels and average HbA1c. The study also reported a significant improvement in patients' knowledge of diabetes.

Based on the studies discussed above, there is a lack in the literature regarding the effectiveness of the use of the mobile health platform to provide services such as medication refill reminders, doctor appointment reminders, and managing unnecessary follow-up visits of patients with diabetes and hypertension in developing nations. Although some investigation studies have been conducted about diabetes in Saudi Arabia, no research studies in literature investigated the use of mhealth technology for hypertension disease management in the country. Designing a mobile phone application with such features may help patients better manage their diseases and promote their adherence to medication. This also results in limiting the prevalence of chronic diseases, such as diabetes and hypertension in Saudi Arabia. This study, therefore, aims to fill this gap by developing a mobile phone application that aims to help diabetic and hypertensive patients manage their diseases in Saudi Arabia. Also, the developed application provides other services such as doctor appointment reminders and medication refill reminders.

1.4 Research Question

Q1: Does utilizing of refill medication reminder feature of DHA Tracking has a positive statistically significant impact on medication adherence levels of diabetic and hypertension patients in developing countries?

Q2: Does utilizing the pre-appointment checkup feature for Hemoglobin A1c tests have a positive statistically significant impact on decreasing the number of visits per patient for diabetic patients in developing countries?

Q3: Does utilizing doctor appointment reminder feature of DHA Tracking has a positive statistically significant impact on adherence to doctor appointments of diabetic and hypertension patients in developing countries?

1.5 Contribution to the Body of Knowledge

The aim of adopting mhealth technology in developing countries is to increase the effectiveness of healthcare systems and enhance the quality of healthcare services, which will eventually increase customers patients' satisfaction. However, there was a lack of evidence regarding the evaluation of the effectiveness of mhealth technology in developing countries. In Saudi Arabia, the majority of mhealth interventions were either pilot projects or qualitative survey design studies with small-scale settings. This represents a gap in the literature regarding the implementation of mhealth technology in Saudi Arabia. This study, therefore, contributes to the current body of knowledge through enriching the body knowledge related to the mhealth platform use in Saudi Arabia. The study will also help in facilitating health care services by advancing the self-management of diabetes and hypertension diseases.

Also, studies that examined the feasibility of using mobile phone applications to provide healthcare services to diabetic and hypertensive patients in Saudi Arabia focused on disease prevention (Tate et al., 2013) and medication adherence (Alotaibi, 2015). However, no studies have been conducted to provide managing information to patients with hypertension in Saudi Arabia. Thus, this study contributes to the body of knowledge by being the first study in Saudi Arabia that provides managing information to healthcare providers using a mobile health application.

CHAPTER TWO: LITERATURE REVIEW

2.1 Information and Communication Technology and mobile health in Saudi Arabia

Saudi Arabia is a country that could make use of today's focus on technology. Information technology, otherwise known as IT, is growing rapidly and influencing all of its economy (Alshuaibi, 2017). The kingdom wants to diversify its economy rather than relying on oil, and it also desires to fulfill its people's needs to have jobs and careers. IT is the way to do that, and for the Saudi kingdom, it makes sense. They still have oil as a significant contributor to their economy and can use that money to enter the field of IT strongly in the near future. In fact, it intends to do so in its vision of 2030 (Alshuaibi, 2017).

If the Kingdom wishes to complete its goals in vision 2030, it will have to invest in technology, especially in healthcare. Saudi Arabia wants to be the leader of the nations around it, but without a focus on healthcare may not be able to accomplish that goal. The health industry needs information technology. Electronic health records (EHR) is a good software that could be utilized. It reduces paperwork in hospitals, and that means it allows for a patient's records to be found quickly. Doctors can interact with one another and records can be given to a variety of parties that need its information.

Saudi Arabia has started the process of investing in Information and Communication Technology (ICT). The kingdom has adopted ICT as one of its major investments, which it is using to create a more diverse economy that will allow it to continue to grow its economy and get to the place where it can have economic growth that is more sustainable (Al-Maliki, 2013). However, the situation is not perfect. Some problems must be addressed if they are going to become a serious competitor with other countries that are investing in ICT. In the past, the

kingdom has been forced to allow its young people to go to other countries in order to get an education at all and particularly education in ICT (Al-Maliki, 2013). It has been making efforts to increase the skilled labor within its society, but foreigners are still often the ones that take the jobs where they can be found.

On the other hand, Saudi Arabia is doing well in that it has the largest IT market in the region (Al-Maliki, 2013). It is trying to focus on the home market as well and has had a series of five-year plans to approach that goal and others. Some of its other efforts include that it has been either increasing or upgrading the schools in the area of science and technology. This starts at the lower grades and goes on through the entire system. It is also educating its people on the fact that sciences and technology play a role around the world and have tried to accomplish these tasks through the media, exhibitions, and symposiums (Al-Maliki, 2013).

Unfortunately, the kingdom has not accomplished enough and still faces some barriers. While it does have an infrastructure superior to that of its near neighbors, it does not have one that is equal to that of fully developed countries (Al-Maliki, 2013). While it wants to sell its products to its people, it has a simple (or complicated) problem that its people are not very familiar with computers, and it does not protect the rights of intellectual property. It also does not have the infrastructure to support the industry, and so it has some work to be done shortly. The kingdom must move forward in ICT in the future because other kingdoms and countries, even in its area, are working toward the same goal.

There are some definite improvements in Saudi Arabia's ICT situation. According to Abdulgahni, Ahmad, & Salah (2014), there is an improvement in the areas of growth of prepaid and postpaid mobile phones, Internet and fixed wireless facilities, as well as current investment

in ICT. The mobile industry has done well in this regard. The following table 1 supports that view:

Table 1 T-test on Mobile Service Market Growth Subscription (2001- 2013) (Abdulgahni, Ahmad, Salah, & Abdulghani, 2014)

Users	Mean (S±D)	P
*Post-Paid Subscription	5.06 ± 1.54	0.00
*Pre-Paid subscription	23.86 ± 18.77	0.001
Total subscription	28.93 ± 20.26	0.000
** Mobile penetration	107.20 ± 68.47	0.000

The above table shows that there is penetration and increasing subscriptions, although prepaid subscriptions appear to be preferred.

There have also been increases in other Internet and mobile situations, but the authors do admit that more work is needed in this area. They conclude that the kingdom's businesses could benefit from using ICT networks as this would aid in breaking down barriers to go into new markets (Abdulgahni et al., 2014). While progress is being made, there is more that has been left undone.

The major concern and need for good technological devices in Saudi Arabia as in other countries is the need for better health care. The kingdom has advanced in technology in general but lags behind other nations in terms of technology used for health care. The advances in technology have neglected the healthcare industry, while other industries have benefited from its use (ALSADAN et al., 2015). These researchers have investigated this situation using articles in various journals that were published between 2001 and 2014 (ALSADAN et al., 2015). The review of these sources had predetermined requirements included "conceptual, exploratory, and

cross-sectional and action research. Of the over 600 studies, 29 were selected for this review. They found that most Arab countries had the money to pursue the Health Information Technology (HIT) but did not pursue research or implementation of mHealth and suffered from the problem that they did not have the knowledge to pursue the use of HIT. The use of this technology is important to the development of hospitals and other institutions. They are not ready to compete with developed countries and the need for that possibility is great.

Telemedicine is rampant in fully developed countries, but in Saudi Arabia, physicians often do not use such techniques, and the reasons are not necessarily that they do not want to. Research has shown that most physicians in Saudi Arabia are well aware of telemedicine and are open to using it. There is some practice of telemedicine in Saudi Arabia, but it is spread out, and not everyone has access to it (Alajmi et al., 2015). However, the degree to which physicians have good awareness and positive attitude telemedicine depend on age. Older physicians know less about it and are less accepting of it (Alajmi et al., 2015). Those who had more experience with technology in medicine were eager to get involved in its use and to learn about it. This author suggests that the target for change includes older physicians and those who are open to change and training.

Mobile phones are used in Saudi Arabia by medical residents. Jamal et al. (2016) researched the degree of usage of mobile phones using a cross-sectional survey that was web-based. The researcher found that almost all residents used mobile phones within and outside of their medical practice. While they used them in practice, they did not always know the degree to which they could use them with proper training. This suggests that there is a need for encouraging and training medical residents to use the phones fully rather than just for communication (Jamal et al., 2016). Smartphones can be particularly useful in the medical field,

as they have more possible uses than cell phones. Smartphones can be used for appointment reservations, opening and updating medical records, communication with patients and consultation, doctor's directory, requesting medical reports and assessing the health risk for patients (Saad, 2016). The researcher undertook to decide whether or not these extra uses would be necessary and essential for patients since they are the true end-user. If they are useful, the researcher wants to know to what degree they are useful. They point out that using these phones can be helpful, but they are also expensive. This research has not yet been completed.

2.2 Healthcare System in Saudi Arabia

In the 1950s, Saudi Arabia had witnessed the first organized preventive health services through the campaign that was launched by the Saudi Ministry of Health (MOH), the World Health Organization (WHO), and the Saudi Aramco oil company against malaria in Al Ahsa Oasis and Qatif in the Eastern province of Saudi Arabia (Al Yousuf, Akerele, & Al Mazrou, 2002). Other provinces in the county started similar malaria control programs right after the success of the control program in this province. Afterward, the development of the Saudi health system evolved slowly until the middle of the 1960s, where rapid expansion of the system took place between 1965 and 1985. The healthcare service offered between 1970 and 1980 were curative due to both the nature of health personnel training programs, which was conducted in patient-oriented, hospital-based medical institutes, and general population expectation about the type of healthcare services they consider useful (Al Yousuf et al., 2002). In the 1980s, primary health care centers (PHC) were established where existing health offices, maternal child and health centers, and dispensaries were integrated administratively (Al Yousuf et al., 2002). By initiating the PHC approach, the delivery of integrated healthcare services was developed (Al Yousuf et al., 2002). The health system of Saudi Arabia is a three-tier system composing of

primary, secondary, and tertiary layers of healthcare providers (Al Yousuf et al., 2002; Alanazy, 2006). Respectively, these layers are the healthcare centers, the general hospitals, and the specialized hospitals (Al Yousuf et al., 2002). There are three healthcare sectors of which Saudi health system is composed: the MOH, the non-MOH government healthcare providers (i.e., the Ministry of Interior, Ministry of Defense, the National Guard, universities, and King Faisal Specialist Hospital), and the private healthcare sector (Al Yousuf et al., 2002; Alanazy, 2006). The PHC's represent an important component of the Saudi Health System since they are the first point of contact for the patient with the entire national system (Al Yousuf et al., 2002). Out of the 191 countries that were included in the 1997 estimates of WHO for the quality of healthcare services, the Saudi health system was ranked 26th worldwide and 2nd among Arab countries (Al Yousuf et al., 2002).

The responsibility of providing preventive and curative healthcare services in Saudi Arabia is primarily administered by the MOH, which assures the offering of these services to all Saudi populations as free services (Alanazy, 2006). Also, King Faisal Specialist Hospital and Research Center (KFSH & RC) and Universities' hospitals receive complex cases that require special intervention besides their significant role in conducting research in the healthcare area and providing educational and training programs for the medical staff of the country (Alanazy, 2006). Healthcare Services of the non-MOH government hospitals are limited to the workers of the government sector, offering these services and their dependence (Alanazy, 2006). However, like the case with KFSH & RC and universities' hospitals, the general population can access the services of these sectors, through a referral mechanism, should the patient condition require special treatment available only at one of these non-MOH government healthcare institutes (Alanazy, 2006). Other than governmental healthcare providers, there are private healthcare

providers all over the country which, in 2015, covered around 36.7% of total patients and 35.5% of total inpatients of Saudi population (M. o. H. General Directorate of Statistics and Information, Kingdom of Saudi Arabia, 2017).

Healthcare services in Saudi Arabia have been significantly developed in several areas related to preventive, curative, antenatal, and childhood care services (M. o. H. General Directorate of Statistics and Information, Kingdom of Saudi Arabia, 2017). For instance, over the last two decades, mortality rates in children under the age of five decreased from 85 to 8.05 per 1000 live births, infant mortality rate was reduced from 76 to 2.74 per 1000 live births, and the total life expectancy at birth increased from 61 to 71.9 (M. o. H. General Directorate of Statistics and Information, Kingdom of Saudi Arabia, 2017). These indicators are higher than those achieved by other developing and Arabic countries and reflect the significant improvement in the amount and types of healthcare services provided by healthcare institutes to the entire population (M. o. H. General Directorate of Statistics and Information, Kingdom of Saudi Arabia, 2017). Tables 2 and 3 below provide more indicators about the Saudi healthcare system as per the Health Statistics Book of MOH in the Kingdom of Saudi Arabia, which was lastly updated in 2017.

Table 2 Immunization Coverage with primary health care services (2016)
(General Directorate of Statistics and Information, 2017)

Indicator		Year
Hexa. Vaccine	98.5	2016
Oral Polio Vaccine (OPV)	98.5	2016
BCG Vaccine	98.5	2016
MMR Vaccine	98	2016
Pneumococcal Conjugate Vaccine (PCV)	98.7	2016

Table 3 Health status indicators (General Directorate of Statistics and Information, 2017)

Total life expectancy at birth (years)	74.8	2016
Male life expectancy at birth (years)	73.5	2016
Female life expectancy at birth (years)	76.1	2016
The Crude Death rate per 1000 population	2.9	2016
Newborn with low birth weight (%)	8.96	2016
Neonatal mortality rate per 1000 total birth	2.74	2016
Infant mortality rate (per 1000live births)	4.82	2016
Under-five mortality rate (per 1000live births)	8.05	2016
Maternal mortality rate (per 100000 live births)	12	2015

In the 1970s, some physicians and nurses working in different Saudi health institutes were 1172 and 3261, respectively (Ministry of Economy and Planning, 2004). In 2017, the Saudi healthcare sector had 470 hospitals with 70,844 beds, 89,675 physicians, and 107,323 nurses all over the thirteen provinces of the country (M. o. H. General Directorate of Statistics and Information, Kingdom of Saudi Arabia, 2017). Table 4 below presents the distribution of the total number of hospitals, beds, and physicians, in 2017, over the three main sectors of the Saudi healthcare system. In addition, Table 5 presents the rate of Saudi healthcare human and physical resources per 10,000 populations as per the statistical book of Ministry of Health in 2017.

Table 4 Hospitals, beds & physicians' distribution over main sectors of the Saudi healthcare system (2017) (General Directorate of Statistics and Information, 2017)

Sector	Number of Hospital (%)	Number of Beds (%)	Number of Physicians (%)
Ministry of Health (MOH)	274 (58.29)	41835 (59.05)	42768(47.69)
Other Government Health Services	44(9.36)	11581(16.34)	17206(19.18)
Privet Hospital	152(32.34)	17428(24.6)	29701(33.12)
Total	470	70844	89675

Table 5 Human and physical resources indicators (Rate (R) per 10,000 populations) (General Directorate of Statistics and Information, 2017)

Physicians	28.3
Dentists	4.4
Pharmacists	7.9
Nursing	57
Hospital beds	22.3
Primary Health Care Centers - MoH	0.7

Despite the progress in healthcare services provided by various sectors of the Saudi healthcare system, the system is challenged with the continuous improvement of the financial, physical, and human resources involved in providing these services so that they could be offered to all people at all time (M. o. H. General Directorate of Statistics and Information, Kingdom of Saudi Arabia, 2017). Table 6 below presents the annual MOH budget between 2012 and 2016 (M. o. H. General Directorate of Statistics and Information, Kingdom of Saudi Arabia, 2017), although this budget is consistently falling between 6.6 and 7.25 of the total budget of the government.

Table 6 MOH annual budget from 2012 – 2016 (General Directorate of Statistics and Information, 2017)

Year	GOVERNMENT BUDGET (Billion SAR)	MOH Budget (Billion SAR)	(%)
2012	690	47.076	6.80%
2013	820	54.350	6.63%
2014	855	59.985	7.02%
2015	860	62.342	7.25%
2016	840	58.899	7.01%

Nonetheless, Saudi population healthcare demand is expected to the further increase over the coming decades as a result of the following factors (M. o. H. General Directorate of Statistics and Information, Kingdom of Saudi Arabia, 2017):

- The high growth rate of the Saudi population is expected to continue increasing until 2024. In 2016, the Saudi population reached 31.7 million out of which 11.6 million (63.4%) are citizens with a 2.54% average growth rate based on Health Statistics Book of MOH 2017. Because of this high growth rate, compared to 2.1% for other Arabic countries and 1.5% for developing countries, 65.46% of the Saudi population is between the age of 15-64 while 4.17% is over 65 years. Table 7 below presents some of the above-stated data as per the Health Statistics Book of MOH in 2017.

Table 7 Saudi demographic indicators (2017) (General Directorate of Statistics and Information, 2017)

The area in a square kilometer	2,000,000
The total population of thousand	31,742
% Urban population out of a total population	63.4
Crude birth rate /1000 population	17.23
Crude Death rate /1000 population	2.9
% Population Growth Rate	2.54
% Population Under 15 years	30.35
% Population between 15- 64 years	65.46
% Population from 65 & above	4.17
Total fertility rate	2.4

- The Saudi population has developed awareness about the importance of healthcare aspects, especially the preventive-based ones. For instance, a 2017 survey showed a decrease in the rate of German Measles due to high coverage of immunization and the completion of the first stage of the comprehensive Vaccination program for students in middle and high school. Also, the survey showed there was no case recorded of poliomyelitis. Also, the immunization rate of infants by three doses of pertussis, diphtheria, tetanus, anthrax, hemorrhagic influenza, hepatitis B, and poliomyelitis was 98.5% in 2016.
- The Saudi population's life expectancy at birth has increased from 53 years in the 1970s to 73.5 years for males and 76.1 for females in 2016.
- The change in the nature of diseases.
- The change in the Saudi population lifestyles.

As a step to fulfill the increasing demand, the Council of Cooperative Health Insurance (CCHI) was established in 1999 to enforce insurance-based health care services for workers in

private business organizations (Council of Cooperative Health insurance, 2016). By the year 2002, CCHI's responsibilities were expanded to cover the enforcement of providing healthcare services to all Saudi populations on insurance-based schemes. Some of the CCHI tasks include (Council of Cooperative Health insurance, 2016):

- Providing an integrated healthcare services network that covers the whole country.
- Expanding the decentralization of health services management so that each health affair in the thirteen Saudi provinces is given administrative and financial authority enough to handle its duties more effectively.
- Studying the feasibility of privatizing some of MOH hospitals.
- Providing policies and regulations that assure effective operation of MOH and other government hospitals based on economic and quality considerations.

Table 8 Saudi health expenditure indicators (2015) (World Health Organization, 2015)

Total expenditure on health (per capita) US\$ exchange rate	807.8
Government expenditure on health (per capita) US\$ exchange rate	518.8
Total expenditure on health % of GDP	3.2
General Government expenditure on health as % of total health expenditure	64.2
Out of pocket expenditure as % of total health expenditure	19.8

However, obligations of providing insurance-based healthcare services are still limited to workers of private business organizations, while the remaining population healthcare needs are covered either by MOH and other government hospitals or through private hospitals on the out-of-pocket basis (Ministry of Economy and Planning, 2004). As per Regional Office of World

Health Organization for the Eastern Mediterranean website which was lastly updated in 2015, Table 8 above shows 64.2% of Saudi's total health expenditure in 2015 was provided by the government while only 19.8% of the total expenditure was out-of-pocket (World Health Organization, 2015).

Based on these figures, most of the Saudi population's health needs are still provided by the government for free. Therefore, the Department of Statistics and Information in the Ministry of Health in Saudi Arabia in 2017 included the following objectives to cover the increasing healthcare needs of Saudi population (Ministry of Economy and Planning, 2014):

- Reduce the proportion of births below normal weight to less than 5% and improve health and nutrition indicators for children under five years of age;
- Opening new 400 ambulance centers and Securing 25 ambulances and providing 1,500 ambulances in the Saudi Red Crescent plan;
- Expanding the insurance-based healthcare services;
- Determining the number of government hospitals which are going to be privatized;
- Upgrading the healthcare current management information network;
- Delivery within health institutions should be at least 98%;
- Reviewing the current organizational structures and developing new ones;
- Providing new rules and regulations for operating the governmental hospitals on an economic basis;
- Reviewing the current regulations and policies that govern and audit the quality of service;
- Achieving integrated connectivity among governmental hospitals and primary healthcare centers;

- Opening new health Science colleges and renovating 22 of the existing ones;
- Expanding the use of digital and wireless communication systems in order to improve current response rates.
- Opening 750 new primary healthcare centers.
- Establish, produce, and operating public and specialized hospitals with 37,000 beds (Ministry of Economy and Planning, 2014).

2.3 Diabetes and Hypertension and Related Diseases

Diabetes is a serious disease that consists of two different types. Type 1 Diabetes is not as common as type 2 is. However, it is identified as the absolute lack of secretion of insulin from the body's pancreas. Without insulin, the body is not able to correctly deal with sugars in the human cells. The second type is type 2, which is far more common than type 1 (American Diabetes Association, 2010). "Type 2 diabetes ranges from predominantly insulin resistance with relative insulin deficiency to predominantly an insulin secretory defect with insulin resistance" (American Diabetes Association, 2010, p. 563). Diabetes of any kind has an impact on those with this disease. Since there is a resistance to insulin, one of the impacts on the body is due to the fact that the amount of sugar in the blood increases because the sugar is not being used for the good of the cells and the extra sugar leads to other illnesses, making it important that this disease, if it cannot be eliminated can at least deal with the problem of the extra sugar (American Diabetes Association, 2010).

In Saudi Arabia, there are large numbers of adults who are at risk of suffering from heart problems with type 2 diabetes. In 2015, Al Slail investigated the risk profiles of adults for developing cardiovascular risk. They took data from the hospital records for 422 patients in

different diabetes clinics in Riyadh. Their motivation was to discover the number of type 2 diabetes patients seen at facilities, what type of patients were meeting the American Diabetes Association's suggested levels and what conventions were associated with accomplishment best control of coronary illness hazard factors (Al Slail, Abid, Assiri, Memish, & Ali, 2016). The scientists found that 70% of the patients had at least two hazard factors for cardiovascular sickness, and a major extent was not controlling those dangers. There is, therefore, an urgent need to educate these people and encourage them to guard their health.

These researchers also investigated hypertension along with cardiovascular risks. They found that 12% of the patients surveyed had reasonable blood pressure measurements. Al Slail found that the results for blood pressure problems in 2010 were lower, which suggests that there is also a need for educating patients and encouraging them to take blood pressure conditions seriously and adhere to the rules for their disease (Al Slail et al., 2016).

Hypertension is a problem in Saudi Arabia. Researchers such as Al-Tuwijri & Al-Rukban (2006) have investigated this problem. They conducted a cross-sectional study reviewing medical records of over 200 hypertensive patients. These were people being treated at mini-clinics in Saudi Arabia. The nurses at these mini-clinics collected the data developed for the study. The goal of the study was to find out how much control of blood pressure and how many common co-morbidities existed among these hypertensive patients. After the study was completed, the researchers discovered that there is poor blood pressure control in the mini-clinics. They recommended that there should be better physician knowledge and better attitudes toward the reality that blood pressure levels must be kept in a reasonable state in order to prevent further problems for the patients, including the possibility of early death (Al-Tuwijri & Al-Rukban, 2006).

Although diabetes types 1 and 2 are the main types of diabetes that are found in the world, there is a third type of diabetes, the “Gestational Diabetes Mellitus type.” In 2006, Carr research team investigated whether gestational diabetes makes it more likely that a woman with a history of type 2 diabetes is in more serious danger of having cardiovascular disease. This study investigated 332 women who either did or did not have a family history of (GDM). This study included women who were mostly middle-aged and were obese. Those with earlier GDM were more youthful and more probable than the other ladies to be African American. Race/ethnicity was viewed as a potential confounder for the outcomes and was incorporated into the balanced examination (Carr et al., 2006).

Obesity is frequently joined by diabetes, and keeping in mind that the two gatherings were fat, those in the GDM aggregate had higher fasting glucose and insulin levels. Those were more insulin safe. The researchers found that CVD was thoughtfully more typical in ladies with GDM race/ethnicity, age, and menopausal status did not change the connection amongst GDM and cardiovascular disease (Carr et al., 2006).

2.3.1 Diabetes type 2 and Hypertension in Saudi Arabia

Diabetes is one of the Noncommunicable Diseases (NCD) that affected a myriad number of people around the globe. The number of people diagnosed with diabetes has dramatically increased in recent years. According to International Diabetes Federation (IDF), the assessed number of diabetes patients in 2017 is 424.9 million, with an expected growth of nearly 48%, reaching 628.6 million in 2045 (International Diabetes Federation, 2017). Moreover, the number of deaths because of diabetes, according to the same report, is estimated to be four million in 2017.

Saudi Arabia is among the countries that have the highest number of people with diabetes in the middle east, with 17.7% of the country's population having diabetes (International Diabetes Federation, 2017). Several studies evaluated the prevalence of diabetes in Saudi Arabia and its associated risk factors. Al-Daghri conducted a questionnaire to assess the presence of some of the chronic diseases, including type 2 diabetes, in Riyadh, Saudi Arabia (Al-Daghri et al., 2011). A total of 9,149 individuals aged from seven to eighty years were randomly recruited in the study. The diagnosis of type 2 diabetes was based on the World Health Organization (WHO) definitions. Patients' glucose levels and body mass index were calculated. The results revealed that the prevalence of type 2 diabetes was 23.1%. Also, it was found that the prevalence of type 2 diabetes was significantly higher in males than in females.

Also, Ahmed conducted cross-sectional research to evaluate the prevalence of diabetes among school children in Majmaah city in Riyadh Province, Saudi Arabia (Ahmed Syed Meraj, 2017). A total of 950 students (equally distributed between males and females) aged from seven to fourteen were randomly selected to contribute to the study. Parents of the selected participants were asked to fill out a semi-structured questionnaire containing information relevant information about diabetes. The diagnosis process was carried out according to the WHO guidelines. The results showed that 1.6% of the children had a body mass index above the normal range.

The prevalence of diabetes in Saudi Arabia was reported to be significantly higher in urban areas comparing to rural areas (Midhet, Al-Mohaimeed, & Sharaf, 2010). According to the Saudi Health Information Survey for Non-Communicable Diseases in the Kingdom of Saudi Arabia report (2013), there as a positive association between the prevalence of diabetes and the age of the individual. The report revealed that the prevalence rate of diabetes among individuals

aged from 15 to 24 was 4.7%, while the prevalence rate among individuals aged 65 and above was 5.4%. Also, the prevalence of diabetes varied considerably among the different regions in Saudi Arabia, with the lowest rate being in Jazan and the highest being in Ha'il. Figure 2 shows the prevalence of diabetes in different geographical locations in the Kingdom of Saudi Arabia (Saudi Health Information Survey, 2013).

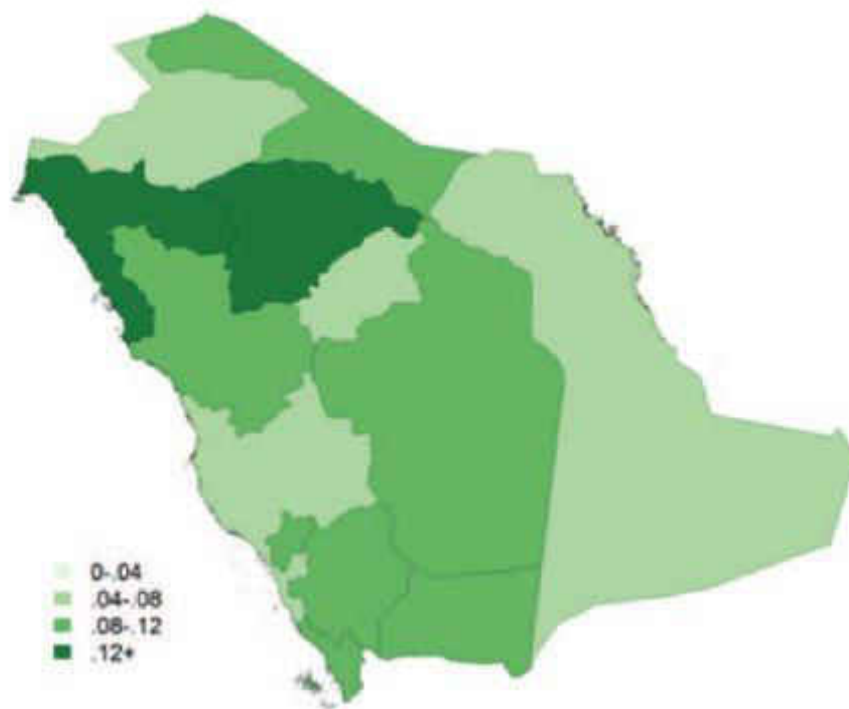


Figure 2 Distribution of individuals with diabetes in Saudi Arabia (Saudi Health Information Survey, 2013)

Individuals who have diabetes may develop other disease complications such as retinopathy, kidney failure, myocardial infarction and stroke, and neuropathy (Klautzer, Becker, & Mattke, 2014). Indeed, several factors associated with the high prevalence of diabetes, especially type 2 diabetes (T2DM) in Saudi Arabia, have been reported. One of these factors is the lack of physical activity, such as regular exercise. Figure 3 shows the level of daily exercises,

defined as less than 10 minutes a day, in some countries in the middle east, including Saudi Arabia (Klautzer et al., 2014). In addition to the lack of physical activity, poor nutrition was also reported to have a considerable effect on the prevalence of diabetes in Saudi Arabia. Poor nutrition was caused by the change in the dietary regimen of the populations in the Gulf Cooperation Council (GCC) countries such as Saudi Arabia from consuming high protein, high fiber food such as milk, fish, dates, whole wheat bread, and fresh vegetables to consuming food that is high in saturated fats, refined carbohydrates, and low fiber (Badran & Laher, 2012).

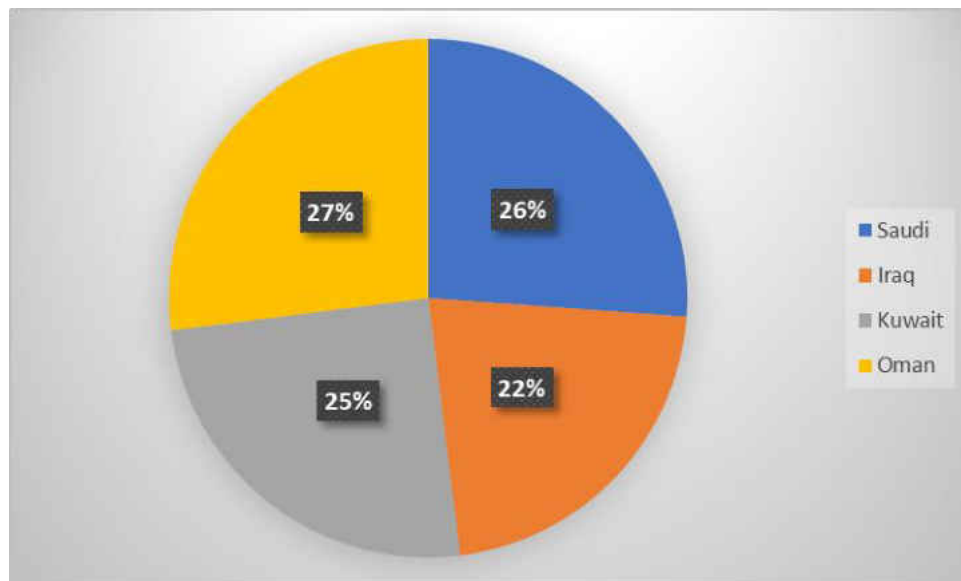


Figure 3 Percentage of individuals with a low level of daily exercise in the middle east (Klautzer et al., 2014)

In the same context, Medhet and his colleagues conducted a case-control study to identify the factors that contribute to diabetes in six primary healthcare centers in Al-Qassim, Saudi Arabia (Midhet et al., 2010). A sample of 283 individuals with type 2 diabetes was randomly selected and used as the case group in the study. Also, a sample of 215 non-diabetic individuals were randomly selected and used as the control group. The results revealed that regular consumption of certain foods such as dates, bakery items, and full-fat dairy products

significantly contributed to the prevalence of type 2 diabetes. Also, lack of physical activity, especially those who live a sedentary life, had a greater risk of developing type 2 diabetes.

In addition to diabetes, high blood pressure or hypertension is also another NCD that has been reported to have significant spread among human populations of the world. In fact, more than 25% of the global population is diagnosed with hypertension (A. A. Saeed et al., 2011). Also, the prevalence of hypertension is expected to increase by 24% in the industrialized countries and up to 80% in the developing nations by 2025 (Kearney et al., 2005).

In Saudi Arabia, several studies estimated the prevalence of hypertension in Saudi Arabia. For instance, El-Hazmi and his colleagues conducted a study to estimate the prevalence of hypertension in 35 regions in Saudi Arabia (El-Hazmi & Warsy, 1999). The study included a total of 14,660 individuals from both genders. The study indicated that the prevalence of hypertension was 4.37%. Also, significant differences in the prevalence of hypertension between the regions were reported.

In another study, a national survey was designed to estimate the prevalence of hypertension in all regions in Saudi Arabia (A. A. Saeed et al., 2011). A total of 4758 subjects were randomly recruited to participate in the study. The survey included data regarding demographic information, history of blood pressure, blood pressure measurements, and other relevant factors. The study found that the frequency of total hypertension was 25.5%, and the prevalence of blood pressure was higher in females.

According to the Health Information survey of Hypertension in the Kingdom of Saudi Arabia (2013), the prevalence rate of hypertension was 17.8% among males and 16.5% among females. The report also revealed that the prevalence of hypertension was higher (65%) among individuals who are 65 and older, and it was varied across different geographical areas of the

Kingdom. Figure 4 shows the prevalence of hypertension among different regions in Saudi Arabia. Furthermore, the results of this survey indicated that the prevalence of hypertension was positively correlated with obesity (26.4%) and diabetes (38.9%). To control the burden of hypertension in Saudi Arabia, the ministry of health has initiated several health programs that focused on the role of nutrition and physical activities promoting health and fighting chronic diseases (Saudi Health Information Survey, 2013).

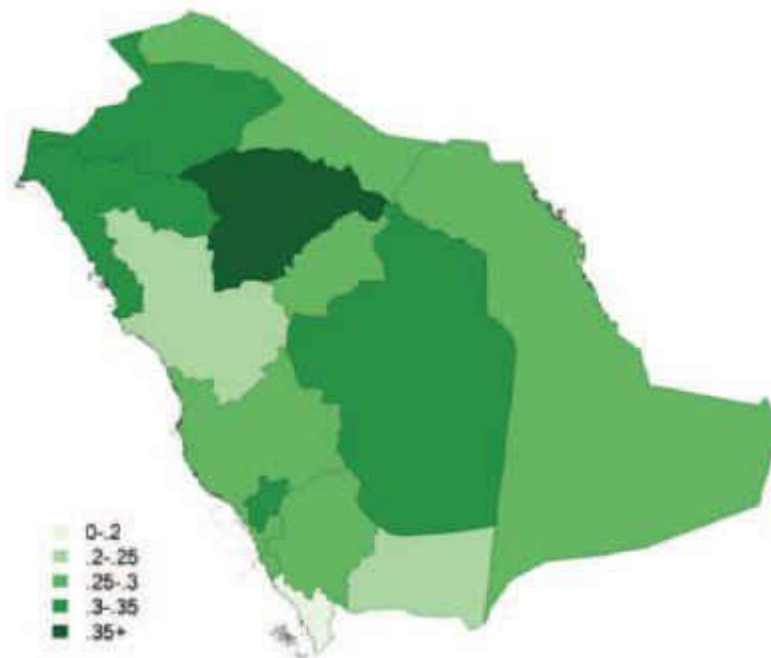


Figure 4 The prevalence of hypertension in different regions in Saudi Arabia (Saudi Health Information Survey, 2013)

In a recent study, Saeed conducted a study to evaluate the prevalence of hypertension among residents of Saudi Arabia (A. A. W. Saeed, 2017). A community-based survey containing information about blood pressure and other relevant factors was conducted, and a total of 4588 individuals aged from 5 – 64 years were randomly selected from 20 regions and primary health

care centers to participate in the study. The study indicated that the overall prevalence of hypertension was 20.7%.

In addition to the assessment of the prevalence of hypertension in Saudi Arabia, some studies investigated the potential risk factors associated with the prevalence of hypertension. For example, a study conducted by Al-Hamdan and his colleagues to determine the factors affecting hypertension found that there is an association between the development of hypertension and age, gender, geographical location, education level, and employment status (Al-Hamdan, Saeed, Kutbi, Choudhry, & Nooh, 2011). Also, the study indicated that lack of physical activity, body weight, smoking, and diabetes significantly contributes to hypertension.

Hypertension is of great concern around the world. In 2014, a special communication was suggested containing important guidelines for managing high blood pressure in adults. Hypertension is dangerous and can lead to strokes, renal failure, and can even cause a person's death (Al-Hamdan et al., 2011). These researchers claim that there is heavy evidence that supports treating high blood pressure at the age of 60 years or more with a hypertension goal under 150/90 mm Hg and the hypertension person the age of 30 to 59 years to a diastolic goal of under 90 mm Hg (Al-Hamdan et al., 2011). However, in each clinic, there may be differences, and that should be respected, given they each human being is different, and physicians who have treated the patient in the past might have different treatments of care.

Nevertheless, the researchers made certain recommendations and guidelines for people with hypertension. The recommendations were based on rigorous research about hypertension that was well backed up by science. They also took evidence from randomized controlled trials that aided in determining both the efficacy and effectiveness of recommendations. The recommendations indicated what should be done based on a person's age (James, 2015). An

older person needs different types of treatment than most younger people. There is also a difference based on ethnic backgrounds. For example, people of color tend to be more susceptible to hypertension than others. Therefore, in one case, they might suggest pharmacologic treatment to lower the blood pressure to one patient and in another, the recommendation might be antihypertensive treatment. Their recommendations differ from other suggestions in previous literature.

Turner et al. (1998) investigated tight blood pressure control's impacts on certain harmful risks. These researchers noted that type 2 diabetes and hypertension are very related to one another. They each provide increased risk for patients with cardiovascular and renal disease. Their research included subjects with hypertension and some having type 2 diabetes. The patients were between the ages of 25 and 65, and a total of 4297 subjects took part in this research. The patients were divided into two different groups, and in one, there was tight control, and in the other, there were those under light control without drug treatment (UK Prospective Diabetes Study Group, 1998). The patient visited clinics every 3 to 4 months, and plasma glucose concentration, hypertension, and weight were calculated, the research continued for more than eight years.

This study result shows that tight control patients had higher hypertension readings than those with high control. The low control patients showed a trend toward decreasing levels of blood pressure, but it was a minimal decrease. The researchers suggest that their results show that tight control of hypertension did reduce their risk of death, strokes, and microvascular disease (UK Prospective Diabetes Study Group, 1998).

A similar study aimed to examine the potential risk factors that influence high blood pressure in Saudi Arabia (El Bcheraoui et al., 2014). The study included a total of 10,735

participants from all regions in Saudi Arabia. It was indicated that age, gender, history of diabetes, and hypercholesterolemia were significantly related to hypertension. Also, the study revealed that the prevalence of hypertension was found to be lower among females comparing to males. Contrary to previous research, smoking status, level of education, and level of physical activity were not found to have significant effects on hypertension. Surprisingly, according to the same study, hypertension is estimated to be the number one risk factor for death in Saudi Arabia, as cited in the Global Burden of Disease 2010, GBD2010 report.

In the same context, Saeed also conducted a study to identify the potential risk factors that influence high blood pressure in Saudi Arabia (A. A. W. Saeed, 2017). Demographics and lifestyle characteristics such as gender, age, education, occupation, region, family income, physical activity, fruit and vegetable consumption, and smoking status were included in the study. Also, anthropometric and blood measurements such as Glucose, Cholesterol, Triglycerides, and high-density lipoprotein were also included in the study. The results indicated that there was a significant association between gender, age, education level, occupation, physical activity, and high blood pressure. Moreover, it has been found that, among the anthropometric and blood measurement, only high-density lipoprotein did not have a significant impact on high blood pressure.

Saudi Arabia is not the only nation faced with problems of hypertension (Ong, Cheung, Man, Lau, & Lam, 2007). Ong and colleagues found the prevalence and hypertension in the period from 1999 to 2004. They found that there was no significant increase in hypertension during that period, but also that overall three periods, hypertension increased as people aged and with their body mass index BMI (Ong et al., 2007). In all 3 of the periods, the prevalence of hypertension increased with increasing age and BMI. There were no significant differences

between the sexes, but there was a difference based on education (Ong et al., 2007). One of the factors also appears to be awareness. Those who are aware of their blood pressure and the dangers of hypertension were more able to control it and get the treatment they need.

To assess the quality of healthcare services provided to individuals with high blood pressure, Al-Saleem and his developed a questionnaire in the city of Aseer, Saudi Arabia (Al-Saleem, Al-Shahrani, & Al-Khalidi, 2014). The study aimed to measure the satisfaction of healthcare providers regarding factors such as patients' cooperation and compliance with the appointment system, availability of essential drugs for high blood pressure, and other relevant factors. The results revealed that the satisfaction level of healthcare providers with community participation was low (43%). Furthermore, the low satisfaction level of the healthcare providers regarding patients' compliance with the appointment (32%), and coordination with hospitals (20%) were reported.

Nevertheless, given the stated facts about the burden of chronic diseases such as diabetes and hypertension and their potential risk factors in Saudi Arabia, the need for improving the quality of healthcare services to manage and control the prevalence of such diseases cannot be more emphasized. Indeed, some researchers and healthcare providers started imitative programs and interventions such as using the mobile phone technology, known as mhealth, to improve the quality of healthcare service provided to diabetic and hypertensive patients in Saudi Arabia. Such mhealth interventions are discussed in the subsequent sections.

2.4 Mhealth Interventions Related Diabetes type 2 and Hypertension in Saudi Arabia

The use of a technology-based intervention such as the mobile phone or mhealth to enhance the quality of healthcare service has been explored recently. There are many advantages to incorporating mobile phone technology in healthcare, such as its high penetration, ease of use,

and cost-effectiveness make it a potential feasible intervention to address most of the challenges of any healthcare system (Mokaya, 2010). According to the Information and Communications Technology (ICT) facts and figures report of 2016, there were almost seven billion people in the world who had access to a mobile phone network (SANOU, 2016). In developing nations, around 3.6 billion people are subscribed to a mobile phone network (SANOU, 2016).

Community interventions can be useful in decreasing the number of people harmed by diabetes. Afifi, Omar and El Raggal (2013) found in their research that if a person is not genetically vulnerable to diabetes and exercises and maintain good body weight, that person will be less likely to be a victim of diabetes. The food of the diet was more fiber and more polyunsaturated to saturated fat ratio and decreased the average of the glyceimic. Also, the other factors that were important were not smoking, drinking alcohol in moderation, and normal weight (Afifi, Omar, & El Raggal, 2015). Not only is it possible that people will be able to control their diabetes, but it is also possible to aid in preventing them from getting diabetes.

Also, other studies reviewed the feasibility and effectiveness of using mobile health applications in promoting better health conditions for patients with hypertension. In one study, a review of current mhealth interventions and the evaluations of their effectiveness for the management of hypertension and hyperlipidemia was presented (Rehman et al., 2017). The study reported that using mhealth interventions such as SMS for management of hypertension was effectively based on the literature. However, the cost-effectiveness of such interventions has not been evaluated. Thus, the authors suggested that future research should consider the feasibility of using mhealth interventions for the management of hypertension through its costs and benefits.

In South Africa, a mobile health intervention using SMS text messaging to promote health knowledge for patients with hypertension was examined (Hacking et al., 2016b). The

study included a total of 223 hypertensive patients who were tested for their current knowledge of hypertension and were then randomly assigned to two groups: the intervention group and the control group. Over a period of 17 weeks, patients in the intervention group received a total of 90 SMS text messages, including knowledge of hypertension and guidelines for lifestyle changes. Consequently, patients in both groups were tested for their knowledge of hypertension using the same questionnaire that was used before the intervention. The results showed that no significant difference between the intervention and the control group regarding their knowledge of hypertension was observed. However, the intervention group showed a positive increase in self-reported behavior change (Hacking et al., 2016a).

To explore the trends, opportunities, and challenges of mhealth, a literature survey was conducted to achieve this goal (Jusoh, 2017). The author also surveyed the current mhealth applications on Google Play. In reviewing the Apple App Store and the Google Play Store, more than 60,000 mhealth applications (James, 2015). The majority of these applications, according to the same study, were designed to provide health services in the areas of health fitness and self-health monitoring. Nonetheless, the study discussed some of the challenges of adopting the mhealth technology, which includes lack of security considerations in some mhealth applications, lack of usability, and lack of studies evaluating the effectiveness of mhealth applications. Despite the reported issues of mhealth application, many opportunities are available for researchers and healthcare providers to implement mhealth technology in order to improve the quality of health service delivery.

In Saudi Arabia, many researchers and healthcare providers investigated the adoption of mhealth interventions to improve healthcare services. One study used a mobile phone application to improve healthcare service delivery at the Emergency Department (ED) in Saudi Arabia

(Househ & Yunus, 2014). The developed mobile health application, which is called EDWaT, aimed to reduce patients' waiting time by providing real-time data about the flow of patients to the emergency medical services (EMS) staff. The study also reported some of the challenges of implementing the EDWaT, such as the lack of cooperation of some hospitals regarding sharing the waiting times of their patients. Nevertheless, the effectiveness of EDWaT has not been reported in the study.

In another study, a review of mobile technologies used to help individuals with special needs was explored (Kanjo, Albarrak, Alhakbani, Altammami, & Alghamdi, 2013). The authors organized a workshop hosting a total of 30 participants at King Saud University in Saudi Arabia. The authors classified those with special needs into five categories, namely Memory Loss, Visually Impaired, Hearing Problems, Learning Disability, Behavioral Problems, and Chronic Diseases. Among the mobile applications that the study reported is Ariadne GPS, Talking Maps for Visually Impaired individuals, and Noise Spy for individuals with Hearing Problems. The study reported that awareness and cost are the main factors that limit individuals with special needs from using mobile phone technology. The study also presented some recommendations to integrate different mobile applications to improve the quality of healthcare services provided to individuals with special needs.

In the same context, Uluc conducted a field survey study to identify the main challenges of e-health in four countries, namely Turkey, the Kingdom of Saudi Arabia, Egypt and the United Arab Emirates (Uluc & Ferman, 2016b). A total of 251 participants, including physicians, healthcare IT professionals, and relevant government representatives, were chosen to complete two questionnaires in the four selected countries. Based on participants' feedback, a conceptual framework for the development of e-health practices in the four selected countries was

developed. The framework outlined the factors that may limit the successful implementation of e-health in the selected countries, which include ICT Infrastructure and Readiness, Cultural Adaptation, Regulations, Financing, Supply Chain Management, and Trust. The Analysis of Variance (ANOVA) technique was used to determine the potential effect of these factors on the development of e-health. The results indicated that all of the above factors have a significant effect on the development of e-health in the selected countries.

Moreover, Saad conducted qualitative research to identify mhealth interventions adopted by the Saudi Ministry of Health (SMOH) with the aim to improve healthcare service delivery in Saudi Arabia (Saad, 2016). The author conducted a questionnaire to determine the most vital mhealth administrations from the viewpoint of patients. The Technology Acceptance Model (TAM) was used in this study to explore six areas of mhealth applications namely “appointment reservation, open and update medical record, patient referee and consultation, physician directory, request medical reports and health risk assessments” (Saad, 2016, p. 7). Nonetheless, data analysis and findings of the study were not reported.

2.5 Mhealth and Prevention of Diabetes type 2 and Hypertension in Saudi Arabia

The applications of mhealth technology have also been used to prevent diseases such as diabetes and hypertension. For example, Tate and his colleagues explored the success factors and challenges of using mhealth technology to prevent obesity in children (Tate et al., 2013). The study indicated that the adoption of mhealth intervention yielded several advantages, including its cost-effectiveness, real-time data collection, and its flexibility regarding its application and monitoring capabilities. On the other hand, the challenges of applying mhealth technology to prevent chronic disease were also reported in the study. One of these challenges is the increase in sedentary behavior. The second challenge is the declined ability to focus attention. In fact, these

challenges, according to this study, negatively impact obesity in children due to the possible prolonged communication with mhealth technology. Furthermore, the study also reported other issues of the current mhealth applications such as data security, patient privacy, and lack of evidence of the effectiveness of such applications.

Besides the documentation of the enablers and limitations of the adoption of mhealth interventions in disease prevention, some studies reported successful implementation of mhealth technology to prevent chronic diseases such as diabetes and high blood pressure. Hingle and his colleagues developed a mhealth intervention aimed to prevent type 2 diabetes among children aged 9 to 12 years old in Tucson, Arizona (Hingle et al., 2015). The developed intervention - EPIC Kids ((Encourage – Practice - Inspire - Change) – was tested using a group-randomized trial at three points in time (baseline, post-intervention, and follow up). A total of 60 kids at risk of type 2 diabetes were recruited in the study. Anthropometric, behavioral, and physiological factors were used to evaluate the effectiveness of this intervention. The study reported a potential reduction in children’s high carbohydrate food intake, sugar-sweetened beverages, and a sedentary lifestyle. Also, the study reported a possible increase in kids’ intake of vegetable and whole-grain servings and physical activity.

In Sydney, Australia, Partridge and his colleagues conducted a randomized control trial to examine the effectiveness of a mhealth intervention to prevent weight gain among young adults (Partridge et al., 2015). The proposed mhealth intervention - TXT2BFiT – aimed to help young adults improve their diet and promote exercise. A total of 250 participants aged from 18 to 35 years with a high risk of weight gain were recruited in the study. Bodyweight and height of the participants were measured before and after the intervention. Also, participants in the control group received eight text messages, one email, and five coaching calls as well as other

supporting materials on a weekly basis. The results revealed that more than 90% of the participants showed adherence to coaching calls and text messages. The results also showed significant reductions in the consumption of sugary soft drinks, and energy-dense meals among participants of the intervention group. Moreover, a significant increase in the consumption of vegetables among participants of the intervention group has been reported.

Mhealth technology has also been used to provide care for patients with hypertension. In one study, Diez-Canseco and his colleagues introduced an SMS intervention to prevent blood pressure in different Latin American countries. A sample of 36 patients with hypertension was chosen in each country to participate in the study. The patients received an initial set of 64 SMS messages aimed to encourage healthier lifestyle changes. The messages included information about salt and sodium intake, fruits and vegetables, fat and sugar consumption, and physical activity. Patients' feedback regarding the mhealth intervention was then assessed using a questionnaire. The results revealed that more than 96% of the participants responded to the questionnaire and provided an adequate understanding of the content of the SMS text messaging intervention. The study concluded that the use of SMS text messaging could contribute to the prevention of hypertension (Diez-Canseco et al., 2015).

In addition, a case study reviewed the feasibility of using a mobile phone application - Dietary Approaches to Stop Hypertension (DASH) – for patients with hypertension (Mann, Quintiliani, Reddy, Kitos, & Weng, 2014). In specific, the aim of developing DASH was to promote prevention through behavioral change and lifestyle modifications for patients with hypertension. The study reviewed the stages of developing DASH, starting from the design stage and ending with the prototype stage. The study reported some of the potential challenges of using the DASH in providing care for patients with hypertension, although no actual use of DASH was

carried out in the study. Moreover, the study concluded that mobile health applications could promote a behavioral change in patients with hypertension, given the availability of robust infrastructure.

In developing countries, Déglise and his colleagues reviewed the applications of SMS text messaging for disease prevention in the nation (Déglise, Suggs, & Odermatt, 2012). Among the mhealth interventions reported is a mobile phone game called Freedom HIV/AIDS, which was developed to promote awareness and provide information about HIV and AIDS in India. A similar intervention called Star Project was initiated by the same company in six African countries for the same purpose. The authors stated that most of the studies were pilot projects, few including an evaluation. Limitations of the reported mhealth interventions included language, the timing of messages, mobile network fluctuations, lack of financial incentives, data privacy, and mobile phone turnover. (Déglise et al., 2012).

Limited research has been conducted on the use of mhealth technology to prevent diseases in Saudi Arabia. Alqahtani conducted a pilot study to examine the feasibility of using a mobile phone application to monitor the health conditions of travelers during the Hajj pilgrimage of 2014 (A. S. Alqahtani et al., 2016). A cohort study was conducted in three phases: before, during, and after Hajj 2014, including a questionnaire in each phase. The authors developed an iPhone application – Hajj Health Diary – to monitor the health conditions of the travelers. Participants in the study were recruited over two phases. The first phase of recruitment was conducted using a travel seminar in Sydney, Australia, and the second phase of recruitment was conducted virtually by releasing the Hajj Health Diary to the Apple app store. There were 41 respondents to the application aged between 21 and 61. The study revealed that more than half of

the participants found the app to be convenient. The authors concluded that mobile phones could feasibly be used to collect data, conducted surveys for disease prevention and control.

In another study, AlKlayb evaluated the effectiveness of a mobile phone application in providing preventive dental care by educating mothers of children most aged at six years (AlKlayb, Assery, AlQahtani, AlAnazi, & Pani, 2017). The authors developed a mobile phone application - iTeethey™ - for IOS and Android operating systems, and it is available for free in Google Play and Apple App Store. The application was distributed to 3879 mothers, 1055 of whom downloaded the application at eight healthcare facilities in the cities of Riyadh and Najran in Saudi Arabia. The authors reported that the use of the iTeethey™ significantly improved mothers' knowledge of oral health conditions after three months of using the application. Moreover, there is a significantly higher level of maternal knowledge of mothers in Riyadh comparing to those in Najran. The authors also found a positive correlation between the number of children in the family and the change in the knowledge score.

2.6 Mhealth and Medication Adherence for Diabetes type 2 and Hypertension in Saudi Arabia

Several studies examined the use of mobile phone technology to manage chronic diseases such as diabetes and hypertension. In one study, mobile phone technology was used to provide management and education for patients with type 2 diabetes in Saudi Arabia (Alotaibi, Istepanian, Sungoor, & Philip, 2014b). A mobile phone application – SAED – was developed to help patients manage their diabetes. The SAED is composed of two components, namely the “SAED mobile patient/healthcare provider” and “the SAED intelligent diabetes management” (Alotaibi et al., 2014b, p. 1). The first component consisted of two units: a diabetic patient unit designed to collect patients' information such as blood glucose levels; and a specialist diabetic

nurse unit designed to facilitated communication between nurses and diabetic patients. The second component consisted of four modules, namely a SAED database module for storing patients' information, an intelligent decision support module for data processes and analysis, SAED SMS reminder module, and diabetes educational module. Patients information such as glucose levels is transferred to SAED from the glucose meter, see figure 5.

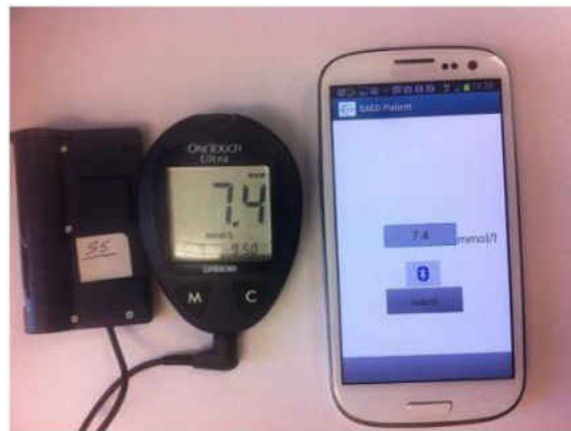


Figure 5 Data transfer from glucose meter to SAED application(Alotaibi, Istepanian, Sungoor, & Philip, 2014a)

Also, a randomized control trial was conducted over a six-month period to evaluate the effectiveness of SAED to manage and educate diabetic patients in Tabuk, Saudi Arabia (Alotaibi et al., 2016). A total of 20 patients aged from 20 to 65 years were randomly nominated to contribute to the study, and they were separated into two groups, with ten patients allocated to the nonintervention group and ten patients allocated to the intervention group. Patients' information, such as blood glucose levels, were recorded two to three times a day on two to three different days a week. Moreover, patients in the control group received weekly SMS text messages to promote their knowledge of diabetes and related risk factors. The results revealed a significant reduction in blood sugar levels of patients in the intervention group compared to the control group. Furthermore, patients' knowledge about diabetes was higher in the intervention

group comparing to the control group, although both groups showed a significant improvement in their knowledge before and after the intervention.

Furthermore, a nonrandomized experiment was used to evaluate the effectiveness of mobile phone SMS text messaging to control blood sugar levels of patients with type 2 diabetes in Riyadh, Saudi Arabia (B. B. Abbas et al., 2015). The study lasted for four months and included a sample of 100 patients with type 2 diabetes. Patients' relevant data were recorded before and after the SMS intervention. The developed SMS intervention was designed to increase patients' knowledge of diabetes by sending five to seven messages per week, providing general information about diabetes, such as its symptoms, signs, diagnosis, etc. The results revealed that a significant reduction in fasting blood sugar was observed after the intervention. Also, patients' knowledge of diabetes was significantly improved following the intervention.

For the management of hypertension, Kang and Park (2016) developed a mobile phone application that was based on clinical practice guidelines (CPGs) in Seoul, South Korea. The hypertension management application (HMA) included medical items such as blood pressure readings, medication records, and lifestyle data. A sample of 38 patients with hypertension was selected to participate in the study. The mobile phone application was evaluated regarding "perceived usefulness, user satisfaction, and medication adherence" (Kang & Park, 2016, p. 1). The results showed that patients' medication adherence was significantly improved since their use of HMA. Also, the scores of the perceived usefulness and user satisfaction were above 3 out of 5 (Kang & Park, 2016).

To evaluate the feasibility of extracting data from Electronic Medical Records (EMR), Velthoven conducted a comparative study in 16 countries, including Saudi Arabia (van Velthoven, Mastellos, Majeed, O'Donoghue, & Car, 2016). Moreover, the study aimed to

measure the quality, consistency, and extent of adopting EMR data for managing type 2 diabetes in the selected countries. Structured questionnaire targeted physicians, scholars, and relevant stakeholders to collect information regarding the adoption of EMR in these countries. The questionnaire included questions on the treatment of type 2 diabetes and the adoption of EMR in this regard. The results indicated that Saudi Arabia was among the countries that had high EMR adoption rates.

2.7 Mhealth and Diagnostic of Diseases

Many researchers have investigated the effectiveness of using mhealth technology in the diagnosis of some diseases. In the United Kingdom, for instance, Eze and his colleagues used mobile phone digital photos to examine the accuracy of diagnosing some ear, nose, and throat (ENT) emergency in radiological investigations (Eze, Lo, Bray, & Toma, 2005). Fourteen patients were randomly selected to participate in the study. A comparison between CT scans and X-ray images transmitted via a mobile phone and images processed via a conventional X-ray box was carried out by six ENT consultants and five registered specialists. The results showed that no incorrect diagnosis was reported for cases included in the study. Moreover, the study concluded that there are significant differences in terms of accuracy, confidence in diagnosis, and compatibility.

In rural New Zealand, a study was to evaluate the feasibility of using mobile phone images in the after-hours triage of primary care (Jayaraman, Kennedy, Dutu, & Lawrenson, 2008). A total of 480 patients attending two healthcare facilities in rural New Zealand were surveyed. Moreover, 30 health professionals divided into three groups were recruited and given a quiz regarding the use of mobile phone images and their effect on the diagnosis of confidence. The study revealed that the use of mobile phone cameras at diagnosis was acceptable by patients

and medical specialists, especially those who work in rural areas. The study also reported that the mobile phone images in a clinical environment significantly increased diagnostic confidence in most of the cases considered.

Also, Breslauer and his colleagues evaluated the feasibility of incorporating a microscope to a mobile phone for diagnosis of some diseases such as Malaria, Anemia, tuberculosis in California, USA (Breslauer et al., 2009). A Nokia N73 mobile phone equipped with a 3.2-megapixel camera was used in this study to capture images of malaria-infected blood samples and sickle cell anemia blood samples. The results showed that the resolutions of the blood cell samples were higher than the expected level. Moreover, the authors indicated that the use of this mobile-based integrated system yielded many advantages, such as the cost-effectiveness and ease of use of technology.

In the developing countries, Breslauer and colleagues examined the effectiveness of using mobile phone text messaging in the diagnosis of HIV infection among infants in Zambia (Breslauer et al., 2009). To reduce the turnaround time of blood test results, the authors introduced an SMS text messaging intervention to report the results to certain healthcare facilities for results analysis. The turnaround time of the results sent by mail to 10 healthcare facilities was recorded and used as baseline data. The results revealed that a significant reduction in the mean turnaround time was observed in nine out of 10 healthcare facilities using the SMS text messaging intervention.

Chin and his colleagues designed a mhealth intervention that consisted of a mobile phone and a satellite communication technology for diagnosing HIV in Kigali, Rwanda (Chin et al., 2013). The developed mhealth intervention – mChip – was used to collect blood samples from patients with HIV as well as to track and analyze these data for diagnosis purposes. A total of

167 participants were recruited in the study. The study indicated that the sensitivity and specificity of the diagnosis were 100% in most of the cases. The study also indicated that the use of mChip was effective in the diagnosis of HIV in this set.

Another study examined the influence of the diagnosis of obese and overweight persons by mobile decision support systems for individuals in the United States (Lee et al., 2009). A randomized controlled trial with two groups was designed to explore the results. The results presented that there was a significant difference between the three groups yielding more obesity-related diagnoses.

Few researchers have evaluated the role of mhealth interventions to diagnose diseases in developing countries. Quinley et al. (2011) examined the use of a mobile phone camera to diagnose women with HIV in Gaborone, Botswana, for the potential risk of cervical cancer. The authors used a 5-megapixel-camera mobile phone manufactured by Samsung to take the images of the cervix and then transmitted by Multimedia Messaging Service (MMS) to a remote location where an expert performed the diagnosis process, after which a visual inspection was carried out by midwife nurses. The results revealed that nearly 67% of the images were of good quality for the expert to perform the diagnosis. Also, identical results of the visual inspection and the expert were obtained in more than 80% of the cases (Quinley et al., 2011).

Another study evaluated the effectiveness of using the mobile phone to diagnose patients with common skin diseases in Cairo, Egypt (Tran et al., 2011). Following a face-to-face inspection, the relevant medical information and dermatologic images of 30 patients were sent to an online database and then evaluated by two senior dermatologists independently using a 5-megapixel-camera mobile phone model U900 manufactured by Samsung. The results showed

that consistency in diagnoses between the face-to-face and remote diagnosis was achieved, on average, in 75% of the cases (Tran et al., 2011).

To the knowledge of the author, no research studies using mhealth technology for disease diagnosis have been reported in Saudi Arabia. This represents a gap in the literature. Thus, future research should focus on exploring the effectiveness of using mhealth interventions in the diagnosis of chronic diseases.

2.8 Potential mhealth Interventions for Replication in the Developing Countries

Given the formerly discussed mhealth interventions in Saudi Arabia and their limited effects in providing high-quality healthcare services, there are many other successful implementations of mhealth interventions in the developed nations that could be replicated in Saudi Arabia. For instance, one study evaluated the effectiveness of a mobile phone application that was designed to help elderly patients with diabetes, high cholesterol, and hypertension manage their health conditions in an outpatient clinic in Health Centre South in Vienna, Austria (Brath et al., 2013). Specifically, the mhealth application was developed based on a remote medication adherence measurement system (mAMS) to assess the patient's behavior and adherence to four medications. Using a randomized single-blinded (doctor blinded), controlled, single-center study with a crossover design, 150 participants with the potential risk of cardiovascular conditions accompanying by at least two of type 2 diabetes, hypertension, and hypercholesterolemia were divided into two groups. The study revealed that a significant difference in adherence to one medication between the two groups was observed, while no significant differences in adherence to the other three medications were reported (Brath et al., 2013).

Another study evaluated the feasibility of using a mhealth intervention to help patients manage their diabetes in Boston, USA (Hanauer, Wentzell, Laffel, & Laffel, 2009). The developed mhealth intervention consisted of SMS text messaging and email reminders that aimed to help patients monitor their blood glucose levels. A total of 40 individuals with diabetes were randomly selected to participate in the study. The selected participants received SMS text messages or email, reminding them to check and resend their blood glucose levels during a three months period. The results of the blood glucose levels were then analyzed using a Computerized Automated Reminder Diabetes System (CARDS). The study indicated that the response rate of the participants who received the SMS text messages was significantly higher than that of those who received the email reminder. Thus, it can be concluded that using mobile phone SMS text messages to collect patients' information provided more acceptability comparing to other technologies such as using email.

In Nashville, Tennessee, USA, Nelson, and his colleagues conducted a study to examine the relationship between patients' certain characteristics and the level of participation in a mobile Health medication adherence intervention (MED) for patients with type 2 diabetes (Nelson et al., 2015). The MED intervention consisted of SMS text messaging and phone calls that aimed to promote medication adherence and medication reminders (Nelson et al., 2015, p. 13). Eighty patients were selected to participate in the study. Data collected from patients included demographic characteristics, health literacy, and depressive symptoms. The study reported that significant associations were found between patients' characteristics and the prospect of participation in the mhealth intervention program.

In the developing countries, Abbas and his colleagues introduced mhealth applications to improve healthcare service delivery in Karachi, Pakistan (Z. Abbas, Burney, & Bari, 2016). The

first application – DocsLab – was designed to help individuals search for nearby specialists or laboratories throughout the city of Karachi. Moreover, the application provides the location of the clinic and the time of the day the specialists are available. The data incorporated into the application included around 500 specialists in different areas in the city. The second application – Drugs-Pharma – was designed to provide a variety of services that include, but not limited to: searching for a certain medicine, its usage, its availability, its form, and its possible side effects; providing different brand names of a certain drug as well as the chemical name in case the brand name is not known; listing pricing information of different brands; providing alternative drugs in case the prescribed drug cannot be found.

Moreover, Abbas and his colleagues reported a third mhealth application to improve healthcare service in Pakistan. This application – Healthcare App – was designed to provide general information about illnesses and medical terms. This application was developed for the Android operating system only due to its wide use in the city. Regardless of the implementations of these applications, no evaluation of their effectiveness has been reported (Z. Abbas et al., 2016).

Also, Wolff-Piggott and his colleagues presented an implementation of the mhealth application in a public clinic in South Africa (Wolff-Piggott, Coleman, & Rivett, 2017). The mhealth application – MomConnect – was designed to provide information to pregnant women during different stages of pregnancy. The goal of the study was to evaluate clinic workers' feedback regarding the use of the application. To collect relevant information regarding workers' experience with the implementation of the mhealth program, interviews and observation sessions were carried out. The authors identified the hierarchical relationships between professional nurses and support staff as one that influenced the performance of the MomConnect.

Hoque, 2017 conducted a study to identify the factors that may affect the use of ehealth by patients in Bangladesh. These factors included perceived usefulness, perceived ease of use, privacy, ant-trust. These factors have been evaluated from patients' perspectives using the technology acceptance model (TAM). To collect data, a survey was designed, and 350 participants from both private and public hospitals in Dhaka were included in the study. The results demonstrated that perceived ease of use, perceived usefulness, and trust significantly affected patients' intent to use ehealth (Hoque, Bao, & Sorwar, 2017).

2.9 Mobile Health Application in Saudi Arabia

Mobile devices are overtaking PCs in today's world as "there are currently about 7.6 billion mobile connections covering 4.7 billion subscribers" (M. M. Alqahtani & Atkins, 2017, p. 222). In fact, mobile internet usage around the globe has become greater than the use of personal computers. Saudi Arabia is just one of many countries in which mobile devices are used more than PCs. It is also true that the value of these mobile devices has been appreciated and reported. For example, the King's Fahad report. This report listed technologies that are likely to create a revolution in healthcare. Smartphones are one of these devices, and according to the King's Fahad report, their usage in the healthcare field will result in cost reduction for the healthcare industry, better outcomes for patients, and proactive and targeted care improvements. Some Smartphone apps can monitor patients in real-time and can aid in analytics. It is expected that mobile health applications will generate revenue worth \$23 billion when measured globally (M. M. Alqahtani & Atkins, 2017).

A case study in Saudi Arabia found that there is an excellent Electronic Health Records give information on demand (M. M. Alqahtani & Atkins, 2017). When patients believe that quick access to records will improve their care, they will be likely to use the EHR app. Their

ideas about the use of apps aid in getting doctors and other clinical staff to use them. If a doctor is unsure of a diagnosis, for example, he or she cannot give the patient the proper treatment. If the diagnosis can be reached the patients by Smartphones or other apps, health care improves in quality and quantity. More patients mean that more people who are ill will get the treatment they need in time.

In Saudi Arabia, there has been an adaptation of EHR (Electronic Health Records) at a growing rate. The EHR use rate has also been growing over time (Alsulame, Khalifa, & Househ, 2016). However, the rate of grown is higher in some parts of the country than in others. Also, the EHR has been adopted by a few organizations, and they have been proving that EHR is successful. Both EHR and Electronic Medical Records (EMR) have faced some barriers to implementation. While this did not shut down apps such as EHR, it did make the implementation process very time-consuming. For example, The Ministry of National Guard Health Affairs (MNGHA) started by creating a vision consisting of implementing EHR in three different areas in Saudi Arabia (Alsulame et al., 2016). Next, it established project committees and a project team to undertake the implementation of the system. These undertakings together required ten years to implement.

In the Eastern area of Saudi Arabia, doctors have used the EHR effectively. However, EHR is some barrier to the highest rates of use. Research on this subject by El Mahalli (2015) investigated some possible excuses for missed appointments that included financial, technical, time, psychological, social, legal, and organizational and change process difficulties. Saudi Arabia does emphasize using electronic devices for many purposes, including keeping health records and sending those records to those who need them. To discover the reasons for missed appointments, the study used three separate hospitals (governmental), and all are general

hospitals. The departments in the study were many included diabetes mellitus. All of these hospital departments had adopted or were adopting EHR at the time that this study was done. The study was done in a questionnaire form (El Mahalli, 2015). Information gathered included the demographics of physicians, functions of the EHR system, and barriers to use of EHR systems in table 9.

Table 9 Barriers of physicians with the electronic health records system(El Mahalli, 2015)

Barriers	Hospital A (#133)		Hospital B (#144)		Hospital C (#42)		Total		Chi-square	P
	No	%	No	%	No	%	No	%		
Loss of access to medical records transiently if computer crashes or power fails	113	85.0	125	86.8	35	83.3	273	85.6	0.388	0.824
Fastness in utilizing EHR system (Minimal wait between screens, minimal boot-up time, etc.)	114	85.7	119	82.6	36	85.7	269	84.3	0.565	0.754
Additional time for data entry affects utilizing the EHR system	112	84.2	120	83.3	34	81.0	266	83.4	0.245	0.885
System hanging up problem	111	83.5	130	90.3	35	83.3	276	86.5	3.18	0.204
Lack of customizability of the system according to users' needs	105	78.9	111	77.1	33	78.6	249	78.1	0.148	0.929
Lack of continuous training/support from IT staff in the hospital	105	78.9	117	81.3	31	73.8	253	79.3	1.11	0.573
Complexity of technology affects utilizing EHR system	96	72.2	109	75.7	31	73.8	236	74.0	0.444	0.801
Problems with confidentiality, security and data privacy (e. g., place of computer)	92	69.2	103	71.5	23	54.8	218	68.3	4.30	0.117
Disturbing patient-doctor communication	84	63.2	111	77.1	32	76.2	227	71.2	7.13	0.028*
Problem with pregnancy alert system	80	60.2	102	70.8	26	61.9	208	65.2	3.71	0.156
Lack of belief in EHRs adoption	77	57.9	93	64.6	33	78.6	203	63.6	5.99	0.05*
Problem with drug alert system (e. g., drug interactions, drug allergy, etc)	73	54.9	89	61.8	26	61.9	188	58.9	1.54	0.462

* $P \leq 0.05$. EHR: Electronic health record

This chart shows that they faced barriers that involved an inability for a short time to access medical records. They also were concerned about the degree of fastness. There was in attaining information and communication with each other and patients. They did not appear to have a particularly high concern for confidentiality, etc. However, in each area, there were concerns, and usually, they were expressed by over half of the physicians utilizing the system. This suggests that Saudi Arabia is effectively using EHR to some degree, but not to a high enough degree.

The results of the study found that most of the functions being studied were under-used (El Mahalli, 2015). The reasons presented showed that most of the barriers were related to the

system hanging up and loss of access to medical records for short times. There was a lack of speed in utilizing the system as well. A major complaint was that there was a low adoption of the chart system. There was also the low adoption of e-prescribing, which is important to improve the efficiency of patient care (El Mahalli, 2015). Progress needs to be made in medication errors and adverse drug reactions by patients. Few complaints were made involving a lack of faith in the system. However, there was little communication used by hospitals. The EHR system has many tools for communication that allowed information to be exchanged between physicians and between physicians and patients. Email is used more often than other tools, and fax is used for transforming documents either inside or outside. SMS is additionally used to keep patients mindful of their arrangements when they are expected. However, none of these means of communication were used in any of these hospitals. One reason may be that in some cases, there might be a lack of access to the internet within the hospital. Some doctors claimed that there was also difficult to obtain records if a computer either crashes or in case of a power failure. These are barriers to good communication.

Several other problems arose in this study, and one is that there may not be enough computer knowledge among some of the staff of these hospitals. Another complaint was that EHR was too complicated, which suggests that hospitals may not be instituting training for those who lack some of the needed skills. The author suggests that this training may be time-consuming for busy doctors and other personnel, but it is a necessity. If EHR does not work only because no one knows how to use it, then all of its benefits are lost.

Saudi Arabia has a unique need for mobile apps during the Hajj period. Muslims who are able to do so are required by their religion to make at least one pilgrimage during their lifetimes to Saudi Arabia, and these people come from all over the world. With so many people being

involved in the same travel and rituals at the same time, many entities have created apps to aid pilgrims in their travel. There are apps for travel to the area and visit more than one holy place. They may need apps that aid them in finding the locations of each visit if they undertake more than one, and for many other purposes, including health services (E. A. Khan & Shambour, 2017) such as cardiology and the symptoms of heart failure.

2.9.1 Diabetes and Hypertension Management with Mobile Health Technology

Mobile Health technology is used to help doctors and patients manage diabetes. While no known medication can cure diabetes, it can be managed effectively. Electronic technology works well to aid in the management of diabetic patients. These devices have been tested for efficacy, and some research supports that they are effective. Kirwan, Vandelenotte, Fenning, & Duncan (2013) investigated the use of smartphones when used by Type 1 diabetics. The researchers recruited patients with type 1 diabetes in Australia. The research went for six months, and there was a third-month follow-up as well. The researchers divided the 72 subjects into two groups with one group acting as a control group and the second group as the intervention group. They found that the control group was less successful than the intervention group at bringing down their glucose level. They support the use of these apps (Kirwan, Vandelenotte, Fenning, & Duncan, 2013).

One mobile health device is the Few Touch Application or FTA that supports a patient's efforts to manage their diabetes (Årsand et al., 2012, p. 1197). It is a mobile phone-based diary that can update the information both by hand and automatically by wireless transfer and allows the possibility of keeping track of personal health goals. The application can be used by patients with type 1 and type 2 diabetes for the transfer of blood glucose data, receiving educational SMS text messaging, receiving dietary information on diabetes, and tracking physical activities. The

authors found that developed applications were easy to use in terms of data transfer. The applications also facilitated the communications between patients, their patents, and healthcare professionals. The findings also showed that mHealth apps such as the FTA are precious in allowing patients to feel empowered to be more active in their health efforts.

Weinstein et al. (2014) recognized the reality that about the time that this article was written, the Affordable Care Act was about to be implemented. That Act provides rewards from the government's inefficiency in the delivery of healthcare. The authors outline the success factors in telemedicine. These are the specific factors that need to be present for the success of telemedicine. In fact, that possibility of success comes from the fact that what the healthcare providers will have to provide (and correct) are the ones that lead to more efficiency. When telemedicine is used, less time is wasted in completing various tasks such as communication and training for various needs (Weinstein et al., 2014). Some barriers do exist, however. Long-term success is part of efficacy. If healthcare institutions and people find that they do not work, they have spent time and money on something they must throw away.

Goya and Cafazzo (2013) believe there is a gap in that not everyone has access to the devices used in mhealth. The researchers claim that there are problems in the use of these devices that make them less valuable than they should be. They claim that there is a high likelihood that they will not enter data perfectly, and even if they do, there is an inability to get enough data to the healthcare provider to make good decisions for the patient. Also, there is often no real-time feedback and lack of actual behavior change by the patient to make these mobile phone apps to be useful (Goyal & Cafazzo, 2013). In fact, if those problems are not overcome, the apps may not be used or respected at all. These devices should be used more efficiently and

realistically. There needs to be better communication in real-time, the ability to capture data, and the ability to provide support for decisions.

These researchers point out that finding out that one has diabetes can cause psychological stress in patients. Also, they must go through the process of understanding it, finding foods to eat that will make it unlikely that they will have unusual problems, and how to deal with devices that can help them and make their life simpler, but starts out by making it more difficult. The researchers criticize many apps, in fact, because “only 20% of the apps had an educational component, of which only 1/5 delivered personal feedback” (Goyal & Cafazzo, 2013, p. 1068). The problem is not with the diabetic, but with the devices and their manufacturers. The apps are fine and can work well, but too many apps do not provide support for those who must learn to use them.

Sieverdes & Jenkins (2013), claim that mobile health technology is a valuable method of managing diabetes. They point out that there are many people with diabetes, but less than half of them have good control over their diseases. They regard mobile health technology as being an “innovative approach” (Sieverdes, Treiber, Jenkins, & Hermayer, 2013, p. 289) to diabetes management. The technology is most helpful when it can support the guidelines given to people with diabetes-related to controlling and monitoring their blood glucose. They suggest that mobile apps are good and describe each of the values of the various apps for people with diabetes. They clearly support mhealth but at a shallower nature (Sieverdes et al., 2013).

Mobile health applications are being used in managing diabetes, but different apps may be useful for different people and purposes (Eng & Lee, 2013). The authors reviewed the mobile health application that focused on endocrine disease and found that there was a “higher percentage of relevant apps in our searches of the iPhone app store compared with the Android

marketplace” (Eng & Lee, 2013, p. 1). At the iPhone store, most apps focused on health tracking on such indicators as blood sugars, insulin doses, and carbohydrates. These required that the person manually enter the medical data. Only two of the mobile health applications directly put blood in sugars based on glucometers that were added or a part of the cell phone. The rest of the applications consisted of training uses, food databases, and social blogs, as well as those directed by physicians. Some application calculated the insulin dose and met the criteria technically to be a regulated mobile app but failed to find any indication that there had been Food and Drug Administration (FDA) approval. Nevertheless, the consumers were able to purchase and use them. Table 10 shows the available applications and their features:

Table 10 apps and features (Eng & Lee, 2013)

Application name	Operation System	Description
Welldoc Diabetes Manager	IOS/Android	Graphs, graphs, blood glucose maps. Provides customized guidance and encouragement to patients through a patented analysis framework, delivered via an organization or contractor of health care, safely transmitted to a cloud, and embedded with an electronic record.
Glucose Buddy	IOS/Android	Glucose in plasma, glucose, the dosage of insulin, habits. Blood sugar can be tested for the alert. Including a menu and a platform for the culture.
GoMeals	IOS/Android	Logs glucose in the body, calories, nutrients, and movement, which provides an interactive diet database.

Diabetic Connect	IOS/Android	Links to a diabetic care network, which creates a forum where people with diabetes can speak to other people.
Glucagon	IOS	Shows users how to manage Glucagon correctly. May prepare memoranda while evaluating the operation.
Calorie Counter	IOS/Android	Enables consumers to check barcodes on food for consumer details
Nike Fuel Band	IOS/Android	Needs an additional wearable tracker, which tracks consumer movements and daily activities.

The above table does not include all possible apps, but it does provide information as to its cost (these apps are quite inexpensive) or whether they have approval from the FDA. These authors make it clear that the devices might not be as accurate as they should be, but without oversight by the FDA, there is no way to be sure of their accuracy.

El-Gayar et al. (2013) Researched mobile applications for diabetes. They indicated that while Arsand et al. (2012) reviewed some of the tools for diabetes management, but did not provide any detailed on the functionality of these smartphones and how they managed to compare them with the clinical guidelines. El-Gayar et al. (2013) wanted to fill in that gap “by evaluating the functional requirement with other, related issues for large-scale adoption of these interventions” (El-Gayar, Timsina, Nawar, & Eid, 2013, p. 247). Their purpose is to determine whether these apps have helped people with diabetes to self-manage.

They researched various apps, but only selected those with “following characteristics:

- Support for blood glucose monitoring as a minimum requirement

- The patient as the intended primary user of the application to be used as an enabler for diabetes self-management by supporting one or more of the self-management tasks” (El-Gayar et al., 2013, p. 248).

The apps used in this case showed that there are not only many different apps but also many that deal with blood sugar, which is important for a person with diabetes.

The authors concluded that mobile apps often are beneficial to patients who are already keeping paper logbooks. The electronic system is better, faster, and open to allowing data to be easily shared with clinicians or certified diabetes educators for the purpose of review. In general, most made communications much easier. The articles used to determine the valuation of the app, and some found that there was little or no benefit with the use of that app. However, only two articles of 16 gave that report. The others had at least some value, especially regarding recording medication, blood glucose measurement, etc. if they can be used relatively easily, they can help those who are involved in trying to keep track of information easily and quickly.

The people with diabetes are of all ages, from children to the elderly. (2014) Researched mobile applications that can be used by older people. The subjects of this research were diabetics who were 50 years old or more. They did a systematic review of all the diabetic apps for IOS and Android. The purpose was to find out if apps could be improved so that they could be used by older people who might have poorer eyesight or other problems associated with age. They looked at a “range of functions, target user groups languages, acquisition costs, user ratings, available interfaces, and the connection between acquisition costs and user ratings” (Arnhold, Quade, & Kirch, 2014, p. 1). They also discerned whether the apps could meet the needs of those people with diabetes who were aged 50 or older. Also, the researchers present the requirements for apps that consider the difficulties that senior citizens can have in reading and understanding

what mobile applications can do for them. This researcher found that the usability of apps for diabetic patients over the age of 50 was between moderate and good. The multifunctional apps performed worse on the item of stability. The best feature was the screen reader (Arnhold et al., 2014).

2.10 Patients' Compliance with Medications and Appointments in Saudi Arabia

In addressing the issue of diabetes and hypertension in Saudi Arabia, the important problem is that some patients miss their physician appointments. In fact, not all patients are compliant in general. Compliance in healthcare can be defined as “the extent to which a patient’s behavior...coincides with the healthcare provider’s recommendations for health” (A. R. Khan et al., 2012, p. 26). If the patient missed appointments, that patient is as noncompliant as the patient that never misses an appointment but does not follow what the physician informs the patient that he or she must do in order to deal with the disease. In healthcare, patient non-compliance is a serious problem that makes it difficult for physicians to give the best health care. Noncompliance is reported all over the world, and in one study, researchers found that one third to one-half of all American patients are non-complaint in some way (A. R. Khan et al., 2012). In developing countries, the extent of noncompliance is likely worse. Noncompliance is dangerous, especially for those with chronic diseases such as diabetes, are more likely to go through serious difficulties in the long and short-term (A. R. Khan et al., 2012).

The problem of noncompliance is present in Saudi Arabia, as in any other country. In Saudi Arabia, the eastern and central regions of the country have huge numbers of patients who missed their appointments reached (23.7% and 30%, respectively) (Alhamad, 2013b). These appointments have economic and clinical impacts. For patients, it could mean missing out on

treatment or screening for the illness they may have. This problem of missing appointments contributes to less control for patients.

Research by Alhamad (2013) addressed this issue by exploring reasons that patients missed appointments in general clinics in Riyadh Military Hospital. The patients involved in this study were either patients who missed at least one appointment that had been scheduled ahead of time, or they were patients who came so late to their appointments that they were not seen at all even though they were technically present in the clinic. There were 654 subjects in the research. Upon completion of this study, the author found that the most significant reasons for missing appointments were difficulties for booking a new appointment, long-distance between the patients and the clinic, work commitment, and difficulty in transportation. The following table reveals all of the reasons mentioned by subjects (Alhamad, 2013a).

Table 11 Causes of Missing Appointments Reported (Alhamad, 2013a)

Reasons	Group N %	Control Group N %
Difficulty in booking an appointment	159 (45.8)	138 (45.1)
Long distance travel	119 (34.3)	108 (35.3)
Work commitment	113 (32.6)	132 (43.1)
Unavailability of transportation	112 (32.3)	104 (34)
Visiting another health care facility or alternative medicine	65 (18.7)	55 (18)
child care	49 (14.1)	30 (9.8)
Not having a companion	40 (11.5)	34 (11.1)
Inconvenient appointment time	38 (11)	47 (15.3)
Feeling better	23 (6.6)	30 (9.8)
Forgetting the appointment	20 (5.8)	38 (12.4)
Mix up over the date/time of the appointment by a pt or practical error	13 (3.7)	9 (3)
Not being well enough to attend	10 (2.8)	13 (4.2)
Long waiting time at the clinic from previous experience/ Perception of Disrespect by the Health Care System	6 (1.7)	42 (13.7)
financial difficulties	5 (1.4)	8 (2.6)
Others	16 (4.6)	20 (6.5)

The above table suggests that the reasons for missing appointments were mainly related to the patients' problems rather than difficulties with staff. Patients might forget the appointment or not be able to attend for some reason, such as illness.

A second study on the issue of noncompliance for diabetic patients was carried out by Khattab, Abollfotouh, Khan, Humaid & Al Kaidi (1999) in Saudi Arabia. This study checked for noncompliance among people with diabetes with diet, drugs, and the appointment system. Compliance for appointments was based on the number of visits during a six-month period. "Great compliance was recorded when the patient went to the facility on in excess of two events, reasonable compliance was recorded when the patient went to on just a single event, and poor

compliance was recorded when the patient had not gone to the center over a six-month time frame” (Khattab, 1999, p. 756). The following figure 6 shows the outcome of appointment compliance:

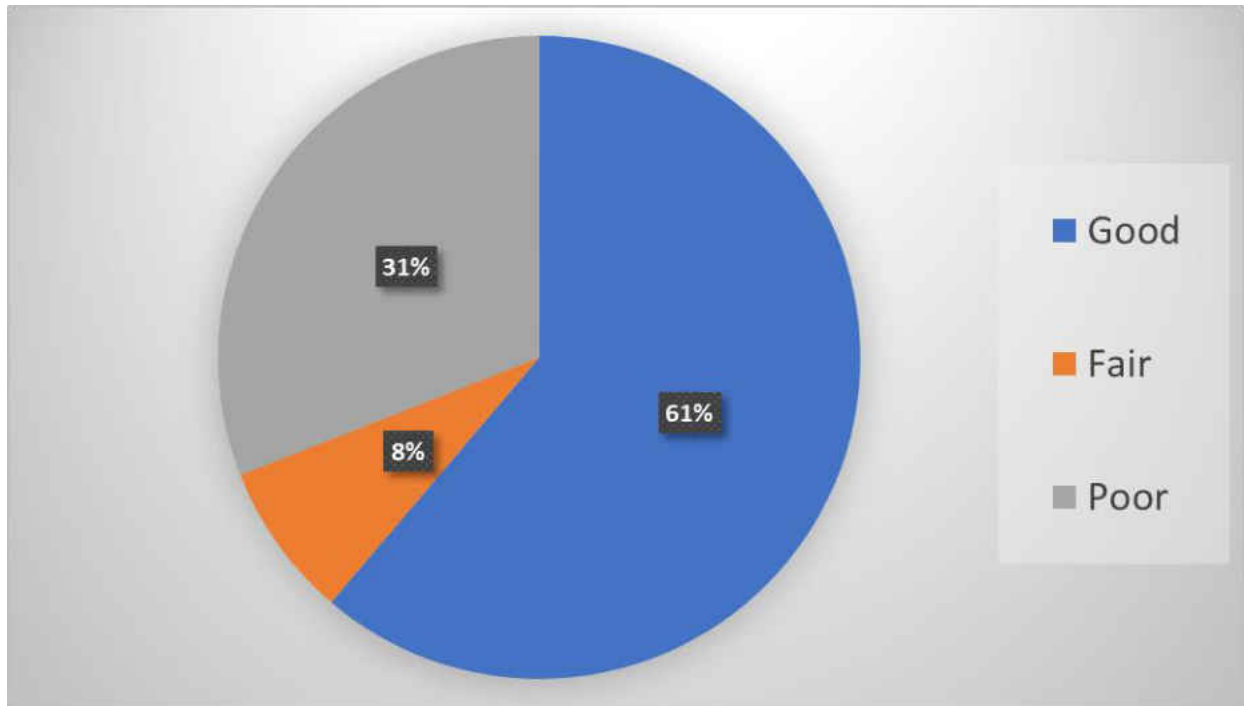


Figure 6 Patterns of compliance by diabetic patients(Khattab, 1999)

By far, most patients were compliant with their appointments, and about half that number rated poor in compliance.

Salam & Siddiqui (2013) also investigated noncompliance, focusing on diet, exercise, medication, and follow-up. While the researchers did not directly investigate whether appointments were missed, they did investigate follow-up, which is an important issue in diabetes as it is a chronic disease. This study investigated some possible problems people with diabetes may have had with compliance, such as following diet suggestions, exercise requirements, taking medication, and follow-up. The participants were grouped by age group and

gender as well. The following table 12 shows the outcome of the investigation (Salam & Siddiqui, 2013).

Table 12 Aspects of Compliance (Salam & Siddiqui, 2013)

Variables	Diet	Exercise	Medication	Follow-up
	Compliant	Compliant	Compliant	Compliant
	Number %	Number %	Number %	Number %
Age group <40	(43.4) 21 (100.0)	17 (81.0)	5 (23.8)	21* (100.0)
40-60 years (44.8)	153 (53.5)	128 (44.8)	231 (80.8)	216 (75.5)
> 60	56 (56.6)	32 (32.3)	77 (77.8)	72 (72.7)
Gender				
Male	140 (57.6)	96 (39.5)	190 (78.2)	197* (81.1)
Female	90 (55.2)	81* (49.7)	123 (75.5)	112 (68.7)
Education				
Illiterate	88 (51.5)	69 (40.4)	132 (77.2)	137 (80.1)
Primary/inter	64 (69.6)	54 (58.7)	73 (79.3)	68 (73.9)
Secondary	37 (44.6)	22 (26.5)	60 (72.3)	56 (67.5)
University	41 (68.3)	32 (53.3)	48 (80.0)	48 (80.0)

The findings, in this case, were that there is little compliance in most cases with diet and exercise being the main two categories in which there were failures. Most of the participants did well on follow up while in other areas, there was a lack of compliance. Follow up does not necessarily mean that a patient will comply with what they learn during an appointment or follow-up.

One study on the issue of compliance in diabetes patients is a review of the literature on the subject undertaken by Al Qasem et al. (2011). They found a total of 19 studies that were relevant to the issue. They were looking at the degree and indicators of nonadherence to medicine while tending to different health conditions. They evaluate that nonadherence occurred between 1.4% to 88% (Al Qasem et al., 2011). They found that the reasons given for nonadherence included such excuses as having forgotten about the medication, side effects in some cases, wanting a holiday from taking the medication the sense that the medication was not helping, feeling well, and a poor education about the importance of the medication (Al Qasem et al., 2011). There was no breakdown indicating the degree of nonadherence for the various chronic diseases.

Further, Al Harbi et al. (2015) investigated the degree to which patients in primary care in Saudi Arabia who have diabetes are adhering the American Diabetes Association's standards of care. Investigations into the degree to which Saudi citizens with diabetes are cared for in primary care settings and these researchers want to see if these patients are adhering to 11 ADA standards of the care of diabetics. The study was record-based and included a one-year follow-up of patients with diabetic patients. The study was undertaken at the Wazarat HealthCare facility in Riyadh, Saudi Arabia. There were 450 type2 diabetes patients in this study with a mean age of 31.4 (Al Harbi et al., 2015).

When the research was completed, the results were not as good as they might have been. The study included 450 patients: included men and women. The information about these people is found in the following table 13:

Table 13 Statistic qualities and diabetic medicines of 450 sort two diabetic patients going to an essential care focus in Saudi Arabia (Al Harbi et al., 2015).

Characteristics	Frequency (%)
<i>Age (years)</i>	
<40	31 (6.9)
40-49	65 (14.4)
50-59	138 (30.7)
60-69	136 (30.2)
≥70	80 (17.8)
Mean±SD	58.5±12.2
<i>Gender</i>	
Male	199 (44.2)
Female	251 (55.8)
<i>Body mass index*</i>	
Underweight (≤18.5)	2 (0.5)
Normal weight (18.5-24.9)	50 (11.3)
Overweight (25-29.9)	134 (30.3)
Obesity (≥30)	256 (57.9)
Mean±SD	31.4±4.4
<i>Medication</i>	
None	10 (2.2)
Oral hypoglycemic only	170 (37.8)
Insulin only	16 (3.6)
Both	254 (56.4)
*8 wheel-chaired patients could not have this measurement	

The table above shows that the majority of the patients were between 50 and 69, that less than half were male, and about 85% were either overweight or obese.

The researchers pointed out that there was a large difference in adherence from 92.9% to 35.6%.

Researchers have also dealt with compliance and adherence in a family practice setting in Saudi Arabia. The study's purpose was to identify the reasons that some patients comply with the diet, anti-diabetic drugs, and appointments. Their research showed that when it comes to diet, there was good compliance for men, but not for women. Compliance regarding appointments was related to good care. Compliance with medications did not show an association with any of the determinants. The only determinants of control of diabetes were duration and care. These two determinants were the only ones that had any effect (Khattab, 1999).

There are connections between some diseases for which people are not always compliant with their doctor's request. AlHewitt (2014) provides research on the degree to which people

adhere to long-term therapies as related to their beliefs about the medications they are assigned. The research was undertaken in family repeated medicine clinics. AlHewitt evaluated the relationship between compliance with their medications, and their beliefs about medicine, adequate information about those medications and other factors. This research was conducted through questionnaires (AlHewiti, 2014)

The results of this investigation should show that more than half reported that they were not very compliant with their medication requirements.

AlHewiti points out that education is very important in order to improve the degree of compliance by people with diabetes. Patients are going to be more likely to comply with medications if they understand them well (AlHewiti, 2014).

Compliance with medication can also occur due to health beliefs. Alatawi, Kavookjian, Ekong, & Alraees (2016) investigated this possibility. Their purpose was to evaluate the self-report of drug-taking in Saudi Arabia. Each purpose related to those with type 2 diabetes. They did a cross-sectional study at an outpatient pharmacy. They gathered statics and analyzed them to explain self-report adherence.

The researchers found that most patients reported taking their medications. However, about 60% were not taking it in the number of times per day that was required. About 50% were not taking doses at the correct time, and more than 40% reported reducing in adherence at the phase of change. The patients that perceived that the medication was helping them and those who believed in their ability to make decisions were the ones that more likely to adhere to medication requirements (Alatawi et al., 2016).

An investigation of hospital pharmacy practice in Saudi Arabia was conducted by Alsultan, Mayet, Khurshid, Salamah & Al-jedai (2012). A national survey was conducted to

assess hospital pharmacists practice in Riyadh, Saudi Arabia. They want to discover if there were effective monitoring and patient education. They asked 48 pharmacy managers in different hospitals to participate in this study. They used specific pharmacist's questionnaire. Of these hospitals, about 60% only did monitoring for 26% of their patients. There were some shortcomings in that the percentage of patients they monitored tended to be low. Nevertheless, the researchers claimed that these pharmacists actively participate in monitoring medical therapy and educating patients about the medication (Alsultan, Khurshid, Salamah, Mayet, & Al-jedai, 2012).

Hypertension is a problem and a long-term, chronic problem for those with the disease. Research also is being done to determine adherence of people with hypertension in Saudi Arabia by Al-Gelban et al. (2011). The purpose of the research on this issue was to determine the degree of knowledge of physicians and how well they adhere to the recommendations of clinical practice guidelines of the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC7). To evaluate these events, the author used "a modified version of the World Health Organization Physician Inquiry Questionnaire" (Al-Gelban et al., 2011, p. 941). The study included all physicians working at PHC centers in the region of Aseer in southeast KSA. The results revealed that there were some instances in which physicians didn't comply with the JNC7 guidelines while treating and diagnosing patients with high blood pressure. In fact, the noncompliance rate from almost 25% to as high as 94%. The researchers reported that these are low numbers and that these physicians need additional therapeutic instruction and instructional classes on the rules for hypertension administration.

In another study, Alotaibi and his colleagues developed a mobile phone intervention - Social Hypertension Awareness and Management System (SHAMS) – that aimed to promote the management and awareness of hypertension among hypertensive patients in Gulf countries, including Saudi Arabia (Alotaibi et al., 2016). The SHAMS consists of two components namely patient/healthcare provider component and hypertension management component. The patient/healthcare provider component consists of a patient unit, a nurse unit, and an admin unit. The patient unit consists of a mobile phone and a blood pressure monitoring device. The nurse unit consists of a data management system that enables the nurses to contact and follow up with their patients in the virtual space. The admin unit performs several tasks such as maintenance, repair, and other technical tasks. On the other hand, the hypertension management component consists of a hypertension awareness module and a data mining module. These models provide patients with knowledge about hypertension and help them predict their health conditions based on their medical history. The system database server was installed at the computers and information technology faculty at the University of Tabuk in Saudi Arabia. Nevertheless, no evaluation or effectiveness of SHAMS was conducted.

Finally, Tourkmani et al. (2012) researched medication adherence for people in a chronic disease clinic to determine the motivation and knowledge of medication adherence and to assess their predictors in an ambulatory setting. To determine medication adherence, they did a cross-sectional survey of patients that were attending a chronic disease clinic. They used the Modified Morisky Scale. They interviewed the patients, and most had at least two and sometimes more chronic disease and were taking 6.3 medications and 6.5 pills per prescription. Adherence attention was low at only 4.6% (Tourkmani et al., 2012).

2.11 Readiness of Diabetes and Hypertension Patients to Manage Their Diseases by Using Mobile Health Applications in Saudi Arabia

The readiness and acceptability of patients and other consumers to use mobile health applications to receive healthcare services by researchers and healthcare providers in the developing countries have been evaluated in the literature. Using the Technology Acceptance Model (TAM), El-Wajeeh and his colleagues investigated the factors that might affect the acceptance of patients and medical staff from Egypt and Yemen to use mobile health technology (El-Wajeeh, Galal-Edeen, & Mokhtar, 2014). These factors include, among others, perceived ease of use, perceived usefulness, patients' trust in using mobile health services, social influence, data privacy, and resistance to change. A total of 302 subjects was selected to complete a questionnaire, including different items that measure the selected factors. The results revealed that 90% of the respondents intended to use mobile health applications. Also, it was found that perceived usefulness and social influence have a significant effect on consumers' intention to use mobile health applications. Nevertheless, a major limitation of this study is that participants provided their feedback without experience in using mobile health applications.

In rural Bangladesh, a similar study was carried out to identify the factors that contribute to patients' readiness to use mobile health applications (Khatun et al., 2015). A conceptual model containing three dimensions, namely technological, motivational and resource readiness was developed. A total of 5152 individuals randomly chosen to complete a questionnaire containing items of the three dimensions mentioned above. The study indicated that 73% of the subjects showed an interest in participating in mhealth programs. Moreover, it has been reported that the perception that mhealth may yield slower treatment comparing to conventional treatment

procedures was cited as one of the reasons that contribute to a lack of interest in participating in mhealth applications.

In Puducherry, India, a cross-sectional study was conducted to assess the readiness of residents to participate in mhealth applications (Reddy, Majella, Selvaraj, Jayalakshmy, & Kar, 2016). The assessment was conducted using interviews, which was designed to measure residents' access to a personal mobile phone, knowledge of using mobile phones, including making and receiving calls and SMS messages, and willingness to use the mobile phone for healthcare services. A total of 299 individuals were selected to participate in the study using systematic random sampling. The study reported that more than 42% of the participants know about using mobile phone features such as calls and SMS. Also, half of the participants were willing to receive health information via mobile phones.

In Saudi Arabia, few studies explored the acceptability and readiness of patients and healthcare professionals to use mobile health applications. For instance, Jamal and his colleagues conducted a cross-sectional study to explore the user experience regarding perception and attitude towards using mobile phone technology among medical staff for academic and medical purposes in Riyadh, Saudi Arabia (Jamal et al., 2016). A web-based questionnaire was designed, and a total of 133 medical specialists were chosen to participate in the study. Factors such as confidentiality, safety, and access to patients' information, as well as the challenges of using mobile phone technology, were investigated. Of the 133 chosen to participate in the study, 101 participants completed the survey leading to a response rate of almost 76%. The results showed that the majority of the participants believed that healthcare facilities should adopt the use of mobile phones to share patients' information, drug references, and medical references. Moreover, the majority of the participants believed that mobile phone technology should be

integrated with hospitals' information systems. Limitations of using the mobile phones that were reported by the participants included short lifespan of mobile phone battery and using a mobile phone for nonmedical purposes causing physicians to distract from their work.

Also, Alkhudairi assessed the acceptability of using a mobile phone intervention by patients, physicians, and specialists to manage diabetes in Saudi Arabia (Alkhudairi, 2016). The study is comprised of two phases. The first phase aimed to measure perceptions, attitudes, and living experiences of patients with diabetes by interviewing specialists in diabetes. The second phase of the study included a questionnaire developed to evaluate patients' perceptions and experiences of diabetes. The questionnaire also aimed to measure the feedback of the doctors who provide treatment of diabetic patients. The findings of the study indicated that both diabetic patients and physicians provided positive feedback regarding the adoption and use of mhealth interventions to manage diabetes. The study also reported that culture, age, gender, education level, income, and location influenced the adoption of such interventions in Saudi Arabia. Moreover, some limitations, such as lack of direct interaction between the patient and the physician may affect the successful implementation of mhealth interventions.

In another study, Alajmi and his colleagues conducted a survey to evaluate the level of awareness and attitude of selected physicians in Al-Dammam, Saudi Arabia (Alajmi et al., 2015). Factors considered in the study were age, gender, and work experience. The study also aimed to measure physicians' perceptions, requirements, and priorities to promote mhealth interventions in Saudi Arabia. A total of 121 physicians were chosen to be invited to participate in the survey, 93 of which complete it is leading to a response rate of 77%. The results revealed that the majority of physicians reported high levels of willingness and preferences towards the

use of technology in healthcare. Also, physicians' age and knowledge were found to influence their willingness to use technology in healthcare practices.

In the same context, Alotaibi (2015) conducted a preliminary study to measure patients' perception of using mobile phone technology for providing management and knowledge of fasting diabetes in Saudi Arabia. The study was conducted in two phases. The first phase was comprised of interviews with physicians to outline the requirements of designing a mobile phone educational program for fasting diabetes in Saudi Arabia. The second phase included a questionnaire designed for diabetic patients to measure patients' perspectives regarding the educational elements of the program. Specifically, a total of 62 patients, mostly youth, with type 1 and type 2 diabetes and three physicians were recruited in the study. The results revealed that the majority of the patients (more than 96%) have not participated in any fasting diabetes educational program, which indicated an urgent desire for such programs. Also, the study showed that the majority of the patients provided positive feedback on the use of the mobile phone features such as SMS text messaging and video tutorials to receive fasting diabetes educational programs (Alotaibi, 2015).

The readiness of patients with diabetes to use mobile phone applications to receive healthcare services was explored in Saudi Arabia (Alenazia et al.). A Mobile Health Effect and Readiness Questionnaire (MHERQ) was developed and distributed among a sample of 30 diabetic patients selected to participate in the study. The results revealed that more than two-thirds of the participants acknowledged that they would feel healthier and their management of diabetes would be enhanced using mobile health technology. Moreover, 63% of the patients surveyed reported that they were willing to send their medical information, such as blood glucose levels to a physician using mobile phone technology.

2.12 Conclusion

After careful review of the above studies, it becomes clear that there was a gap related to the effectiveness of mobile health technology regarding self-management and diagnostic for diabetes and hypertension diseases in developing countries and especially in Saudi Arabia see table 14. The problem was identified by different stakeholders to protect those patients and to provide them with the best services. Many articles talked about how the intervention of mobile health technology improved healthcare service with patients in developed countries. There were very few articles that talked about this subject in developing countries. Therefore, this study will focus on the effectiveness of mobile health intervention in Saudi Arabia.

Table 14 Gap Identification

	Review of mhealth applications	Mhealth for health promotion	ICT & telemedicine in Saudi Arabia	mhealth in Saudi Arabia	mhealth for postnatal care	mhealth in ED	Mhealth for individuals with special needs	mhealth for disease prevention	mhealth for disease management	mhealth for disease diagnosis	mhealth for medication adherence	Compliance with appointments	Readiness to use mhealth	Mhealth for medication refill reminders and appointment reminders
Rehman et al., 2017	×													
Hacking et al., 2016		×												
Alshuaibi, 2017			×											
Al-Maliki, 2013			×											
Abdulgahni et al., 2014			×											
ALSADAN et al., 2015			×											
Alajmi et al., 2015			×											
Jamal et al., 2016				×										
Saad, 2016				×										
Mokaya, 2010					×									
Jusoh, 2017	×													
James, 2015	×													
Househ & Yunus, 2014				×		×								
Kanjo et al., 2014				×			×							
Uluc & Ferman, 2016				×										
Tate et al., 2013				×				×						
Hingle et al., 2015								×						
Partridge et al., 2015								×						
Diez-Canseco et al., 2015								×						

	Review of mhealth applications	mhealth for health promotion	ICT & telemedicine in Saudi Arabia	mhealth in Saudi Arabia	mhealth for postnatal care	mhealth in ED	mhealth for individuals with special needs	mhealth for disease prevention	mhealth for disease management	mhealth for disease diagnosis	mhealth for medication adherence	Compliance with appointments	Readiness to use mhealth	Mhealth for medication refill reminders and appointment reminders
Mann et al., 2014								×						
Déglise et al., 2012								×						
Alqahtani et al., 2016		×		×				×						
AlKlayb et al., 2017				×				×						
Alotaibi et al., 2014				×					×					
Alotaibi et al., 2016				×					×					
Abbas et al., 2015									×					
Kang and Park, 2016									×					
Velthoven et al., 2016			×											
Eze et al., 2005										×				
Jayaraman et al., 2008										×				
Breslauer et al., 2009										×				
Breslauer et al., 2009										×				
Chin et al., 2013										×				
Lee et al., 2009										×				
Quinley et al., 2011										×				
Tran et al., 2011										×				
Brath et al., 2013									×					
Hanauer et al., 2009									×					

	Review of mhealth applications	mhealth for health promotion	ICT & telemedicine in Saudi Arabia	mhealth in Saudi Arabia	mhealth for postnatal care	mhealth in ED	mhealth for individuals with special needs	mhealth for disease prevention	mhealth for disease management	mhealth for disease diagnosis	mhealth for medication adherence	Compliance with appointments	Readiness to use mhealth	Mhealth for medication refill reminders and appointment reminders
Nelson et al., 2015											×			
Abbas et al., 2016		×												
Wolff-Piggott et al., 2017		×												
Hoque et al., 2017	×													
Alsulame et al., 2016			×											
Alqahtani et al., 2017			×											
El Mahalli, 2015			×											
Khan & Shambour, 2017	×			×										
Kirwan et al., 2013									×					
Arsand et al., 2012		×							×					
Weinstein et al., 2014	×													
Goya and Cafazzo, 2013	×													
Sieverdes & Jenkins, 2013									×					
Eng & Lee, 2013	×													
El-Gayar et al., 2013	×													
Arnhold et al., 2014	×													
Khan et al., 2012				×								×		
Alhamad, 2013												×		
Khatab et al., 1999												×		

	Review of mhealth applications	mhealth for health promotion	ICT & telemedicine in Saudi Arabia	mhealth in Saudi Arabia	mhealth for postnatal care	mhealth in ED	mhealth for individuals with special needs	mhealth for disease prevention	mhealth for disease management	mhealth for disease diagnosis	mhealth for medication adherence	Compliance with appointments	Readiness to use mhealth	Mhealth for medication refill reminders and appointment reminders
Salam & Siddiqui, 2013												×		
Al Qasem et al., 2011												×		
Al Harbi et al., 2015												×		
AlHewiti, 2014												×		
Alatawi et al., 2016												×		
Alsultan et al., 2012												×		
Al-Gelban et al., 2011												×		
Alotaibi et al., 2016				×								×		
Tourkmani, et al., (2012)												×		
El-Wajeih et al., 2014													×	
Khatun et al., 2015													×	
Reddy et al., 2016													×	
Jamal et al., 2016													×	
Alkhudairi, 2016													×	
Alajmi et al., 2015													×	
Alotaibi, 2015													×	
Alenazia et al.													×	
Khan, 2020														×

CHAPTER THREE: METHODOLOGY

3.1 Introduction

The purpose of this study was to evaluate the effectiveness of mhealth application intervention to remind the patients for a doctor appointment, medication adheres and to managing the number of unnecessary patient's follow up visits in developing nations. In order to do so, the researcher arranged to collect the related data from a sample of diabetic hypertriton patients monitored by various centers at Al-Noor Specialist Hospital in Makkah, Saudi Arabia. These centers are Diabetes and Endocrine Center, hypertension and kidney center, and internal medicine center. This section illustrated the methodology applied in this study. The first part talked about the research hypothesis, which includes the three questions of this study with the hypotheses for each question and the variables which were analyzed to respond to the research questions. The second part talked about the mhealth application and intervention, which describe the application that used in this research and the intervention of mhealth. The third part described the methodology of this study, including the procedures of sampling, preparation procedures for nurses and patients, procedures for the experiment and data collection procedures. The last part of this chapter talked about threats to validity and moral procedures.

3.2 Research Hypothesis

Q1: Does utilizing of refill medication reminder feature of DHA have a positive statistically significant impact on medication adherence levels of diabetic and hypertension patients in developing countries?

Ho₁: No, utilizing of refill medication reminder feature of DHA does not have a positive statistically significant impact on medication adherence levels of diabetic and hypertension patients in developing countries

Ha₁: Yes, utilizing of refill medication reminder feature of DHA has a positive statistically significant impact on medication adherence levels of diabetic and hypertension patients in developing countries.

Q2: Does utilizing the pre-appointment checkup feature for the Hemoglobin A1c test has a positive statistically significant impact on decreasing the number of visits per patient for diabetic patients in developing countries?

Ho₂: No, utilizing the diagnostic feature does not have a positive statistically significant impact on decreasing the number of visits per patient for diabetic patients in developing countries.

Ha₂: Yes, utilizing the diagnostic feature has a positive statistically significant impact on decreasing the number of visits per patient for diabetic patients in developing countries.

Q3: Does utilizing doctor appointment reminder feature of DHA have a positive statistically significant impact on adherence to doctor appointments of diabetic and hypertension patients in developing countries?

Ho₃: No, utilizing of doctor appointment reminder feature of DHA does not have a positive statistically significant impact on adherence to doctor appointment levels of diabetic and hypertension patients in developing countries.

Ha₃: Yes, utilizing of doctor appointment reminder feature of DHA has a positive statistically significant impact on doctor appointment levels of diabetic and hypertension patients in developing countries.

3.2.1 Independent and Dependent Variables

There were three independent variables in this study, namely the refill medication state, the doctor appointment state, and the Hemoglobin A1c test result. The first variable was the refill medication state. This variable was a dichotomous variable that has two only values (1) if a patient was present and (0) if a patient was absent. The second variable was the doctor's appointment state. This variable was also dichotomous and took only two values (1) if a patient was present and (0) if a patient was absent. Finally, the third one was the Hemoglobin A1c test result, which obtained from the analysis center in Al-Noor Hospital. In addition, the study includes three dependent variables, namely the adherence to refill medication time, adherence to doctor appointments, and the frequency of clinic visits.

A covariate is a variable which observes during the research or statistical analysis, but cannot control it, and it is not the focus of the study analysis (Miller & Chapman, 2001). The covariates were identified in this study were five, and they were based on previous studies in the same field. The first covariate was the age (Alajmi et al., 2015; Alkhudairi, 2016). Age was the second question that the patients have to answer it after setting up the application. Age is a ratio variable calculated by years. The second covariate was weight (Afifi et al., 2015; Al-Hamdan et al., 2011). Weight was the third question, and it is also a ratio variable that is measured by kilograms. The third covariate was chronic disease history (Carr et al., 2006; El Bcheraoui et al., 2014). Chronic disease history was the fourth question and it is a dichotomous variable. The dichotomous variable is “a nominal variable which has two categories or levels” (Montgomery &

Runger, 2010). Chronic disease history was obtained from the application for patients who received mobile health intervention. Any diseases were considered except diabetes for diabetes patients and hypertension for hypertension patients. The assigned value for no chronic diseases = (0) and yes if there were chronic diseases =(1).

3.3 Mhealth Application and Intervention

This research measured the effectiveness of mobile health intervention by added three new features to use it in Diabetes and Endocrine Center and two features to use it in hypertension and kidney center and internal medicine center at Al-Noor Specialist Hospital in Makkah, Saudi Arabia. The three new ideas of this study were refilled medication reminders (RMR), managing the number of follow-up visits and doctor appointment reminders (DAR). These ideas were used for diabetes patients but for hypertension patients, the first and the third features were used only. Al-Noor Specialist Hospital in Makkah is one of the essential medical clinics. It was established in 1989G by order of the king of the Kingdom of Saudi Arabia as a health care hospital to serve the citizens, residents, and pilgrims of the holy city and surrounding area. It is a public hospital under the supervision of the Directorate of Health Affairs in Makkah. It is in the heart of the city near the holy sites (Muzdalifah) and 3.5 km from the Grand Mosque. It has a capacity of 500 beds, and it includes all medical specialties and supported by specialized medical staff to provide a wide range of services such as general surgery and medical and therapeutic units that provide other services, including heart disease, intensive care unit and burns (Kaser).

SAED application is a wise versatile diabetes administration and instructive framework focused on Saudi Arabia. It was set up in 2014 in Medical Information and Network (MINT) Research Excellence Center at Kingston University, London. It comprises two fundamental segments. The primary segment was the SAED versatile patient/medicinal services supplier

segment, which incorporates the diabetic patient unit and expert unit. The second part was SAED insightful diabetes administration segment which incorporates a SAED database module, a canny choice help module, SAED SMS update module, and diabetes instructive module figure 7 explains the two components (Alotaibi et al., 2014b).

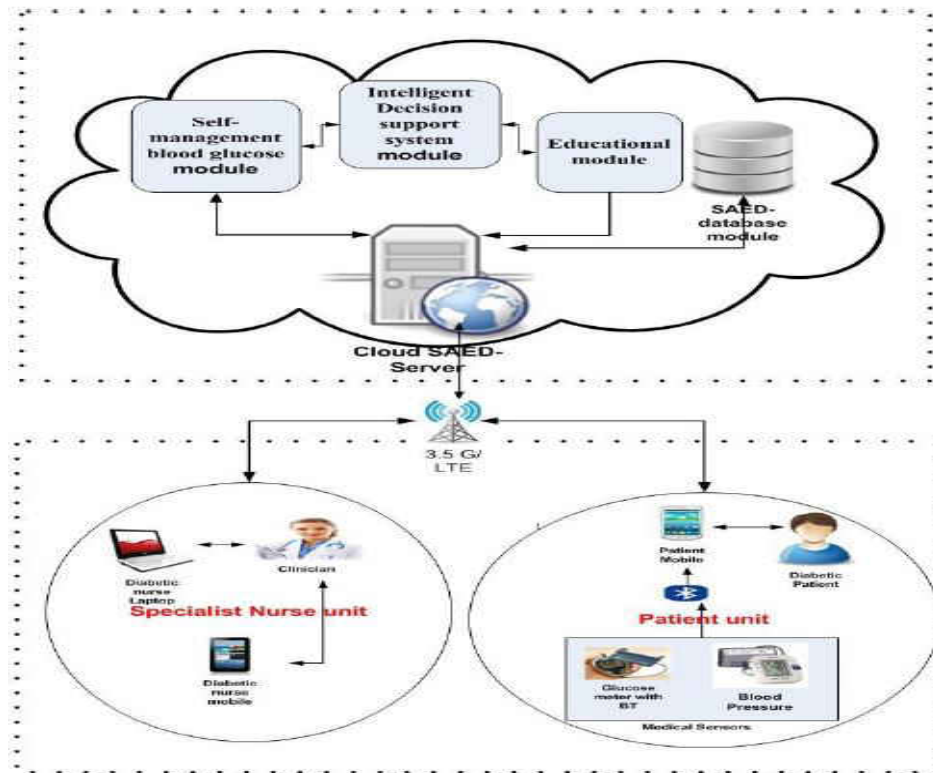


Figure 7 description the two components (Alotaibi et al., 2014a)

The features of SAED application as follow:

- 1- “A specific schedule of readings for each diabetic patient set by the diabetic nurse rather than the patient.
- 2- Reminding the diabetic patient to send the glucose test readings, blood pressure test readings, and food intake reports on a schedule.
- 3- Providing brief feedback on the patient’s status when the patient inserts a reading.

- 4- Establishing a sufficient connection between the medical staff and the diabetic patient using SMS or e-mail.
- 5- Managing the hypoglycemia via the system without the need for diabetic nurse intervention, based on the critical time of the hypoglycemic event.
- 6- Providing the specialist diabetic nurse, the ability to send SMS feedback regarding blood glucose or blood pressure level readings.
- 7- Providing the diabetic patient and specialist nurse with a data visualization tool to display the data in tables and charts.
- 8- Supporting the specialist nurse with a diabetic decision support system.
- 9- Supporting the diabetic patient with an educational program.” (Alotaibi et al., 2014b, p. 2)

DHA application is covering different areas than the SEAD application. Table 15 describes the new features added to the DHA Tracking application.

Table 15 The features that have been created for DHA application

Diseases	Application Features of DHA
Diabetes	Refill medication reminder (RMR)
	Doctor appointment reminder (DAR)
Hypertension	Refill medication reminder (RMR)
	Doctor appointment reminder (DAR)

3.4 Methodology

3.4.1 Procedures of Sampling

The sample size of this study comprised of diabetic and hypertensive patients, male and female, who have visited Al-Noor Specialist Hospital during the period from September 01, 2019, to October 30, 2019. A total of n= (364) patients, 199 of which are diabetic patients and 165 patients of which are hypertension patients, were selected to participate in the study. All patients were 18 years old or older and had a smartphone with an applicable system to install the DHA application. The exclusion patients were the prisoners, pregnant, and disabilities patients as per Institutional Review Board (IRB) agreement.

There were two different groups in this study, which were the diabetes group and the hypertension group. Both groups received their health care service with mobile health intervention for 60 days, and the author considered these data as post-intervention data. The pre-intervention data was collected from the hospital records for each selected patient for 60 days.

The sample of each group was selected based on a stratified random sample approach depend on demographic information such as gender, age, weight, and the history of patients' chronic diseases. "A stratified random sample is a population sample that requires the population to be divided into smaller groups"(Mahardika & Gustomo, p. 627). The comparison will be between the data for each patient before the intervention and after the intervention.

The sample size was determined based on the sample size formula for discrete data. The formula of sample size is: $n = p*(1-p)*(Z/E)^2$ which n is the minimum sample size, p is the effected percentage of the population or probability of previous similar studies, z value is value of standard normal distribution and E is the maximum allowable deviation or error of the estimate (Montgomery & Runger, 2010). For diabetes sample size, p=17.7%, Z value= based on

confidence level that the researcher chooses which is 95% is 1.96, $E = 0.05$. The sample size for the diabetes group is 199. For hypertension sample size, $p = 34.3\%$, Z value= based on confidence level that the researcher chose which is 95% is 1.96, $E = 0.05$. The sample size for the hypertension group is 165.

3.4.2 Preparation Procedures for Nurses, And Patients

The author recruited three nurses and medical assistants at Al-Noor Specialist hospital to assist in the implementation of the mhealth intervention. The team obtained approval from the ministry of health to implement the mhealth intervention and to collect data from the selected patients. The mhealth team ensured that patients' confidentiality, data quality, and assurance were fully maintained during the data collection period. Patients were approached by the mhealth team in the waiting rooms and were asked if they would like to participate in the study after giving them a brief description of the intervention. Patients who agreed to enroll in the study were then asked to complete and sign a participation form, which includes information such as permitting to receive notifications from the application reminders regarding medication refill and doctors' appointments and permission to get their information from the hospital health record.

3.4.3 Procedures of the experiment

The application consisted of two main features covering the first and third research questions. The first feature dialed with the refill medication reminder (RMR) process, which was answered the first question. After the participants completed the registration steps, they were received a refill medication reminder (RMR) messages. Refill a medication reminder (RMR) is a feature to remind the participant to refill the medication date. The first message was sent to the participant three days before the refill date. The content of the message was "Your medication

refill date will be ready within three days.” A second message was sent to the participant one day before the medication date. The content of the second message was “Your medication refill date will be ready tomorrow.” After that, the participant was asked whether or not he or she got the medication. If the answer was yes, then the participant has received a message for the next refill medication date. If the answer was no, then the application was sent to the participant reminders message every day until the participant gets the medication. Subsequently, a new message was sent to the participant for the next refill date. This process illustrated in the left-hand side of figure 8.

The second feature of the application dialed with the doctor's appointment reminder (DAR) process, which answered the third question. After the participants completed the registration steps, they received a doctor appointment reminder (DAR) messages. A doctor appointment reminder (DAR) is a feature to remind the participant to adhere to the doctor's appointment. The first message was sent to the participant three days before the doctor's appointment date. The content of the message was, “Your doctor appointment will be within three days.” A second message was sent to the participant one day before the doctor's appointment. The content of the second message was “Your doctor appointment will be tomorrow.” After that, the participant was asked whether or not he or she presented to his or her appointment. If the answer was yes, then the participant received a message for the next doctor's appointment date. If the answer was no, then the participant asked to enter the new doctor's appointment date after rescheduled it with a specialized team. The procedures were as illustrated in the right-hand side of figure 8.

The second research question dialed with managing the number of unnecessary follow-up diabetic patients. To answer this question first, it is important to know the mechanism of dealing

with patients in the hospital, which was as followed: (1) a patient will do the cumulative blood sugar test (Hemoglobin A1c) in the laboratory at the hospital. (2) The results will be entered into the hospital database under the name of each patient. (3) the doctor will see the participant and his or her result, then the doctor will determine the participant's condition and give the necessary treatment and adjust the dose according to the test results. So, to calculate the number of unnecessary follow-up visits, the exact number of patients without their names or any information were getting for five different diabetics clinics and got the Hemoglobin A1c test result for each patient. Then the doctors were met by the principal investigator to see how many patients should not be seen based on their test result.

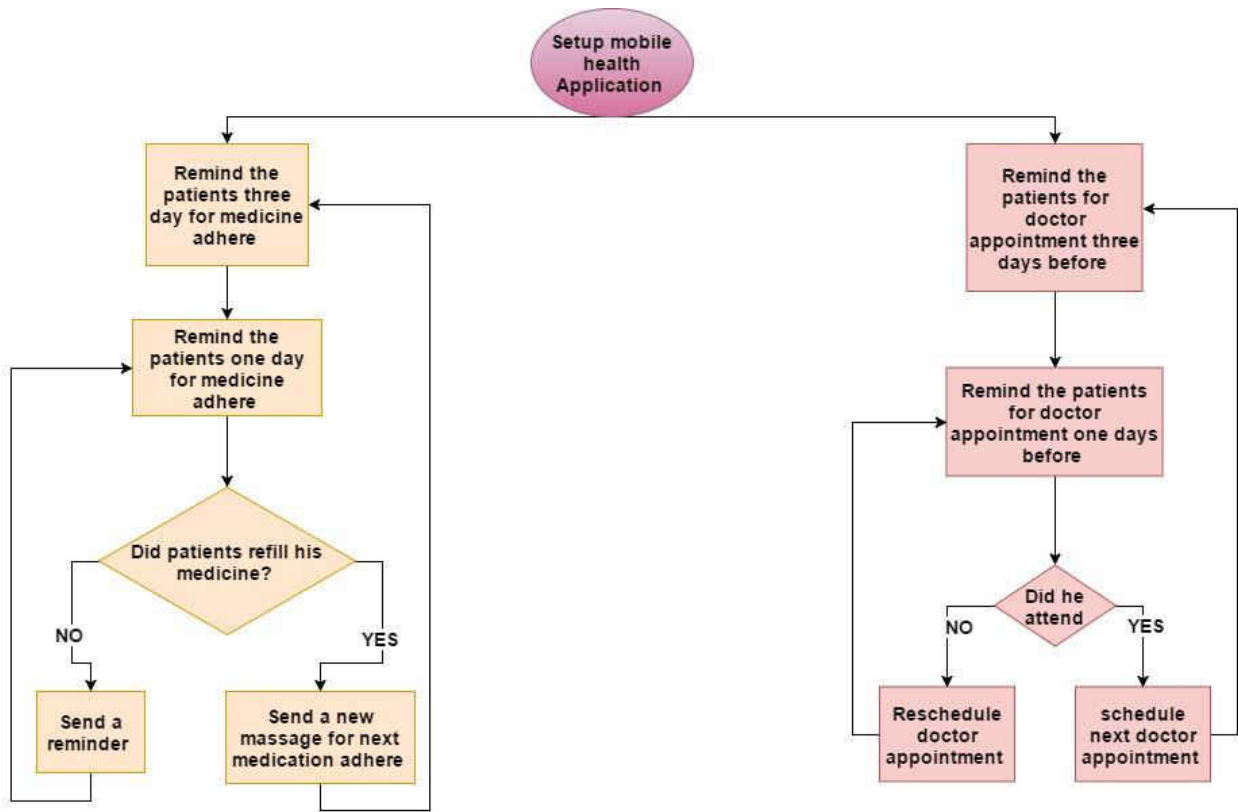


Figure 8 explanation of the process for two new features

3.4.4 Procedures for Data Collection

Data for this study was obtained in two different ways, the data for questions number one and three was obtained from the application, and hospital record for diabetic and hypertension groups, and the research team recorded these data in an excel sheet daily. For the second question, the data was obtained from the hospital record recorded in the excel sheet, see table 16. Then the data was converted to Statistical Package for the Social Sciences program (SPSS) to analyze it. Each variable of this study was assigned a variable name and value. Data such as age, weight and chronic disease history were used as input data to the developed mobile phone application. Also, demographic and clinical information were also collected through an electronic database system. These data were collected by the research team. There were four data sources for this study. The first source was from the pharmacy section in the hospital, the second source was from the appointment section, the third source was from the application and the fourth source was from the health record system.

Statistical Package for the Social Sciences program (SPSS) was used to analyze the data and aid in the interpretation of the results. Statistical tests such as logistic regression and Chi-Square test were used to determine whether there are significant differences existed between the pre- and post-intervention and the previous cases regarding managing the number of unnecessary follow-up visits, the refill medication reminder, and the doctor appointments reminder.

Table 16 The instruments for each question pre-intervention of mobile health application and after.

No.		Pre MHI	Post MHI
Q1	Does utilizing of refill medication reminder feature of DHA has a positive statistically significant impact on medication adherence levels of diabetic and hypertension patients in developing countries?		
1	Refill medication reminder (RMR)	Hospital Record	Application
Q2	Does utilizing the pre-appointment checkup feature for Hemoglobin A1c test have a positive statistically significant impact on decreasing the number of visits per patient for		

	diabetic patients in developing countries?		
2	Decrease number of visits per patients for the doctor	Hospital Record	Hospital Record
Q3	Does utilizing of doctor appointment reminder feature of DHA has a positive statistically significant impact on adherence to doctor appointments of diabetic and hypertension patients in developing countries?		
3	Doctor appointment reminder (DAR)	Hospital Record	Application

3.5 Threats to Validity

The results of the study may be affected by two types of validity, which are internal and external validity. Internal validity refers to the researcher's confidence of the existence of a relationship between the independent and the dependent variables. Factors that may threaten the internal validity, according to Michael (2014), include history, maturation, selection bias, and mortality. External validity, on the other hand, refers to the researcher's extent to generalize the results to other populations (Michael). Both the internal and external validity will be measured after the implementation of the mhealth intervention

3.6 Ethical Procedures

The mhealth team fully complied with the regulations set by the ministry of health in Saudi Arabia regarding researching Saudi hospitals. As part of these regulations, the principal investigator had to obtain approval from the ministry of health to conduct the study at Al-Noor Specialist Hospital. The approval was obtained from the ministry of health. Consequently, the team received a letter of permission to conduct the project, communicate with patients, and have access to medical information records.

Ethical behavior regarding patients' recruitment process, data collection, and other relevant intervention activities were fully practiced during the implementation period of the study. Also, there is no risk to the patients as a result of their participation and use of the refill

medication reminder and the doctor appointment reminder applications. In coordination with Al-Noor Specialist hospital, the mhealth team used different tools to protect patients' confidentiality. The research team also used patients' IDs issued by the hospital in the collection and classification of data.

Based on a meeting with the hospital top management, patients' demographic and clinical information were made available to the researcher. Moreover, raw data were also made available to the researcher only and installed on his personal computer and protected by a login password.

Also, the mhealth team had applied to the Institutional Review Board (IRB) at the University of Central Florida (UCF) to implement the mhealth intervention in Saudi Arabia to make "sure that the rights and welfare of human participants involved in the project are protected" (IRB). As part of the UCF IRB application process, "all Human Research conducted by UCF faculty, staff, and students must be reviewed by the IRB and approved for compliance with regulatory and ethical requirements before it may be undertaken" (IRB). Thus, the UCF IRB application was approved in 2018. Moreover, letters of permission for conducting this study were obtained from the Saudi ministry of health and at Al-Noor Specialist Hospital and were included in the UCF IRB application.

In addition, the proposed mhealth intervention was described as a low-risk intervention by the mHealth team in the UCF IRB application, which means that the participants had a low risk of adverse events resulting from participating in the project. In fact, the mHealth team used specific measures to protect patients' confidentiality as required by the UCF IRB. Once the UCF IRB approval was received, the mHealth team at Al-Noor Specialist Hospital made the project data available to the researcher. However, patients' identities are not made available to the researcher as required by the UCF IRB.

CHAPTER FOUR: FINDINGS

4.1 Introduction

The purpose of the study is to evaluate the effectiveness of mhealth intervention for diabetic and hypertensive patients at Al-Noor Specialist Hospital in Makkah, Saudi Arabia. The mhealth intervention has two features, namely, refill medication reminder and doctor appointment reminder. In these features that were built in the mhealth application, a third feature was investigated in the study, which is managing the number of unnecessary follow-up patients. The research questions were formulated to assess these three features. The hypotheses were reported to indicate whether or not statistically significant differences in the level of adherence exist between the pre- and post-intervention groups.

This chapter starts with a review of the research objective, research questions, and research hypotheses. This is followed by a detailed description of the research participants and data collection. A discussion on the analysis of results, which includes descriptive statistics, testing of covariates, and logistic regression. This is followed by treatment and/or intervention fidelity. The chapter concludes with a summary of the findings and the introduction to chapter 5.

4.2 Data Collection

As mentioned in Chapter 3, the data for this study was obtained from the hospital's database and the application. These data include the demographic information of the participants, such as age, gender, and weight, and patients' medical history. Patients at Al-Noor Specialist Hospital refill their medications based on their health status. In this regard, the study period was divided into two months before the intervention, where patients refill their medication and see their physicians at least two times, and two months after the intervention, where patients refill their medication and see their physicians for at least two times. The pre-intervention period lasted two months starting from August 15, 2019, to October 15, 2019, while the post-intervention period lasted for two months starting from October 15, 2019, to December 15, 2019.

The sample sizes for patients with diabetes and hypertension were 199 and 165, respectively. For diabetic patients, 101 of the 199 were male, and the remaining were female. For hypertension patients, 82 were male, and the remaining were female. Participants were selected using a stratified random sampling method where patients stratified based on their gender, age, weight, and history of chronic diseases.

4.3 Result

4.3.1 Descriptive Statistics

Study Population for diabetes patients:

For diabetes, the study sample size was $N = 199$ participants of whom $n = 98$ (49.2%) were female and $n = 101$ (50.8%) were male. The demographic and descriptive characteristics of the sample population are summarized in Table 17 diabetes patients with Refill medication reminder features and Table 18 diabetes patients with doctor appointment reminder features.

Diabetes Patients -Refill Medication Reminder (RMR):

Before mobile health intervention: 111 patients in the Adherence group and 88 in the non- Adherence group

111 in the Adherence group: (female= 53 (48%), male=58 (52%)), (have chronic diseases= 75 (68%). No chronic diseases= 36 (32%)), weight (Mean=85, SD=18.6), age (Mean=41, SD=13), Height (Mean=166.6, SD=8.7).

88 in the non-Adherence group: (female= 75 (51), male=43 (49%)), (have chronic diseases= 66 (75%). No chronic diseases= 22 (25%)), weight (Mean=84, SD=18.2), Age (Mean=42.4, SD=13.7), height (Mean=165, SD=8.4).

After mobile health intervention: 155 patients in the Adherence group and 44 patients in the non-Adherence group.

155 patients in the Adherence group: (female= 80 (52%), male=75 (48%)), (have chronic diseases= 46 (30%). No chronic diseases= 109 (70%)), weight (Mean=84.3, SD=18.6), age (Mean=40.7, SD=13.3), height (Mean=165.8, SD=8.5).

44 patients in the non-Adherence group: (female= 18 (41), male=26 (59%)), (have chronic diseases= 12 (27%). No chronic diseases= 32 (73%)), weight (Mean=86.1, SD=17.7), Age (Mean=45.1, SD=12.8), height (Mean=165.6, SD=8.8).

Table 17 Characteristics of participants stratified by Adherence status and the remainder (Diabetes Patients -Refill Medication Reminder) n=199

Characteristics	Without remainder		With remainder	
	Adherence (n=111) n(%)	Non-adherence (n=88) n(%)	Adherence (n=155) n(%)	non-adherence (n=44) n(%)
Gender				
Female	53 (48)	45 (51)	80 (51.6)	18 (40.9)
Male	58 (52)	43 (49)	75 (48.4)	26 (59.1)
chronic diseases				
Yes	75 (68)	66 (75)	109 (70.3)	32 (72.7)
No	36 (32)	22 (25)	46 (29.7)	12 (27.3)

Weight, Mean (SD)	85 (18.6)	84.32 (18.2)	84.3 (18.6)	86.1 (17.7)
Age, Mean (SD)	41 (13)	42.39 (13.7)	40.7 (13.3)	45.1 (12.8)
height, Mean (SD)	166.6 (8.7)	165 (8.4)	165.8 (8.5)	165.6 (8.8)

Diabetes Patients -Doctor Appointment Reminder (DAR):

Before mobile health intervention: 149 patients in the Adherence group and 50 in the non- Adherence group.

149 patients in the Adherence group: (female= 70 (47%), male=79 (53%)), (have chronic diseases= 105 (66%). No chronic diseases= 44 (34%)), weight (Mean=85, SD=18), age (Mean=41.3, SD=13.3), height (Mean=166.1, SD=8.7).

50 patients in the non-Adherence group: (female=28 (56%), male=22 (44%)), (have chronic diseases= 36 (72.5%). No chronic diseases= 14 (27.5%)), weight (Mean=83.8, SD=19.8), Age (Mean=42.8, SD=13.2), height (Mean=164.8, SD=8.4).

After mobile health intervention: 170 patients in the Adherence group and 29 patients in the non-Adherence group.

170 patients in the Adherence group: (female= 79 (46.5%), male=91 (53.5%)), (have chronic diseases= 47 (27.6%). No chronic diseases= 123 (72.4%)), weight (Mean=84.9, SD=18.9), age (Mean=41.5, SD=13.1), height (Mean=165.4, SD=8.2).

29 patients in the non-Adherence group: (female=19 (65.5%), male=10 (34.5%)), (have chronic diseases=18 (62.1%). No chronic diseases=11 (37.9%)), weight (Mean=83.3, SD=15.5), Age (Mean=42.8, SD=14.5), height (Mean=168, SD=10.6).

Table 18 Characteristics of participants stratified by Adherence status and the remainder (Diabetes Patients - Doctor Appointment Reminder) n=199

Characteristics	Without remainder		With remainder	
	Adherence (n=149) n(%)	Non-adherence (n=50) n(%)	Adherence (n=170) n(%)	non-adherence (n=29) n(%)
Gender				

Female	70 (47)	28 (56)	79 (46.5)	19 (65.5)
Male	79 (53)	22 (44)	91 (53.5)	10 (34.5)
chronic diseases				
Yes	105 (66)	36 (72.5)	123 (72.4)	11 (37.9)
No	44 (34)	14 (27.5)	47 (27.6)	18 (62.1)
Weight, Mean (SD)	85 (18)	83.8 (19.8)	84.9 (18.9)	83.3 (15.5)
Age, Mean (SD)	41.3 (13.3)	42.8 (13.2)	41.5 (13.1)	42.8 (14.5)
height, Mean (SD)	166.1 (8.7)	164.8 (8.4)	165.4 (8.2)	168 (10.6)

Managing the number of unnecessary follow-up visits

To manage the number of unnecessary follow-up visits for patients with diabetes, each patient should perform the Hemoglobin A1c test. If the Hemoglobin A1c level is high, an appointment with the physician will be scheduled for this patient. If, on the other hand, the Hemoglobin A1c level is normal, then the patient is directed to a primary care unit to receive regular care.

To calculate the number of unnecessary follow-up visits, patients visiting five diabetic clinics were tested for their Hemoglobin A1c level. Based on this test, the percentages of the unnecessary follow-up visits were calculated for each clinic as shown in the following table.

Table 19 Management of the number of follow up visits for diabetic patients

	Number of patients for 30 days	Necessary follow up	Effective clinical appointment rate	Could be eliminated	From	To
Clinic 1	422	342	19.91	80	4/7/2019	5/5/2019
Clinic 2	399	319	20.55	82	3/8/2019	4/6/2019
Clinic 3	198	138	40.91	81	3/8/2019	4/6/2019
Clinic 4	174	94	21.84	38	3/8/2019	4/6/2019
Clinic 5	525	420	20	105	2/7/2019	3/7/2019

Study Population for hypertension patients:

For hypertension, the study sample size was N=165 patients of whom n=83 (50.3%) were female, and n=82 (49.7%) were male. The demographic and descriptive characteristics of the sample population are summarized in Table 20 of hypertension patients with Refill medication reminder features, and Table 21 hypertension patients with doctor appointment reminder features.

Hypertension Patients -Refill Medication Reminder (RMR):

Before mobile health intervention: 109 patients in the Adherence group and 56 patients in the non-Adherence group.

109 in the Adherence group: (female= 51 (47%), male=58 (53%)), (have chronic diseases= 67 (61.5%). No chronic diseases= 42 (38.5%)), weight (Mean=84.8, SD=17.6), age (Mean=45.4, SD=13.5), height (Mean=166, SD=8).

56 in the non-Adherence group: (female=32 (57%), male=24 (43%)), (have chronic diseases= 36 (64%). No chronic diseases= 20 (36%)), weight (Mean=83, SD=19), Age (Mean=43, SD=12), height (Mean=167, SD=8.1)..

After mobile health intervention: 158 patients in the Adherence group and 7 patients in the non-Adherence group.

158 patients in the Adherence group: (female=79 (50%), male=79 (50%)), (have chronic diseases=100 (63.3%). No chronic diseases=58 (36.7%)), weight (Mean=84, SD=18.3), age (Mean=44, SD=12.4), height (Mean=166.4, SD=8.3).

7 patients in the non-Adherence group: (female=4 (57%), male=3 (43%)), (have chronic diseases=3 (43%). No chronic diseases=4 (57%)), weight (Mean=83.3, SD=12), Age (Mean=55.6, SD=20.9), height (Mean=166.3, SD=6.5).

Table 20 Characteristics of participants stratified by Adherence status and remainder
(Hypertension Patients -Refill Medication Reminder) n=165

Characteristics	Without remainder		With remainder	
	Adherence (n=109) n(%)	Non-adherence (n=56) n(%)	Adherence (n=158) n(%)	non-adherence (n=7) n(%)
Gender				
Female	51 (47)	32 (57)	79 (50)	4 (57)
Male	58 (53)	24 (43)	79 (50)	3 (43)
chronic diseases				
Yes	67 (61.5)	36 (64)	100 (63.3)	3 (43)
No	42 (38.5)	20 (36)	58 (36.7)	4 (57)
Weight, Mean (SD)	84.76 (17.6)	83 (19)	84 (18.3)	85.3 (12)
Age, Mean (SD)	45.4 (13.5)	43 (12)	44 (12.4)	55.6 (20.9)
height, Mean (SD)	166 (8)	167 (8.1)	166.4 (8.3)	166.3 (6.5)

Hypertension Patients -Doctor Appointment Reminder (DAR):

Before mobile health intervention: 102 patients in the Adherence group and 63 patients in the non-Adherence group.

102 patients in the Adherence group: (female= 50 (49%), male=52 (51%)), (have chronic diseases= 63 (61.8%). No chronic diseases= 39 (38.2%)), weight (Mean=85.6, SD=18.3), age (Mean=45.9, SD=13.5), height (Mean=166.3, SD=8.1).

63 patients in the non-Adherence group: (female=33 (52.4%), male=30 (47.6%)), (have chronic diseases= 40 (63.5%). No chronic diseases= 23 (36.5%)), weight (Mean=81.6, SD=17.4), Age (Mean=42.4, SD=12.1), height (Mean=166.4, SD=8.5).

After mobile health intervention: 139 patients in the Adherence group and 26 patients in the non-Adherence group.

139 patients in the Adherence group: (female=70 (50.4%), male=69 (49.6%)), (have chronic diseases=85 (61.2%). No chronic diseases=54 (38.8%)), weight (Mean=84.3, SD=18.43), age (Mean=44.6, SD=13), height (Mean=166.2, SD=8.3).

26 patients in the non-Adherence group: (female=13 (50%), male=13 (50%)), (have chronic diseases=18 (69.2%). No chronic diseases=8 (30.8%)), weight (Mean=83.1, SD=16.4), Age (Mean=44, SD=13.3), height (Mean=167, SD=6.5).

Table 21 Characteristics of participants stratified by Adherence status and the remainder (Hypertension Patients -Doctor Appointment Reminder) n=165

Characteristics	Without remainder		With remainder	
	Adherence (n=102) n(%)	Non-adherence (n=63) n(%)	Adherence (n=139) n(%)	Non-adherence (n=26) n(%)
Gender				
Female	50 (49)	33 (52.4)	70 (50.4)	13 (50)
Male	52 (51)	30 (47.6)	69 (49.6)	13 (50)
chronic diseases				
Yes	63 (61.8)	40 (63.5)	85 (61.2)	18 (69.2)
No	39 (38.2)	23 (36.5)	54 (38.8)	8 (30.8)
Weight, Mean (SD)	85.6 (18.3)	81.6 (17.4)	84.3 (18.4)	83.1 (16.4)
Age, Mean (SD)	45.9 (13.5)	42.4 (12.1)	44.6 (13)	44 (13.3)
height, Mean (SD)	166.3 (8.1)	166.4 (8.5)	166.2 (8.3)	167 (6.5)

4.3.2 Testing of Covariates and Logistic Regression Analyses

Analysis for diabetes patients -refill medication Reminder

Logistic Regression. The first logistic regression for diabetes patients dialed with the refill Medication Reminder feature was conducted with regards to the dependent variable of adherence. Variables: intervention, gender, chronic diseases, weight, age, height were included in the regression model. The results from the logistic regression are presented in Table 22. The model chi-square was significant, $\chi^2 (6, N = 199) = 28.544, p=0.000 < .001$, indicating that the

independent and/or covariate variables significantly predicted adherence at diabetes patients dialed with RMR. The non-significance of the Hosmer and Lemeshow chi-square test indicated that the model adequately fit the data, $\chi^2 (8) = 10.614$, $p = 0.225$.

The classification table output for model 0 (the model without the various predictor variables) correctly classified 66.8% of adherence. In comparison, the classification table for model 1 (which included the various predictor variables) indicated that correctly classified 67.3% of adherence. There was a minimal difference in the classification tables between model 0 and 1. The Nagelkerke R^2 indicated a 7.0% variance in the model.

One variable (Intervention) significantly predicted ($p < .001$) in the dependent variable (adherence), where ($B=1.044$, odds ratio $\text{Exp}(B)=2.84$ CI 95%(1.829-4.41), $p=0.000$) indicates if there was Intervention, so the adherence increases 2.84 times more than without Intervention.

Table 22 Diabetes Patients-Refill Medication Reminder: Intervention and Predictor Variables for adherence (N = 199) according to logistic regression analysis

	<i>B</i>	<i>S.E.</i>	<i>Wald</i>	<i>p</i>	<i>Exp(B)</i>	<i>95% CI for EXP(B)</i>	
						Lower	Upper
Constant	-2.202	2.193	1.009	.315	.111		
Gender							
Female	.068	.222	.092	.761	1.070	.692	1.654
Male	-	-	-	-	-	-	-
chronic diseases							
Yes	-.198	.250	.627	.429	.821	.503	1.339
NO	-	-	-	-	-	-	-
Intervention							
Yes	1.044	.225	21.580	.000***	2.84	1.829	4.413
No	-	-	-	-	-	-	-
Weight	-.001	.007	.013	.910	.999	.986	1.013
Age	-.016	.009	3.071	.080	.984	.967	1.002
height	.020	.014	1.996	.158	1.020	.992	1.048
χ^2	28.544***						
<i>df</i>	6						
<i>Correct Classified</i>	67.3%						

Note: ****p* < .001.

Analysis for Diabetes Patients -Doctor Appointment Reminder

Logistic Regression. The first logistic regression for diabetes patients dialed with doctor appointment reminder feature was conducted with regards to the dependent variable of adherence.

Variables: intervention, gender, chronic diseases, weight, age, height were included in the regression model. The results from the logistic regression are presented in Table 23. The model chi-square was significant, $\chi^2 (6, N = 199) = 14.7, p=0.023 < .05$, indicating that the independent and/or covariate variables significantly predicted adherence at diabetes-visiting the patient. The non-significance of the Hosmer and Lemeshow chi-square test indicated that the model adequately fit the data, $\chi^2 (8) = 6.76, p = .563$.

The classification table output for model 0 (the model without the various predictor variables) correctly classified 80.2% of adherence. In comparison, the classification table for model 1 (which included the various predictor variables) indicated that correctly classified 80.3% of adherence. There was a minimal difference in the classification tables between model 0 and 1. The Nagelkerke R^2 indicated 6.0% variance in the model

Two variables significantly predicted ($p < .05$) in (diabetes-Refill the medicine). Intervention variable was significant ($B=.690$, odds ratio $\text{Exp}(B)=1.994, p=0.008$) indicates if there is Intervention so the adherence increases 1.99 times more than without Intervention. The gender variable was significant ($B=.558$, odds ratio $\text{Exp}(B)=1.747, p=0.032$) indicates if the patient was female so the adherence increases 1.75 times more than male.

Table 23 Diabetes Patients -Doctor Appointment Reminder: Intervention and Predictor Variables for adherence (N = 199) according to logistic regression analysis

	<i>B</i>	<i>S.E.</i>	<i>Wald</i>	<i>p</i>	<i>Exp(B)</i>	<i>95% CI for EXP(B)</i>	
						Lower	Upper
Constant	.349	2.509	.019	.889	1.417		
Gender							
Female	.558	.261	4.584	.032*	1.747	1.048	2.912
Male	-	-	-	-	-	-	-
chronic diseases							
Yes	.436	.275	2.511	.113	1.546	.902	2.651
NO	-	-	-	-	-	-	-
Intervention							
Yes	.690	.262	6.955	.008**	1.994	1.194	3.329
No	-	-	-	-	-	-	-
Weight	-.004	.008	.226	.634	.996	.981	1.012
Age	-.009	.011	.738	.390	.991	.971	1.012
Height	.005	.016	.109	.741	1.005	.974	1.037
χ^2	14.7*						
<i>df</i>	6						
Correct Classified	80.2%						

Note: * $p < .05$, ** $p < .01$, *** $p < .001$.

Analysis for hypertension Patients -Refill Medication Reminder:

Logistic Regression. The first logistic regression for hypertension patients dialed with a refill medication reminder feature was conducted with regards to the dependent variable of adherence.

Variables: intervention, gender, chronic diseases, weight, age, height were included in the

regression model. The results from the logistic regression are presented in Table 24. The model chi-square was significant, $\chi^2 (6, N = 165) = 55.025, p=0.000<.001$, indicating that the independent and/or covariate variables significantly predicted adherence at hypertension patients dialed with RMR feature. The non-significance of the Hosmer and Lemeshow chi-square test indicated that the model adequately fit the data, $\chi^2 (8) = 6.763, p = .562$.

The classification table output for model 0 (the model without the various predictor variables) correctly classified 80.9% of adherence. In comparison, the classification table for model 1 (which included the various predictor variables) indicated that correctly classified 80.9% of adherence. There was a clear difference in the classification tables between model 0 and 1. The Nagelkerke R^2 indicated a 24.7% variance in the model.

One variable (Intervention) significantly predicted ($p < .05$) independent variable (adherence), where ($B=2.469$, odds ratio $\text{Exp}(B)=11.807$, $p=0.000$) indicates if there was Intervention, so the adherence increases 11.8 times more than without Intervention.

Table 24 hypertension patients-refill medication reminder feature: Intervention and Predictor Variables for adherence (N = 165) according to logistic regression analysis

	<i>B</i>	<i>S.E.</i>	<i>Wald</i>	<i>p</i>	<i>Exp(B)</i>	<i>95% CI for EXP(B)</i>	
						Lower	Upper
Constant	3.125	3.153	.982	.322	22.756		
Gender							
Female	-.384	.308	1.554	.213	0.681	.372	1.246
Male	-	-	-	-	-	-	-
chronic diseases							
Yes	-.009	.316	.001	.978	0.991	.534	1.841
NO	-	-	-	-	-	-	-
Intervention							
Yes	2.469	.421	34.342	.000***	11.807	5.171	26.959
No	-	-	-	-	-	-	-
Weight	.007	.010	.461	.497	1.007	.988	1.026
Age	-.001	.013	.006	.940	.999	.974	1.024
Height	-.017	.020	.696	.404	.984	.946	1.023
χ^2	55.025***						
<i>df</i>	6						
Correct Classified	80.9%						

Note: * $p < .05$, ** $p < .01$, *** $p < .001$.

Analysis for hypertension Patients -Doctor Appointment Reminder:

Logistic Regression. The first logistic regression for hypertension patients dialed with doctor appointment reminder (DAR) feature was conducted with regards to the dependent variable of adherence. Variables: intervention, gender, chronic diseases, weight, age, height were included in the regression model. The results from the logistic regression are presented in Table 25. The model chi-square was significant, $\chi^2 (6, N = 165) = 25.73$, $p=0.000<.05$, indicating that the

independent and/or covariate variables significantly predicted adherence at hypertension patients dialed with DAR. The non-significance of the Hosmer and Lemeshow chi-square test indicated that the model adequately fit the data, $\chi^2 (8) = 6.39$, $p = .604$.

The classification table output for model 0 (the model without the various predictor variables) correctly classified 73.0% of adherence. In comparison, the classification table for model 1 (which included the various predictor variables) indicated that correctly classified 73.3% of adherence. There was a minimal difference in the classification tables between model 0 and 1. The Nagelkerke R^2 indicated a 10.9% variance in the model.

One variable (Intervention) significantly predicted ($p < .05$) independent variable (adherence), where ($B=1.21$, odds ratio $\text{Exp}(B)=3.354$, $p=0.000$) indicates if there was Intervention, so the adherence increases 3.35 times more than without Intervention.

Table 25 hypertension patients- doctor appointment reminder (DAR): Intervention and Predictor Variables for adherence (N = 165) according to logistic regression analysis

	<i>B</i>	<i>S.E.</i>	<i>Wald</i>	<i>p</i>	<i>Exp(B)</i>	<i>95% CI for EXP(B)</i>	
						Lower	Upper
Constant	1.937	2.696	.516	.472	6.938		
Gender							
Female	.055	.260	.045	.832	1.057	.635	1.760
Male	-	-	-	-	-	-	-
chronic diseases							
Yes	-.194	.271	.511	.475	.824	.485	1.401
NO	-	-	-	-	-	-	-
Intervention							
Yes	1.210	.269	20.223	.000***	3.354	1.979	5.683
No	-	-	-	-	-	-	-
Weight	.008	.008	1.010	.315	1.008	.992	1.025
Age	.012	.011	1.147	.284	1.012	.990	1.034
Height	-.016	.017	.841	.359	.985	.952	1.018
χ^2	25.73***						
<i>df</i>	6						
Correct Classified	.733%						

Summary of participants' performance presented in table 26. Refill medication reminder feature for diabetic patients was improved by 22% and 10% improvement for doctor appointment reminder feature. Also, the Refill medication reminder feature for hypertension patients was improved by 30% and 22% improvement for doctor appointment reminder feature.

Table 26 Summary of Participants Performance

	Diabetic patients		Hypertension patients	
	Before intervention	After intervention	Before intervention	After intervention
	N (%)	N (%)	N (%)	N (%)
Refill medication reminder	111 (56%)	155 (78%)	109 (66%)	158 (96%)
Doctor appointment reminder	149 (75%)	170 (85%)	102 (62%)	139 (84%)

4.4 Treatment and/or Intervention Fidelity

The validity of the study was evaluated before and after the intervention. The study was conducted as planned, and no dropout or lack of interest of the participants were registered during the study period. However, given the fact that all participants had to use the refill medication reminder and the doctor appointment reminder simultaneously, it was difficult to identify which of the two features were responsible for the improvement in the adherence level. Furthermore, the selection of the participants may pose a threat to internal validity.

4.5 Summary

In response to the research questions, it can be asserted that there is sufficient evidence indicating that the refill medication reminder and the doctor appointment reminders have a significant effect on the medication adherence level of patients with diabetes and hypertension. In addition, the pre-appointment checkup feature for Hemoglobin A1c test was found to reduce the number of unnecessary follow-up visits for patients with diabetes. Regression analyses were conducted for the refill medication reminder and the doctor appointment reminder and revealed that the intervention significantly increased the adherence level for both patients with diabetes

and hypertension. For covariate variables, the only gender showed a significant effect on the doctor appointment reminder for diabetic patients.

The next chapter starts with a discussion of the results. This is followed by conclusions which were drawn from the study findings. The chapter concludes with limitations of the study, recommendations for future research, and implications for social change.

CHAPTER FIVE: DISCUSSIONS & CONCLUSIONS

5.1 Introduction

The purpose of this study was to evaluate the effectiveness of mobile health applications to manage the behavior of diabetic and hypertension patients based on doctor appointment adherence and refill medication adherence by using mobile health applications. In addition, managing unnecessary follow-up visits for them. The three axes of this research were covered by mobile health applications and patient's hospital records. Doctor appointment reminder (DAR) and refill medication reminder (RMR) were covered by mobile health application named (DHA Tracking). The third axis was covered by the patient's hospital record and blood sugar level test (Hemoglobin A1c).

This chapter starts with the interpretation of the findings, including findings in the context of the theoretical framework. This is followed by the limitations of this study and then recommendations. The recommendation will include a recommendation for future study. Last but not least, the implication will be covered including positive social change and the last will be the conclusion.

5.2 Interpretation of the Findings

The study results indicated that the diabetes-refill was significant ($p < .001$) on the adherence level. The descriptive statistics for diabetes-refill showed that only 50 of the participants adhered to refill medication before the intervention compared to 155 adhered to refill medication after the intervention. This indicated that the refill medication features helped 105 of the participants, which is more than half of the sample, adhere to the refill medication. In other words, the intervention increased the adherence level more than ten times. Other variables, such

as gender, chronic diseases, weight, age, and height showed no significant effect on the adherence level of medication refill for patients with diabetes.

The results for diabetes-visiting the patient showed that it has a significant effect ($p=0.023$) on the adherence level. The descriptive statistics for diabetes-visiting the patient showed that the number of participants before the intervention was 149, while the number of participants after the intervention was 170. This means that the doctor's appointment reminder feature of the intervention helped 21 patients adhere to their appointments. In addition, gender has also been found to have a significant effect on the adherence level with female participants being 1.75 more complied with appointment than male participants.

The results for managing the number of follow-up patients also showed significant improvement. As discussed in chapter 4, the study examined five clinics to determine the number of unnecessary follow-up visits of diabetic patients within one month based on their Hemoglobin A1c level. It was found that the percentage of follow up visits that could be eliminated ranged from nearly 20% to almost 40%. Such an action would increase the efficiency of the clinic and increase the number of new patients who could be seen by a physician in a specified period.

For hypertension, the results for the pressure-refill revealed that the model is significant ($p < .001$), meaning that the refill medication reminder feature of the mobile application has a significant effect on the adherence level. Also, the descriptive statistics for pressure-refill showed that the number of participants increased from 51 before the intervention to 158 after the intervention, which represents a threefold increase.

The results for pressure-visiting the patient showed that the model is significant ($p < .001$), meaning that the doctor appointment reminder feature of the mobile application has a significant level on the adherence level. Gender was also found to have a significant effect on the

adherence level. The descriptive statistics for pressure-visiting the patient revealed that the number of participants increased from 102 before the intervention to 139 after the intervention, which represents a considerable improvement. Other variables, such as gender, chronic disease, weight, and age showed no significant effect on the adherence level.

This study reinforces the evidence in the literature regarding the effectiveness of using mhealth platforms to promote medication adherence for patients with diabetes and hypertension. In specific, this study agrees with the results obtained by (Alotaibi et al., 2016), in which the authors examined the effectiveness of using a mobile health application - SAED to manage and educate diabetic patients in Tabuk, Saudi Arabia. The study found a significant decrease in the blood sugar of the participants in the intervention group.

5.2.3 Findings in the Context of the Theoretical Framework

As reported in Chapter 2, the theoretical framework of this study was formulated to investigate the factors that contribute to medication adherence for patients with diabetes and hypertension. Also, the literature identifies a gap in the studies that examined the effectiveness of using mhealth to promote adherence to medication and appointment reminders for patients with diabetes and hypertension. Few studies evaluated the effectiveness of mhealth platforms to management and treatment of patients with diabetes, while no studies evaluated the use of mhealth models to manage and treat patients with hypertension in Saudi Arabia. This study meets this gap as it was conducted to evaluate the effectiveness of mhealth applications in providing care and treatment for patients with diabetes and hypertension in Saudi Arabia.

5.3 Limitations of the Study

There were many limitations to this study. One of these limitations was the redness of the patients to use technology. Principle investigator and the team met around a thousand patients totally for two months. Patients who interact with the app were few which is 364 compared to approximately a thousand patients. Many patients were interested in using technology, especially the youngest patients, but some of them did not know how to use a smartphone or did not have one. Some patients were living alone and had no one to help them. Helpers such as sons, daughters, or nurses who help an old patient were not willing to interact with the app because they considered as extra work. Some old patients had vision problems, and this is one of the critical limitations of this study.

Another limitation of this study was that only a quantitative method was used in this study to measure the effectiveness of DHA features. A mixed method of quantitative and qualitative inquiries would yield accurate results as some variables such as participants' behavior can only be explained by using the qualitative methods.

Another limitation of this study was the environment. The environment in which the team worked was not encouraging due to several factors. For instance, the refill medication process was difficult to track as no records were found in the hospitals or the primary care centers to know the time and frequency of the refill medication process. Also, many patients had some time two or more appointments per visit.

Another limitation was the cost of the application. Creating or Developing a mobile health application is very costly. Indeed, the cost of the application increases with the addition of new features. It should be noted that the author paid for the application from his own pocket

money without support from any organizations. This issue should be taken into consideration when designing future mhealth applications.

Another limitation was collecting data for the refill medication feature for diabetic and hypertension patients. Some patients were taking their medication from the hospital and some of them were taking their medication from primary health care and some of them could not find their medication, so they bought it, and that was giving the team a hard time to check the hospital record and first primary care to find out if the patients were adherence with medication refill or no.

Another limitation was the quality of the data. The data were not of a high quality due to large variations in hospital records. Also, some of the data were missing, and some of them lacked significant elements. A great deal of effort was achieved by the research team to review the data and inquire about any errors or missing elements. In the case of missing elements in the hospital database, for instance, the team manually reviewed the documents and relevant files to double-check any inquiries and ensure that the data have a minimum number of errors.

5.4 Recommendations

5.4.1 Recommendations for Further Study

Based on the results obtained in the study, a few recommendations could be noted. The addition of a survey or questionnaire to the participants to know the motive, readiness, and interest in their participation in the intervention. It may also include items to identify which of the application components were most useful to the participants and which need more improvement. This may include feedback on the content and frequency of the reminders.

Another element that may be considered in future studies is to expand the scope of the study to other areas. The rural areas of Saudi Arabia, where a large proportion of the population resides, lack the resources for efficiently providing care and treatment for patients with chronic diseases. Thus, introducing a study like this one in the area will assist patients with chronic diseases to manage their health conditions and adhere to medications and doctor appointments.

Also, the extension of the study period could be considered in future studies. For instance, the pre-intervention period could be extended to six months or one year, while the post-intervention period could be increased to one or two years. This will allow the study team to observe the behavior of the participants over a long period of time and to what degree the participants continue to use the mhealth application.

Adding a diagnostic feature to the app is also another element that can be considered in future studies. Controlling and managing chronic diseases, such as diabetes and hypertension are very important. However, preventing these diseases and providing awareness to the public about these diseases and their risk factors have the same importance. According to the literature provided in Chapter 2, few studies focused on the design and implementation of mhealth for diagnosing purposes. Thus, including a diagnostic feature in future mhealth intervention may contribute to the current evidence on the effectiveness of mhealth application.

5.5 Implications

5.5.1 Positive social change

This study has a positive impact on social change at various levels. At the individual level, the intervention proved to be an effective tool in assisting patients with diabetes and hypertension adhere to their treatment by reminding them to refill their medication and to show

up for their doctor appointments. According to the study team, the participants showed willingness and readiness to participate in the intervention and use the mobile application for managing their diseases. This behavior is supported in the literature as other studies stated that most of the participants in those studies support the use of mobile phone applications to provide healthcare services, and they showed motivation and commitment to participate in such an intervention.

Also, this study has benefits at the family level. If an individual within the family used mhealth applications, this would encourage other family members with chronic diseases to use mhealth technology. On the organizational level, this study can lead to improving the quality of healthcare services provided within the community. As reported in the results, the third feature of the intervention was designed to manage the number of unnecessary follow-up visits, and it was successful in reducing the number of unnecessary visits in almost 20% of the situations. Such action will increase the efficiency of the hospitals and provide a chance for other new patients to schedule appointments with their physicians.

As in many countries, many patients fail to show up for their appointments. As large as 30% of the patients in Saudi Arabia miss their appointments for different reasons, such as difficulty in reserving an appointment and forgetting the time of the appointment (Alhamad, 2013a). Adopting a mhealth intervention such as DHA can resolve the issue of missing appointments by providing the patients with the opportunity to schedule their appointments and remind them of their appointments a few days before the appointment time. Moreover, the results of this study reported a significant increase in the number of participants adhering to their doctor appointments.

5.6 Conclusion

The study reviewed the literature on the implementation of mhealth technology in the developing countries focusing on Saudi Arabia. Some of the studies reviewed investigated the use of SMS text messages to promote medication adherence of patients with chronic diseases such as diabetes and hypertension. Other studies explored the trends, opportunities and challenges of mhealth. Also, other studies investigated the readiness of patients and medical staff to use mhealth application using the Technology Acceptance Model. In addition, other studies adopted mhealth technology to provide management and education for patients with type 2 diabetes. This study introduced mhealth intervention for patients with diabetes and hypertension in Saudi Arabia. The proposed included new features such as RMR and DAR.

This study aimed to evaluate the effectiveness of mhealth intervention to provide care and treatment to patients with diabetes and hypertension in Saudi Arabia. The proposed intervention was designed to provide three features, namely, the refill medication reminder, the doctor appointment reminder, and managing the number of follow up visits. The study was conducted at Al-Noor Specialist Hospital in Mecca, Saudi Arabia, during the period from July 15 to Sep. 15 of 2019. The number of participants in the study was 199 and 165 for diabetes and hypertension, respectively. The proposed intervention was found to have a significant effect on the adherence level for medication refill and doctor appointment reminders. Also, the intervention was efficient in reducing the number of unnecessary follow-up visits. Through the literature, evidence was found on the effectiveness of mhealth technology, specifically mobile phone applications in promoting medication adherence to patients with chronic diseases such as diabetes and hypertension. Also, these applications have a positive social impact on the individuals, healthcare providers, and the community at large.

The proposed mhealth intervention was validated in terms of its effectiveness in supporting self-management for patients with diabetes and hypertension. It has been found that patients who used the mhealth intervention showed significant increase in their adherence level to their medication and appointments with their physicians. Specifically, the refill medication reminder improved adherence for patients with diabetes and hypertension by 22% and 30%, respectively. Also, the doctor appointment reminder increased the adherence for patients with diabetes and hypertension by 10% and 22%, respectively. Thus, it is evident that the proposed mhealth intervention was successful in enhancing the service delivery to patients with diabetes and hypertension.

The healthcare systems in most of the developing countries is suffering from a lack of medical resources such as physicians and nurses, lack of financial resources, and lack of IT infrastructure. These challenges caused many patients, especially those with chronic diseases, to struggle when seeking healthcare services. The use of mobile technology to provide healthcare services solved many of the problems that patients and healthcare providers face. In today's world, it is very uncommon to find an individual who does not own a cell phone or has no access to the internet. Thus, using mhealth technology facilitates patients' access to healthcare services and support them in managing their diseases. This will also improve the quality of healthcare services and increase the patients' satisfaction.

Research on the adoption of mhealth technology to provide healthcare services in Saudi Arabia is scant. Most of these studies focused on the use of mhealth to areas such as improving healthcare services in the emergency department, improving dental care services, assisting patients with special needs, and promoting disease prevention for obese children, diabetes, and hypertension. In addition, the majority of these studies have not explored the effectiveness of

mhealth in promoting adherence to patients with diabetes and hypertension. Moreover, previous studies have not examined the use of mhealth to provide health services for patients with hypertension. This study is the first study in Saudi Arabia that focused on providing and managing information to hypertensive patients by using a mobile health application. Thus, this study contributes to the body of knowledge on mhealth by investigating the effectiveness of mhealth in increasing adherence to medication and doctor appointments for diabetic and hypertensive patients in Saudi Arabia.

APPENDIX A: IRB AND SAUDI HEALTH MINISTRY APPROVAL

Saudi Health Ministry Approval



السلطنة العربية السعودية
وزارة الصحة
المديرية العامة للشؤون الصحية
بمكتب منطقة مكة المكرمة
اللجنة المحلية لأخلاقيات البحوث
بمكتب منطقة مكة المكرمة
(H-02-K-076)
1439/4/28

Institutional Review Board Opinion Letter

Date of Issue	19-11-2018
Research Title	Mobile Health Technology to Enhance Healthcare Service Delivery in Developing Nations (Saudi Arabia)
Primary Investigator	Nawaf Ibrahim Khan
IRB Number:	H-02-K-076-1118-065
Category of Approval	Approval

Dear Mr. Nawaf,

This is to inform you that the above-mentioned proposal has been reviewed and discussed by IRB Committee and was approved according to ICH GCP guidelines. Please note that this letter is from research perspective only.

You will still need to get permission from the head of research department at the directorate of health affairs, Makkah region to commence data collection and start your project.

We wish you all the best in your project and request you to keep the IRB informed of the progress on a regular basis, using the IRB log number shown in this letter.

Please be advised that regulations require that you submit a progress report on your research every 6 months. You are also required to submit any manuscript resulting from this research for approval by IRB before submission to journals for publication.

As a researcher, you are required to have a valid certification on protecting human research subject.

If you have further questions, feel free to contact me (research-makkah@moh.gov.sa).

Sincerely yours,

DR. Nadir Hamza Motair

Chairman, Institutional Review Board (IRB), Makkah



IRB Approval for Nurses



UNIVERSITY OF CENTRAL FLORIDA

Institutional Review Board
FWA00000351
IRB00001138 Office of Research
12201 Research Parkway
Orlando, FL 32826-3246

APPROVAL

December 9, 2019

Dear Nawaf Khan:

On 12/9/2019, the IRB reviewed the following submission:

Type of Review:	Modification / Update
Title:	Mobile Health Technology to Enhance Healthcare Service Delivery in Developing Nations (Saudi Arabia)
Investigator:	Nawaf Khan
IRB ID:	MOD00000583
Funding:	None
Grant ID:	None
IND, IDE, or HDE:	None
Documents Reviewed:	None

The IRB approved the protocol from 12/9/2019.

In conducting this protocol, you are required to follow the requirements listed in the Investigator Manual (HRP-103), which can be found by navigating to the IRB Library within the IRB system.

If you have any questions, please contact the UCF IRB at 407-823-2901 or irb@ucf.edu. Please include your project title and IRB number in all correspondence with this office.

Sincerely,

A handwritten signature in black ink, appearing to read "AS" or similar initials.

Adrienne Showman
Designated Reviewer

Accomplish CITI Training Certificate For Nurses



Completion Date 31-Oct-2019
Expiration Date 30-Oct-2022
Record ID 34028534

This is to certify that:

Ahl sulaimani

Has completed the following CITI Program course:

Human Research (Curriculum Group)
Human Subjects Research- Group 2.Social / Behavioral Research (Course Learner Group)
Investigators and Key Personnel (Stage)
1 - Basic Course



Under requirements set by:

University of Central Florida

Verify at www.citiprogram.org/verify/?w10171eb8-ed52-404a-b4f5-b275027e24d2-34028534



Completion Date 01-Nov-2019
Expiration Date 31-Oct-2022
Record ID 34037560

This is to certify that:

NAWAI Alluqmani

Has completed the following CITI Program course:

Human Research (Curriculum Group)
Human Subjects Research- Group 2.Social / Behavioral Research (Course Learner Group)
Investigators and Key Personnel (Stage)
1 - Basic Course



Under requirements set by:

University of Central Florida

Verify at www.citiprogram.org/verify/?w75c7dca9-463d-4219-8052-8615a18233c1-34037560

APPENDIX B: CONSENT FORMS AND DATA COLLECTION TABLE

Consent Form in English Language



UNIVERSITY OF
CENTRAL FLORIDA

Consent Form

Title of research study: Mobile Health Technology to Enhance Healthcare Service Delivery in Developing Nations (Saudi Arabia)

Investigator: Nawaf Khan

Faculty Advisor: Dr. Pamela McCauley

Key Information

Why am I being invited to take part in a research study?

We invite you to take part in this research study because you are a patient over the age of 18 with diabetes or hypertension. We want to improve your skills in managing your chronic diseases such as diabetic and hypertension. The idea of the study, which is being applied for the first time in Saudi Arabia, is to remind patients of dates for medication refills and doctor appointments by mobile health application.

Why is this research being done?

The mobile health (mhealth) is defined as the use of cell phone and wireless technologies to provide medical care services. We are hoping to enhance the effectiveness of mobile health platforms in developing nations for diabetes and hypertension diseases through managing patients' adherence to medication refill schedule. Also, we are hoping to manage patients' reminder of physicians' appointments. In addition, we hope to manage the number of unnecessary follow-up patient visits.

How long will the research last, and what will I need to do?

You will be in this study for two months. You will need to upload an application to your IOS device and you will interact with the application for 3 minutes weekly. At beginning, you will enter dates for your medication refill and doctor appointments. Then you will answer if you attended them or not.

Is there any way of being in this study could be bad for me?

The risks to you are minimal and do not exceed the risks associated with activities found in daily life.

Is Will in this study help me anyway?

There are no benefits to you from your taking part in this research. We cannot promise any benefits to others from your taking part in this research. However, possible benefits to others include helping you to manage your hypertension or diabetes.

What happens if I do not want to be in this research?

Participation in research is entirely voluntary. You can decide to participate or not participate. Your decision to participate or not participate will have no impact on your continued medical care or treatment.

Detailed Information: The following is more detailed information about this study in addition to the information listed above.

What should I know about a research study?

- Someone will explain this research study to you.
- Whether or not you take part is up to you.
- You can choose not to take part in.
- You can agree to take part and later change your mind.
- Your decision will not be held against you.

- You can ask all the questions you want before you decide.

Who can I talk to?

If you have questions, concerns, or complaints, or think the research has hurt you, talk to the research team at (+966)5555-45359 or nawwaf_5000@hotmail.com or faculty advisor: Dr.

Pamela McCauley at +1(407)567-3493 or Pamela.McCauley@ucf.edu

This research has been reviewed and approved by an Institutional Review Board (“IRB”). You may talk to them at 407-823-2901 or irb@ucf.edu if:

- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You have questions about your rights as a research subject.
- You want to get information or provide input about this research.

How many people will be studied?

The study will include up to 350 participants. The maximum number of participants who have diabetes will be 200, and the maximum number of participants who have hypertension will be 170.

What happens if I say yes, I want to be in this research?

This research will be conducted at Al-Noor Specialist Hospital in Makkah, Saudi Arabia. The

procedures of this research include:

1. The researchers will check your eligibility for the study:
 - You must have diabetes or hypertension,
 - You must be 18 years of age or older
 - You must have an IOS mobile device to install the application

- Persons who are pregnant, prisoners, cognitively impaired adults, or do not have the eligible device to set up the application cannot be in this study.
2. You will sign this consent form, which includes permission to access to your health record to record if you attended your appointments and your medication refill dates.
 3. You will be instructed to install the application from the Apple Store and will be shown how to use the application.
 4. You will be asked to provide demographic and medical information about you, which are your name, age, gender, medical history, weight, height, and medical record number. There will be no photos or videos required.
 5. Then, you will be asked to enter the dates for your medication refills and doctor appointments in the app.
 6. After that, you will interact with the application for two months. The app will send you reminders about your medication refills or doctor appointments and you will be asked to record when you get your medication or attend the doctor appointment. The investigator will receive data from the app during the 2 months that you are using it. You will be asked to remove the app after 60 days of using it.

What are my responsibilities if I take part in this research?

If you take part in this research, you will be requested to interact with the mhealth application in regard to your doctor’s appointments and medication refill related activities during the two-month period of the study. Also, you will be asked to grant the principal investigator or his team the access to your medical record to extract data related to your adherence to doctor’s appointments and medication refill dates for two months that preceded the study period. That means we will also ask for access to your medical record to record if you attended your

appointments and your medication refill dates.

What happens if I say yes, but I change my mind later?

You can leave the research at any time it will not be held against you.

Is there any way of being in this study could be bad for me? (Detailed Risks)

The risks to participants are minimal and do not exceed the risks associated with activities found in daily life.

What happens to the information collected for the research?

Efforts will be made to limit the use and disclosure of your personal information, including research study and medical records, to people who need to review this information. Your personal health information will be secured in an encrypted file, and only the organizations may inspect and copy your information, which includes the IRB and other representatives of this organization. The data that will be extracted from your medical record by the principal investigator will be used for comparison purposes to assess the effectiveness of the utilized mhealth app in achieving the study stated objectives. Excluding your name, the data that will be entered by you in the application (i.e. age, gender, medical history, weight, and height) will be used for statistical analysis and stratification purposes. Federal law provides additional protection of your medical records and related health information. Saudi Ministry of Health will be allowed to inspect the research records based on the approval that we got it from them. However, any other local committee you will need to get approval to be allowed to inspect the research records. We will also ask for access to your medical record, to record if you attended your appointments and your medication refill dates.

Can I be removed from the research without my OK?

We will tell you about any new information that may affect your health, welfare, or choice to

stay in the research.

Data Management and Confidentiality

The data will be saved in a secure excel sheet, and no one can access that data except the principal investigator. The identifiable data will be destroyed as soon as possible after analysis, and de-identified data must be held for five years after the closing of the research. The data will be saved in a secure excel sheet, and no one can access that data except the principal investigator. The app will not access to any other information, and you will be asked to remove the app after 60 days of using it.

Signature Block for Capable Adult

Your signature documents your permission to take part in this research and for us to access your medical records.

Signature of subject

Date

The printed name of the subject

Signature of the person obtaining consent

Date

The printed name of the person obtaining consent

My signature below documents that the information in the consent document and any other written information was accurately explained to and understood by, the subject and that consent was freely given by the subject.

Signature of witness to the consent process

Date

The printed name of the person witnessing consent process

Consent Form in Arabic Language



UNIVERSITY OF
CENTRAL FLORIDA

خطاب التزام

عنوان الدراسة البحثية: تكنولوجيا الصحة المتنقلة لتعزيز تقديم خدمات الرعاية الصحية في الدول النامية (المملكة العربية السعودية)

المحقق: م. نواف خان

مستشار الكلية: الدكتورة بامبلا مكولي

معلومات أساسية

لماذا دعيت للمشاركة في دراسة بحثية؟

ندعوك للمشاركة في هذه الدراسة البحثية لأنك مريض يزيد عمره عن 18 عامًا مصاب بداء السكري أو ارتفاع ضغط الدم. نريد تحسين مهاراتك في إدارة الأمراض المزمنة مثل السكري وارتفاع ضغط الدم. فكرة الدراسة يتم تطبيقها لأول مرة في المملكة العربية السعودية وهي تذكير المرضى بتاريخ تعبئة الأدوية ومواعيد الطبيب عن طريق تطبيق في الجوال.

لماذا يجري هذا البحث؟

يتم تعريف الصحة المتنقلة (الصحة) على أنها استخدام الهاتف الخليوي والتقنيات اللاسلكية لتوفير خدمات الرعاية الطبية. نأمل في تعزيز فعالية المنصات الصحية المتنقلة في الدول النامية لمرض السكري وارتفاع ضغط الدم من خلال إدارة التزام المرضى بجدول إعادة تعبئة الأدوية. ونأمل أيضًا في إدارة تذكير المرضى بمواعيد الأطباء. بالإضافة إلى ذلك ، نأمل في إدارة عدد زيارات المرضى الغير ضرورية للمتابعة .

ما المدة التي سيستغرقها البحث وماذا علي أن أفعل؟

سوف تكون في هذه الدراسة لمدة شهرين. ستحتاج إلى تحميل تطبيق على جهاز IOS الخاص بك وسوف تتفاعل مع التطبيق لمدة 3 دقائق أسبوعيًا. في البداية ، سوف تقوم بإدخال التواريخ الخاصة بملء عيوات الدواء ومواعيد الطبيب. ثم سوف تجيب إذا حضرتهم أم لا .

هل هناك أي طريقة في هذه الدراسة يمكن أن تكون سينة بالنسبة لي؟

إن المخاطر التي تواجهك ضئيلة للغاية ولا تتجاوز المخاطر المرتبطة بالأنشطة الموجودة في الحياة اليومية.

هل ستساعدني هذه الدراسة على أي حال؟

لا توجد فوائد لك من مشاركتك في هذا البحث. لا يمكننا أن نعد بأي فوائد للأخريين من مشاركتك في هذا البحث. ومع ذلك ،

تشمل الفوائد المحتملة للأخريين مساعدتك في إدارة ارتفاع ضغط الدم أو مرض السكري.

ماذا يحدث إذا كنت لا أريد أن أكون في هذا البحث؟

المشاركة في البحث طوعية تمامًا. يمكنك أن تقرر المشاركة أو عدم المشاركة. لن يكون لقرارك بالمشاركة أو عدم المشاركة

أي تأثير على استمرار الرعاية الطبية أو العلاج.

معلومات مفصلة: فيما يلي معلومات أكثر تفصيلاً حول هذه الدراسة بالإضافة إلى المعلومات المذكورة أعلاه.

ماذا يجب أن أعرف عن دراسة بحثية؟

• شخص ما سوف يشرح لك هذه الدراسة البحثية.

• ما إذا كنت تشارك أم لا ، فإن الأمر متروك لك.

• يمكنك اختيار عدم المشاركة.

• يمكنك الموافقة على المشاركة وتغيير رأيك لاحقًا.

• لن يتم اتخاذ قرارك ضدك.

• يمكنك طرح جميع الأسئلة التي تريدها قبل أن تقرر.

من الذي يمكنني التحدث إليه؟

إذا كانت لديك أسئلة أو مخاوف أو شكاوى ، أو تعتقد أن البحث قد أضر بك ، فتحدث إلى فريق البحث على (+966) 555-

45359 أو nawwaf_5000@hotmail.com أو مستشار هيئة التدريس: **Dr. Pamela McCauley** على (+1) (407)

3493-567 أو Pamela.McCauley@ucf.edu

تمت مراجعة هذا البحث والموافقة عليه من قبل مجلس المراجعة المؤسسية ("IRB"). يمكنك التحدث إليهم على الرقم 407-

2901-823 أو irb@ucf.edu إذا:

• لا يتم الرد على أسئلتك أو مخاوفك أو شكاواك من قبل فريق البحث.

• لا يمكنك الوصول إلى فريق البحث.

• تريد التحدث إلى شخص ما بجانب فريق البحث.

• لديك أسئلة حول حقوقك كموضوع بحثي.

• تريد الحصول على معلومات أو تقديم مدخلات حول هذا البحث.

كم عدد المشاركين في هذه التجربة؟

ستشمل الدراسة ما يصل إلى 350 مشارك. سيكون الحد الأقصى لعدد المشاركين الذين يعانون من مرض السكري 200 ،

والحد الأقصى لعدد المشاركين الذين يعانون من ارتفاع ضغط الدم سيكون 150.

ماذا يحدث إذا قلت نعم ، أريد أن أكون في هذا البحث؟

سيتم إجراء هذا البحث في مستشفى النور التخصصي بمكة المكرمة بالمملكة العربية السعودية. تشمل إجراءات هذا البحث:

1. سيتحقق الباحثون من أهليتك للدراسة:

• يجب أن يكون لديك مرض السكري أو ارتفاع ضغط الدم ،

• يجب أن يكون عمرك 18 عامًا أو أكبر

• يجب أن يكون لديك جهاز محمول **IOS** لتثبيت التطبيق

• لا يمكن للحوامل أو السجناء أو البالغين المصابون بضعف إدراكي أو من ليس لديهم جهاز مؤهل لإعداد الطلب في هذه

الدراسة.

2. سوف تقوم بتوقيع نموذج الموافقة هذا ، والذي يتضمن إذنًا للوصول إلى سجلك الصحي للتسجيل إذا حضرت مواعيدك

وتواريخ إعادة تعبئة الدواء.

3. سيطلب منك تثبيت التطبيق من متجر **Apple** وسيتم عرض كيفية استخدام التطبيق.

4 سيطلب منك تقديم معلومات سكانية وطبية عنك ، وهي اسمك وعمرك ونوعك وسجلك الطبي ووزنك وطولك ورقم السجل

الطبي. لن تكون هناك صور أو مقاطع فيديو مطلوبة..

5. بعد ذلك ، سيطلب منك إدخال تواريخ تعبئة الدواء ومواعيد الطبيب في التطبيق.

6. بعد ذلك ، سوف تتفاعل مع التطبيق لمدة شهرين. سيرسل لك التطبيق رسائل تذكير حول موعد تعبئة الدواء أو مواعيد

الطبيب وسيطلب منك التسجيل عند حصولك على الدواء أو حضور موعد الطبيب. سيتلقى المحقق بيانات من التطبيق خلال

الشهرين اللذين تستخدمهما فيه. سيطلب منك إزالة التطبيق بعد 60 يومًا من استخدامه.

ما هي مسؤولياتي إذا شاركت في هذا البحث؟

إذا شاركت في هذا البحث ، فسيُطلب منك التفاعل مع التطبيق فيما يتعلق بمواعيد طبيبك والأنشطة ذات الصلة بملء الدواء خلال فترة شهرين من الدراسة. أيضًا ، سيُطلب منك منح الباحث الرئيسي أو فريقه حق الوصول إلى السجل الطبي الخاص بك لاستخراج البيانات المتعلقة بالالتزام بمواعيد الطبيب وتواريخ إعادة تعبئة الدواء لمدة شهرين سابقين لفترة الدراسة. هذا يعني أننا سنطلب أيضًا الوصول إلى سجلك الطبي للتسجيل إذا حضرت مواعيدك وتواريخ إعادة تعبئة الدواء.

ماذا يحدث إذا قلت نعم ، لكنني غيرت رأيي لاحقًا؟

يمكنك ترك البحث في أي وقت لن يعقد ضدك.

هل هناك أي طريقة في هذه الدراسة يمكن أن تكون سيئة بالنسبة لي؟ (المخاطر التفصيلية)

إن المخاطر التي يتعرض لها المشاركون ضئيلة ولا تتجاوز المخاطر المرتبطة بالأنشطة الموجودة في الحياة اليومية.

ماذا يحدث للمعلومات التي تم جمعها للبحث؟

سيتم بذل الجهود للحد من استخدام والكشف عن معلوماتك الشخصية ، بما في ذلك الدراسة البحثية والسجلات الطبية ، على الأشخاص الذين يحتاجون إلى مراجعة هذه المعلومات. سيتم تأمين معلوماتك الصحية الشخصية في ملف مشفر ، ويمكن فقط للمؤسسات فحص ونسخ المعلومات الخاصة بك ، بما في ذلك **IRB** وممثلين آخرين لهذه المنظمة. سيتم استخدام البيانات التي سيتم استخلاصها من السجل الطبي الخاص بك من قبل الباحث الرئيسي لأغراض المقارنة لتقييم فعالية التطبيق **mhealth** المستخدمة في تحقيق الأهداف المعلنة للدراسة. باستثناء اسمك ، سيتم استخدام البيانات التي سندخلها في التطبيق (أي العمر والجنس والتاريخ الطبي والوزن والطول) لأغراض التحليل الإحصائي والتطبيقية. يوفر القانون الفيدرالي حماية إضافية لسجلاتك الطبية والمعلومات الصحية ذات الصلة. سيتم السماح لوزارة الصحة السعودية بفحص سجلات البحث بناءً على الموافقة التي حصلنا عليها منها. ومع ذلك ، ستحتاج أي لجنة محلية أخرى للحصول على الموافقة على فحص سجلات البحث. سنطلب أيضًا الوصول إلى السجل الطبي الخاص بك ، لتسجيل ما إذا كنت حضرت مواعيدك وتواريخ إعادة تعبئة الدواء.

هل يمكن إزالتني من البحث دون موافقتي؟

سنخبرك عن أي معلومات جديدة قد تؤثر على صحتك أو رفاهيتك أو اختيارك للبقاء في البحث.

إدارة البيانات وسريتها

سيتم حفظ البيانات في ورقة اكسل آمنة ، ولا يمكن لأحد الوصول إلى تلك البيانات باستثناء الباحث الرئيسي. سيتم إتلاف

البيانات المحددة في أقرب وقت ممكن بعد التحليل ، ويجب الاحتفاظ بالبيانات غير المحددة لمدة خمس سنوات بعد إغلاق البحث. سيتم حفظ البيانات في ورقة اكسل آمنة ، ولا يمكن لأحد الوصول إلى تلك البيانات باستثناء الباحث الرئيسي. لن يصل التطبيق إلى أي معلومات أخرى ، وسيطلب منك إزالة التطبيق بعد 60 يومًا من استخدامه. يوثق توقيعك إنك بالمشاركة في هذا البحث ولكي تتمكن من الوصول إلى سجلاتك الطبية.

توقيع المشارك	التاريخ
اسم المشارك	
توقيع الباحث الرئيسي	التاريخ
اسم الباحث الرئيسي	التاريخ

إن توقيعك أدناه يوضح أن المعلومات الموجودة في وثيقة الموافقة وأي معلومات مكتوبة أخرى قد تم شرحها وفهمها بدقة من قبل الموضوع وهذا الموافقة تم منحها بحرية من قبل الموضوع.

توقيع الشاهد علي عملية الموافقة	التاريخ
اسم الشاهد علي عملية الموافقة	

The Datasheet Will Be Used To Collect Information From The Medical Record For Question
Number 2

	Number of patients for 30 days	Necessary follow up	Effective clinical appointment rate	Could be eliminated	From	To
Clinic 1						
Clinic 2						
Clinic 3						
Clinic 4						
Clinic 5						

APPENDIX C: INFORMATION ABOUT THE EXPERIMENT

An Informative Brochure On The Experiment



لارتفاعه بالوعي الخاص بمرضى السكر والضغط وزيادة كثافة الكالسيوم الطبي



لأول مرة في المملكة العربية السعودية
هل أنت مريض سكر أو ضغط؟
نحن نخدمك من بيتك



مرضى سكر أو ضغط يتراوح عمره بين 18 إلى 62 سنة

الشروط الواجب توفرها في المريض
لإستخدام التطبيق:

- 1- ان لا تكون المريض حامل
- 2- ان لا يكون المريض من ذوي الاحتياجات الخاصة
- 3- ان يكون لدى المريض جهاز يدعم احدى النظامين الخاصين بالتطبيق



تطبيق مرضى السكري والضغط
Diabetes and Hypertension
Application
(DHA Tracking)



مواكبة رؤية 2030 وذلك بالوصول الى اعلى مستويات مرضى المريض بتوفير الوقت والجهد والمواد المادية



تم الحصول على الموافقة من جهة الأبحاث من وزارة الصحة بمنطقة مكة المكرمة باستخدام هذا التطبيق



مهام التطبيق:

متابعة المؤشرات الحيوية للمريض من المنزل بإشراف فريق طبي مختص والرد على المريض عن طريق التطبيق تنكير المريض بموعد الطبيب مع امكانيه تقديم او تاخير الموعد حسب حالة المريض تنكير المريض بموعد تعبئة الدواء



المهام المطلوبة من المريض:

ادخال المعلومات المطلوبة عند التسجيل وبعد ذلك ادخال المؤشرات الحيوية وحالته الصحية حسب تعليمات الطبيب لمدة ستين يوما



يمكنك الحصول على التطبيق بالذهاب الى غرفة الاجتماعات بالدور الثاني او بالتواصل مع الباحث نواف ابراهيم خان عن طريق الاتصال او بالواتس اب رقم الجوال: 0555546780 او عن طريق الايميل: nawwaf_5000@hotmail.com

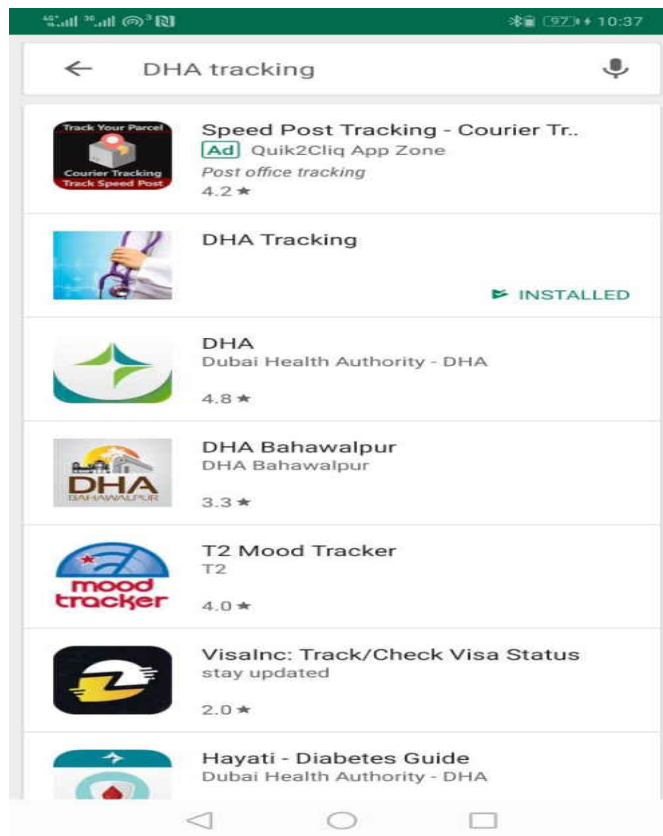
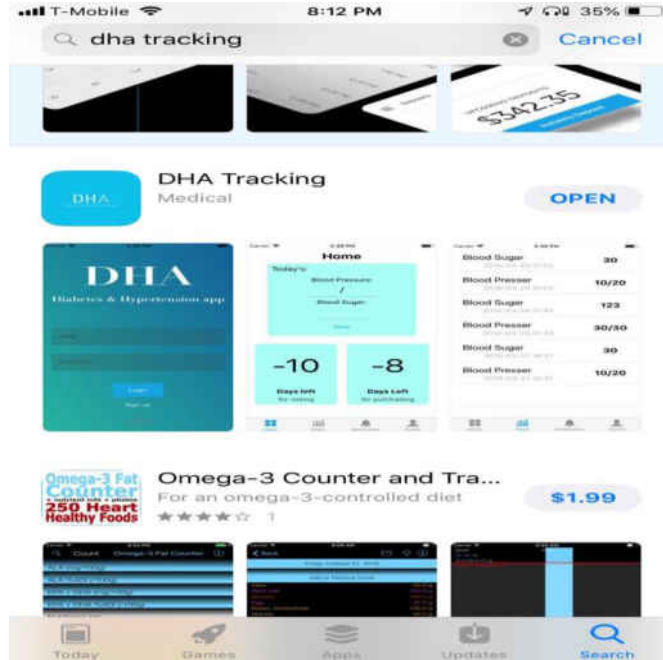


مسرد على المرضى فريق طبي مختص لمرضى السكر والضغط



اي جهاز يعمل بنظام ال IOS او الاندرويد مثل الايفون او الجالكسي او هواوي او غيرها من الاجهزة التي تدعم النظامين السابقين

Pictures of Mobile Health Application





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