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Use of Mobile Technology: Effects on Diabetic Health Outcomes and Health Care Costs in the Kingdom of Saudi Arabia

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USE OF MOBILE TECHNOLOGY: EFFECTS ON DIABETIC HEALTH OUTCOMES AND HEALTH CARE COSTS IN THE KINGDOM OF SAUDI ARABIA

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To: Dean Ora L. Strickland
College of Nursing and Health Sciences

This dissertation, written by Ahmad Rayani, and entitled Use of Mobile Technology: Effects on Diabetic Health Outcomes and Healthcare Costs in the Kingdom of Saudi Arabia is referred to you for judgment.

We have read this dissertation and recommend that it be approved.

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DEDICATION

I dedicate this dissertation to my family; my father, my mother, my wife, and my six kids. Without your love, support, and guidance, especially during the most difficult time in my life, I could never have completed this work. Your support has helped me through the most difficult challenges of life and has given me the courage to face any challenge to achieve my goals.

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ABSTRACT OF THE DISSERTATION

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Professor Jean Hannan, Major Professor

Diabetes in Saudi Arabia has reached an epidemic rate and is a significant cause of major medical complications, premature death, and health costs. Recent statistics indicates that up to 30% of Saudi population are diabetic and this number is expected to increase. As diabetes is increasing in extremely high rates in Saudi Arabia, a texting intervention has the potential in improving the health outcomes for this population. This data is needed in Saudi Arabia to improve the outcomes with diabetic patients and to guide the development of practice models with the aim to improve diabetics non-adherence to medically prescribed treatments and their complex self-management plans. The purpose of this randomized clinical trial was to examine a texting intervention using a Smartphone with diabetics in Saudi Arabia.

Methods: An intervention group received text message reminders 3 times a week for two months plus the routine care. Control group received the routine care. Data were collected on quality of life, medication adherence and healthcare costs on day 1 (baseline), weeks 4, and 8. Results: Findings indicate that intervention group benefited from the texting intervention as reflected in their health outcomes, quality of life, medication adherence and healthcare costs. The intervention group had higher scores for quality of life, medication adherence, decreased unscheduled healthcare visits and healthcare costs.

These study results indicate that an educational texting intervention with this sample of diabetic Saudi Arabians was culturally receptive by them and an effective, safe intervention that improved their quality of life, increased their medication adherence and decreased healthcare costs Relevance to Clinical Practice: Text messages aimed at improving the health of diabetics had a significant effect on healthcare charges and health outcomes in this sample. The intervention group benefited from 2 months text messages intervention. Healthcare providers are in a unique position to apply these interventions in regions that are lacking this technology such as Saudi Arabia.

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CHAPTER I.

INTRODUCTION

Diabetes a rapidly growing chronic disease, is a global medical epidemic and is a major health problem (Alzahrani & Alanzi, 2019). Most often, diabetes results in premature mortality accounting for an estimated 1.6 million annual deaths worldwide (AlBuhairan et al., 2016; World Health Organization [WHO, 2020]). According to the World Health Organization, approximately 422 million people worldwide are living with diabetes (WHO, 2020). The number of people with diabetes have been steadily increasing over the past few decades and is expected to increase by 200 million more by the year 2040 (WHO 2020). Most often, the incidence of diabetes varies depending of the country of origin and the persons cultural and health beliefs. In lower resource countries, diabetes is seen in higher numbers compared to higher resource countries (WHO, 2020). An exception to this is Saudi Arabia, a high resource country where diabetes rates are extremely high. This country currently ranks the second highest in the Middle East; and is 7^{th} worldwide (WHO, 2020; Robert et al., 2017; Naeem 2015). Saudi Arabia, according to the International Diabetes Federation report (2020), 18.3 % of the Saudi Arabian adult population are diabetic, and many more are likely to be either undiagnosed or pre-diabetic, a condition that leaves many on the edge in having this chronic disease.

In Saudi Arabia, a major contributory factor resulting in diabetes is their way of life. This includes the Saudi Arabian culture, beliefs and customs which substantially influence how the Saudi Arabian people understand and manage their health, their health seeking behaviors and how they make decisions related to their health. Their lack of health awareness about diabetes, their health beliefs, attitudes, and lifestyle increase their risk substantially for this chronic illness (Alanzi, 2018). Factors such low activity levels, a poor diet resulting in obesity, a lack of knowledge about the importance of a healthy lifestyle all contribute to these increasing rates of diabetes for the Saudi Arabians (Robert et al. 2017).

Diabetes is also one of the most demanding chronic illnesses to manage. Patients adherence to medically prescribed treatments and careful self-management plans are achieved with improved outcomes by patients with positive, strong support systems (i.e., significant others, families, support groups). These demands of managing diabetes have been shown to produce high levels of emotional distress, and many feel overwhelmed, frustrated, and discouraged (Kalra, 2018) resulting in adherence to medically prescribed treatments and self-management concerns. Many of the Saudi Arabian health beliefs stems from their culture and religion which is in conflict with the demands of managing this illness. This in itself increases not only the risk of diabetes but also many are overwhelmed leading to non-adherence and poor outcomes (Kalra, 2018).

Investigators analyzing interventions for diabetes self-management have shown that the most effective intervention in improving diabetic patients' health outcomes target physiologic, behavioral, and psychological outcomes with the highest improvements seen in interventions using peer support/coaching and technology-based interventions such as Smartphones for texting health promotion messages (Carpenter et al., 2018). Studies using text-messaging interventions with diabetic patients have shown increased patient satisfaction, changes to their diet, improved hemoglobin HbA1c levels and many other health behavior changes by improved knowledge in self-management (Arambepola et al., 2016; Fortmann et al., 2017; Dobson et al., 2015). In this era of technology, numerus studies have documented that texting interventions with chronic illnesses including diabetes, have shown positive outcomes (Fortmann et al., 2017; Hassan, 2017; Hussein, 2011; Abaza & Marschollek, 2017). However, data on texting interventions with diabetics in Saudi Arabia are very limited. Saudi Arabia lacks behind in the research using texting to improve health outcomes. Saudi Arabian researchers, Alzahrani & Alanzi, (2019) documented that diabetic participants are receptive to using a smartphone for a texting intervention. In their study it was found that most (96%) of the participants use smartphones for texting. This important data indicates the Saudi Arabian people are receptive and able to use smartphone interventions such as a texting intervention to improve health outcomes.

As diabetes is increasing in extremely high rates in Saudi Arabia, a texting intervention has the potential in improving the health outcomes for this population. This intervention would provide them with texts messages that would include such health behavior reminder messages such as: medication adherence, medical appointment reminders, health information, educational information, community support information amongst others. This data is needed in Saudi Arabia to improve the outcomes with diabetic patients and to guide the development of practice models with the aim to improve diabetics non-adherence to medically prescribed treatments and their complex self-management plans.

Significance

People with Diabetes in Saudi Arabia

Diabetes in Saudi Arabia has reached an epidemic rate and is a significant cause of major medical complications, premature death and health costs (Al Dawish et al., 2016). Recent statistics indicates that up to 30% of Saudi population are diabetic and this number is expected to increase unproportionally (Alotaibi et al., 2017). It is well documented that the rapid increases in diabetes may reach to alarming levels unless strategic measures are put into place.The people of Saudi Arabia have multifaceted variables increasing their risk of diabetes. One of the most impactful variables is the Saudi Arabian culture and lifestyle which attributes in their astronomical diabetes rates. Saudi Arabia is known for its strong culture which is also based in its religion beliefs (Al-Wassia et al., 2019; Shahin et al., 2019) making a healthy lifestyle challenging. The majority of the Saudi Arabian people are Islamic which strongly influences their belief systems on their self-perception, health seeking behaviors, diet, and care when ill (Dillon, 2020; Shahin et al., 2019; Yeary et al., 2020). Because of these beliefs and a strong will to follow their cultural and religious directives, many Saudi Arabians are not compliant and are nonadherent with seeking healthcare or following their medical provider's recommendations. Their deep-rooted belief system and generations of passed down customs such as a high sugary diet, a lack of exercise and accessing healthcare act as barriers to self-care regimens (Robert et al., 2017). The foundation of diabetes management is a healthy diet, increased physical activity and maintaining a healthy body weight. However, many of the Saudi Arabians are challenged in following the medically prescribed complex diabetic management regimens.

Diabetes Healthcare Costs

Diabetes is one of the major chronic illnesses that carries significant healthcare costs. Globally, the cost is approximately $1.31 trillion a year (Alotaibi et al., 2017; Bommer et al., 2017). The costs of diabetes include the direct costs for health care and the indirect costs incurred through loss of wages, medical supplies and increased non-routine medical visits, all which contribute enormously to this global financial burden (Boomer et al., 2017). As the rates of diabetes are expected to rise, these costs are also expected to rise creating a major medical and a financial burden including in Saudi Arabia.

The cost of diabetes has significantly increased making it an economic burden in Saudi Arabia (Robert et al., 2020). Most diabetic patients in Saudi Arabia accrues a cost approximately ten times more compared to those without diabetes ($3,686.0 vs. $380.0) (AlMazroa et al., 2018; Robert et al., 2020). The most current report from the Ministry of Health (2017) documented that the cost of diabetic patients was 17 billion Riyals ($4.5 billion USD), constituting approximately 13.9% of the Saudi Arabian total health budget. Because of the increased healthcare needs, the Saudi Arabian healthcare system is rapidly developing (Al-Hanawi, 2019) and has expanded the number of its hospitals, currently with a total of 487 healthcare facilities. However, with this expansion it is projected with the rapidly rising rates of diabetes, the hospital system with its increased facilities may not be able to accommodate this rapidly growing health problem or the rising cost burdened on the health system. The Saudi Ministry of Health is challenged with the increasing number of people with diabetes and the effects of subsequent increasing societal cost. With the rising number of the Saudi Arabian population diagnosed with diabetes and predictions of these numbers doubling, it is expected that the healthcare costs for treating diabetes will extremely burden the healthcare system leaving it unprepared. Interventions are being developed and are desperately needed to educate the people about diabetes, promote healthier daily habits, and establish more broad-based protocols of healthy lifestyles to improve health outcomes and to reduce healthcare cost.

Diabetes Intervention Saudi Arabia

Many self-management interventions have been used to improve the outcomes of patients living with chronic illness including diabetes. Commonly used self-management interventions incudes: Cognitive behavioral therapy, mindfulness (a type of meditation practice), lifestyle modification programs, peer health coaching/peer and technology-based interventions (telephone follow up, smartphone for texting, video, Apps) Carpenter et al., (2018). These self-management interventions have shown mixed results, as the best results are seen in peer support/coaching and technology-based interventions. Interventions such as texting by a smartphone diabetic health information and reminders have shown great improvement in health outcomes with diabetic patients (McGill et al., 2020; Fortmann et al., 2017; Hassan, 2017; Hussein, 2011; Abaza & Marschollek, 2017). Although, this type of intervention is not readily available to diabetics in Saudi Arabia, there is an enormous demand from the Saudi Arabian government to develop interventions to improve the health and the quality of life of diabetics (Istepanian et al., 2014). When compared with other high resource countries, the research and interventions focusing particularly on improving diabetes in Saudi Arabia is distressingly inadequate (Al Dawish et al., 2016). Using a texting intervention holds great potential given that Saudi Arabia has one of the highest rates of smartphones use in the world (88% of the population) (Statista, 2020; Alanzi, 2018). Because of the rapid advances in texting interventions by a smartphone and as diabetes is quickly reaching disturbing proportions, there is a need to explore its potential impact in countries with limited use of technology such as Saudi Arabia. Therefore, the purpose of this study is to examine a texting intervention using a Smartphone with type 2 diabetic patients in Saudi Arabia over 2 months.

Study Purpose

Research Questions

This randomized clinical trial is designed to address the following:

1: Comparing the control and the text messages intervention group, are their differences in health outcomes?

2: Comparing the control and the text messages intervention group, are their differences in medication adherence?

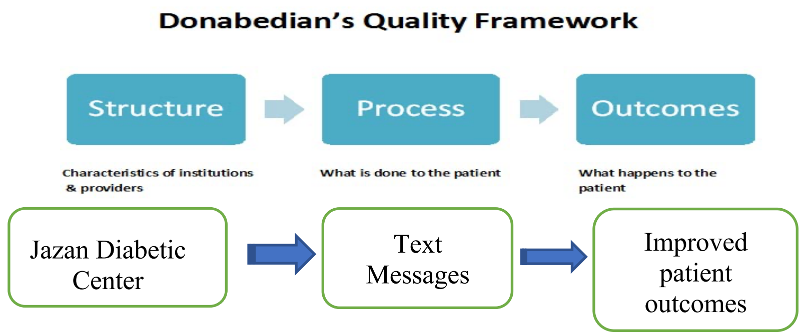
3: Comparing the control and the intervention group, are there differences in (healthcare costs) (i.e., urgent care visits, emergency room visits, rehospitalizations, lost employment time, and texting costs for the intervention group only.

The demographic and health data will be collected at enrollement upon dischage from the Jazan Diabetic Center medical clinic. Using repeated measures, the health and cost data will be collected on months 1& 2. The intervention group will receive text messages three times a week for 8 weeks in addition to usual care. The control group will receive usual care only. Results of this study will provide healthcare professionals with data on the effectivness of a texting intervention with diabetics. These data are important to develop interventions for improved health outcomes for this group in Saudi Arabia.

Conceptual Framework

The conceptual framework to guide the study is Donabedian framework. This quality of care model has three categories which are structure, process, and outcomes. The conceptual framework linking the variables are examining the health services where care is received, the process of services received and evaluating the quality of health care outcomes.

Conceptual Framework



Study Variables for the Framework:

The structure will include Jazan Diabetic Center, one of the largest centers for diabetic patients in Saudi Arabia. The Process is usual care plus the addition of the text message intervention to the participants after discharge from the Jazan Diabetic Center. The outcomes are medication adherence, quality of life, and cost of healthcare compared. The study will examine the process of care and its effects on the outcomes from the process of care.

CHAPTER II.

REVIEW OF LITERATURE

Introduction

Living with diabetes presents challenges to patients in their daily life due to the complex medical regime, dietary restrictions, exercise, and the frequent monitoring of blood glucose (AlBuhairan et al., 2016). Diabetes, a common chronic illness requiring long-term management has risen globally to 422 million (WHO, 2020) and the healthcare provided to diabetic patients most often does not meet the established diabetes clinical guidelines (American Diabetes Association, 2019). It is well documented that diabetes attributes to a high death rates, major health complications and high healthcare costs (Al-Quwaidhi et al., 2014; WHO, 2020).

Saudi Arabia is the largest countries in the Arab World with an approximately a population of 30.77 million people. However, there is a large number of people living with diabetes and this is unfortunately increasing (Meo, 2016; Owolabi et al., 2020).

There are many reasons associated with increasing the prevalence of the diabetes in Saudi Arabia such as culture, religion, lifestyle and the increased wealth especially from after discovering oil. This has dramatically impacted the people's lifestyle, diet, exercise and education, resulting in a more sedentary way of life.

Medical professionals understand that adherence to medication treatment, diet, and exercise are critical factors to the health of patients with chronic illnesses such as diabetes, but struggle to find the most effective methods to educate, motivate and monitor patients to self-manage their care, and therefore reduce complications, healthcare costs, and improve the quality of life of the patients. Carpenter et al., (2018) has shown that interventions with the best outcomes results are seen in technology-based interventions that focus on health reminders and self-management support such as texting interventions. The use of text messaging is used globally in both high resource and low countries. This form of communication that is easy to use provides connectivity to family, friends, and healthcare providers, among others. Globally, it is estimated that 75% of people utilize text messaging regularly to communicate and stay in contact with others (Jones et al., 2014). The majority of the Saudi Arabian people have smartphones text regularly (Insight, 2018). Studies in the United States using texting interventions for diabetics have shown to have significant positive health outcomes (Fortmann et al., 2017). This technological intervention is underdeveloped in Saudi Arabia creating a need to improve the health outcomes in Saudi Arabia.

People of Saudi Arabia: Increased Risk for Diabetes Culture and Healthcare

Culture, religion, and belief systems both influence an individual's worldview as well as impact their everyday decision-making including healthcare decisions (Hawley & Morris, 2017; Singer et al., 2019). One's beliefs are firmly instilled by their family which places individuals into a social system. There are many types of variation surrounded in one's cultural beliefs and traditional beliefs passed down from generation to generation that rules their lifestyle and ultimately effects their health outcomes. Culture can affect the educational level one is able to obtain, their social class perceptions, morally acceptable of right and wrong and for many their ability to seek healthcare. Unfortunately, some strong-willed cultures have a pronounced effect which inadvertently prevents a person from seeking healthcare.

Saudi Arabia has a strong culture which is also rooted in religion (Al-Wassia et al., 2019; Shahin et al., 2019). For the people living in Saudi Arabia, the educated and the upper class are more accepting and open to Western medicine. However, those in rural regions most often have strong cultural and traditional beliefs, are under educated and are inflexible with modernizing healthcare beliefs such as acceptance of Western medicine. The traditionalist believe that God will heal them (Shahin et al., 2019). Some Saudi Arabians are believers in the Quran rather than in modern medicine. The Quran instructs believers that 'nothing will affect them unless Allah (God) wills it.' Therefore, many are not compliant with seeking healthcare or following their medical provider's recommendations. These beliefs act as a barrier to self-care and accessing healthcare (Robert et al., 2017).

Self-Perception.

The majority of the Saudi Arabian people are Islamic. Islam is a religion and a culture most commonly seen in Middle Eastern countries (Abdel-Latif & Saad, 2019; Albargawi et al., 2017). Islamic beliefs govern their self-perception, how people eat, care for an illness, and subsequently define self, including their health perceptions and health seeking behaviors (Dillon, 2020). The Islamic religion is a cultural system that shapes and defines not only their belief system but how individuals seek care during an illness (Shahin et al., 2019; Yeary et al., 2020). An example of this is the Sharia, an Islamic law. According to Alyaemni, et al., (2013) this law dictates a person's gender role expectations and is upheld more strictly in Saudi Arabia than other countries. Saudi Arabia is also a male-dominated society where women are subservient to men. There is a strong sex segregation among men and women. Because of the Sharia, women have restrictions on any public outing, obtaining an education, and have a defined work role. In most instances, a woman cannot do anything on their own. Men are the ones to make most of a women's decisions including when and how to seek health care. Women are to ask for permission to seek medical care from their spouse or their father if not married. A male also must accompany them during their medical visit. This type culture creates barriers especially for women when seeking healthcare because it may not be their preferred type of care resulting in poorer outcomes. Because women must wear certain clothing such as a veil in public including a health physical examination, serious conditions may go undetected. Following cultural expectations has a direct impact on health care delivery especially for the women of Saudi Arabia (AlQarni et al., 2019) and those in rural regions.

Other cultural traditions impacting health is their way of life such as: diet, leisure activities, how they travel, exercise, and seek medical attention. It is widely believed amongst the Saudi Arabians that illnesses are related to their fate of a human being experience and a consequence of God's Will. Saudi Arabian women confront disease with humbleness and acceptance of things that come from God (AlQarni et al., 2019). Culture has a great impact on health and wellness outcomes for the Saudi Arabian people. Being socialized into a cultural system driven by strong religious beliefs and the rigidity of these expectations can negatively impact their overall health. Their traditional beliefs leave them with a lack of many self-care practices and a lack of health seeking behaviors making them more vulnerable for illness (Shahin et al., 2019; Yeary et al., 2020).

Al-Ghamdi et al., (2018) conducted a cross-sectional multicenter survey with Saudi Arabians participants living with diabetes to examine the participants' perception of their illness who were all Islamic. It was reported that the unemployed and the undereducated participants had a significantly longer duration of illnesses compared to the more educated and employed (51.4% vs 48.6%). The insulin-dependent participants (42.6%) statistically significant ($p = 0.000$) had a longer duration of illnesses than participants with the oral hypoglycemic agent (57.4%). Because of the cultural and Islamic beliefs, most of the women participants were not employed and were under educated. The participants reported their perceptions of their diabetes was driven by heredity (75.5%), eating habits or diet (62.4%), aging (46.7%), self-care behavior (43.9%), poor medical care (39.9%), and stress or worry (40.5%). Consequently, 80% of the participants believed that they could control symptoms of the diabetes. However, all their health behaviors and health beliefs were strongly influenced by their culture being that all the participants were Islamic (Robert, 2017). Thus, though not explicated, results suggested that cultural barriers effected their healthcare practices and perceptions. God's Will does not require insulin; exercise is not manifested in daily practice; adherence to Western prescriptions are a cultural conflict (Shahin et al., 2019).

For the Saudi Arabians, most have a cultural reluctance to access care at a modern healthcare delivery system (Abu Hassan et al., 2013). It is well known that if healthcare accessed by attending a diabetic management programs, patients with have better outcomes. However, according to Abu Hassan et al., (2013) because of traditional beliefs, many of the new scientifically developed cures and improved technologies are not being utilized and are affecting healthcare outcomes.

In Saudi Arabia, as with so many other places, culture and its religion having a significant impact on cultural patterns such accessing healthcare, medical beliefs with illness and their health perceptions (Al-Wassia et al., 2019; Shahin et al., 2019). Major inner cities in Saudi Arabia such Riyadh, is extremely wealthy where resources are available to many. In these regions, the people are culturally beginning to modernize and accept some non-traditionally beliefs (Al-Hanawi et al., 2020; Al-Zalabani et al., 2015). In contrast, rural communities often are very poor and don't have these insights available to them. Additionally, rural communities which many are poor, have inferior access to quality healthcare and other modernizing beliefs. As such, educational opportunities, traditional gender inequalities persist, and Western healthcare is non-normative. The over-reliant response to these inequities is due to predominant religious practices which drastically impacts their health, life longevity, and opportunity for change. The Saudi Arabian cultural systems are a significant and profound barrier to receiving adequate healthcare (Al-Hanawi et al., 2020; Al-Zalabani et al., 2015).

Management of Care

Self-Care. For the Saudi Arabians, there are cultural conflicts to medical recommendations including self-care and medical adherence. Given the urban-rural normative variations, diet and exercise traditions, as well as sex-segregation by the Sharia expectations (Islamic law), self-care is affected. The overreliance of a high sugar diet and a sedentary lifestyle both have negative consequences on their health outcomes (Sami et al., 2020). Most Saudi Arabian people believe that when they are in good health, its God's Will and it is celebrated; poor health is believed to be the individual's fate and experience with God (Alyami et al., 2019). As such, self-care may be limited and in certain circumstances it may be not practiced at all. An example of limited selfcare, is foot sitting. This is a practice in which people sit on the ground to eat, relax, and rest for religious purposes. For those with diabetes, however, it can produce foot ulcers and negatively affect their health. To practice self-care, one would not to preform foot sitting but this would not be culturally acceptable (Fakhri, 2006).

Albargawi et al., (2017) conducted a pilot study in Saudi Arabia to examine the relationship between health beliefs with a self-care management regimen and diabetic foot ulcers (DFU) in an outpatient setting. There were a total of 30 Saudi participants, most of them without foot ulcers (60%). Results indicated there were statistically significant interactions between health beliefs and self-care management regimens. Participants with high self-care management regimen ($p = 0.045$) believed that doctors controlled and improve their diabetic outcomes by adhering to their doctor's treatment recommendations. However, participants that doubted their doctor's recommendations or who believed that God would take care of their diabetes, had a lower self-care management regimen ($p = 0.013$). Those who followed their doctor's directives had a good adherence to their diet, treatment modalities ($p = 0.48$). These findings support the belief that culture has an impact on an individual's health decision-making and had a direct impact on treatment adherence, and their overall health.

Diet. The typical Saudi Arabian diet is mainly affected by its cultural beliefs. Their typical diet includes meats such as; goat, sheep, rabbit, camel, lamb and liver along with, rice, bread, dates, and milk including (goat, cow, and camel) (Weetas, 2019). The most popular and traditional dishes daily in Saudi culture are Kabsa, Mutabbak, Jereesh, and Saleeg combined with meats are high in calories, carbohydrates, salt, and fats (Weetas, 2019). The social expectations of the Saudi Arabian diet are strongly embedded in traditions and common to the culture. Most of the people continue to passively follow their dietary traditions. One of their traditions is the consumption of Khat, salt, rice, dates, and sugar-rich foods. According to Moradi-Lakeh et al., (2017) very few people meet the dietary expectations for healthy living. The dietary guideline recommendations are met by only 5.2 % of individuals for fruits, 7.5 % for vegetables, 31.4 % for nuts and 44.7 % for fish (Moradi-Lakeh et al., 2017). Further, the Saudi Arabia National Survey of 2018 reported that most of the nation is far off target in achieving a healthy diet and obesity, diabetes, and hunger are beyond the expectations (Global Nutrition Report, 2018). Many of the Saudi Arabians 42.9% are malnourished, with high rate of diabetes 42.3%, and obese (30.8%). According to Flink (2018), obesity is the leading cause of diabetes and preventable death in this country.

Cultural Dietary and Religious Occasions. A diet tradition that effects their health is the Saudi Arabian people generally follow is the word of Mohammed. One of the Mohammad traditions is eating dates in the amounts of 1, 3, 5, or 7 (Nalamkandy, 2011). However, some people do not adhere to the number specified and they eat a higher amount which affects blood sugar. Some may refuse to change their diet as they feel it goes against their cultural belief system.

Another cultural food is the Khat leaves. The leaves are chewed for its euphoric effect also known as Catha Edulis. Khat leaves comes from Ethiopia and Yemen and are very popular in Jizan. About 33.2% of the people chew Khat leaves due to culture habit and its border proximity to Yemen. Khat chewer culturally believe that, chewing Kat will control and decrease the blood glucose. Badedi et al., (2020) examined Khat Chewing and the association of type 2 diabetes. Results suggested that there was a significant association between Khat chewing and diabetes ($p < .001$). The Khat chewers had higher percentage of diabetes than those who did not chew Khat (29.3%). In addition, 83% of chewers reported that they drank sugary beverages while using Khat. The addition of sugar into the diet was associated with higher levels of diabetes.

A religious Occasion that Affects Diet is Ramadan. Ramadan is the ninth month in the Islamic calendar when all healthy adolescent and adult Muslims fast during sunrise until sunset which includes abstinence from all types of food, drink, sexual activities, and smoking (Abaïdia et al., 2020). Ba-Essa et al., (2019), conducted a 2-year prospective, non-randomized study to describe the rate of hypoglycemia during Ramadan with type 2 diabetes participants in Saudi Arabia. Results suggested that 80% of participants were at a high risk of diabetic complications. The high-risk diabetics were advised to avoid fasting during Ramadan. However, there was a low percentage (29%) who adhered to such guidance and broke to fasting within 2.6 days. Overall hypoglycemia is experienced about 24.7% when not fasting; hypoglycemia during fasting during Ramadan was reported at 92.1%. This study indicates that hypoglycemia increased in Ramadan especially for those who were insulin dependent, and most of the participants did not adhere to the healthcare providers' recommendations (82.8%) due to the religious and cultural believes.

The increase of diabetes in Saudi Arabia is attributable to the lack of information and overall culture dictating their lifestyle (Robert et al. 2017). As part of the traditional Saudi Arabian lifestyle, it is expected to consume a diet that is not health driven rather cultural driven.

Exercise. Saudi Arabia is reported to be one of the countries with the highest rates of inactivity in the world (Kulhánová et al., 2020). Most of the population does not commit to new practices due to adherence to normative social rules and religion. Exercise is not common for most these people. Besides culture being a barrier to exercise, other barriers to exercise is the Saudi Arabian climate. It is extremely hot and humid which effects their lifestyle limiting outdoor activities (Aljefree et al., 2017). Because of strong cultural beliefs women are circumscribed from outdoor exercise due to gender stratification, particularly in rural communities. Also, women's clothing does not promote them to engage exercise (Alkhateeb et al., 2019). For men, exercise is viewed as having a health condition or be in poor health.

A study by Sharara et al., (2018) noted that physical inactivity is a cultural normative for the Saudi Arabians. They also noted that there are factors related to inactivity including increasing age, female gender, and urban residence. However, inactivity decreased with higher levels of education and employment indicating a modernizing changing culture. Another study by Al-Zalabani et al., (2015) determined the levels of physical activity gender. Results found the overall physical inactivity for men and women was high for both (66.6% & 73% %). Less than half of either gender exercised regularly. Men were more active than women and is directly attributed to cultural expectations about gender and subsequent social barriers.

Health Seeking Behaviors- Appointments. To maintain a healthy outlook on personal life, accessing healthcare professionals and facilities is essential in the maintenance of good health. However, avoiding health-seeking behavior is counterproductive in maintaining an active mind, body, and spirit. In Saudi Arabia, though Western technology is readily available, many are late to appointments and some do not attend at all (El Bcheraoui et al., 2015). Many of the Saudi Arabians are not customed of maintaining and attending medical appointments. Health care is offered for free to citizens with more than 420 hospitals and 2000 primary health care facilities available. However, most of the people in Saudi Arabia do not adhere to the routine annual checkups (El Bcheraoui et al., 2015). Thus, the Minister of Health is making great efforts by increased spending to promote health and improve the quality of life especially with non-communicable diseases such as diabetes. Even with all the efforts, such as free health services, and healthcare funding, there were still approximately 43.6% of the population who do not adhere to annual checkups, many with diabetes. Traditionally, Saudi citizens do not seek health until developing or reaching advanced stages of illness (El Bcheraoui et al., 2015). Alshareef et al., (2019) noted in their study that most diabetic patients have specialty physicians due to complications from diabetes, however most appointments are not attended (78.3% - 97.9%). Other researchers have similar findings (Alanazy & Brown, 2020; Brewster et al., 2020; Al-Hamad, 2013). Reasons for missed follow up appointments are poor clinic facilities, waiting time, and poor communication.

Medication adherence. When it comes to adherence to medication there are several significant cultural formations that impact the choice to follow medical directives or not. Those who obtain higher levels of education are typically re-socialized to critically assess traditional healthcare delivery systems against cultural mores and norms while developing new methods of addressing common disease problems (AlQarni et al., 2019). Those who have a traditional and religion-based view of healthcare are less likely to accept new directives as it does not mesh with God's Will. Such beliefs are directly related to lower adherence (Albargawi et al., 2017). Cultural beliefs are a restrictive barrier to taking, using, and adhering to Western medical methods to deal with disease. In Saudi Arabia, particularly in rural and remote areas, the consequences are great.

Jamal, et al., (2018) conducted a cross-sectional study to determine the barriers to medication adherence in the patients with uncontrolled diabetes during a three- month follow-up period in Qatar (Gulf region). Result indicated that there were significant higher HbA1c with non-adherence to medication (p = 0.002). Reason for non-adherence included: forgetfulness inconvenience, using traditional medicine, and side effects of the medicine. Such a cultural barrier had a direct impact on health. Other researchers reported similar findings (Alatawi et al., 2016; Hussein et al., 2019).

Costs Associated with Diabetes Cost: Healthcare and Non-Healthcare

Diabetes is a long-term disease which constantly incurs significant healthcare costs. Globally, it is estimated to cost $1.31 trillion annually (Alotaibi et al., 2017; Bommer et al., 2017). The costs of diabetes include the direct costs for health care and indirect costs incurred through loss of wages, medical supplies, special diets and other expenses which contribute to the cost of diabetes (Boomer et al., 2017). These costs are estimated to be greater than reported because estimating since many of the indirect cost are not tracked.

Healthcare System Saudi Arabia

Saudi Arabians Healthcare system is rapidly evolving and developing (Al-Hanawi, 2019). Prior to 1925, healthcare resources in Saudi Arabia were limited and its healthcare infrastructure was not established (Al-Hanawi, 2019). The initial healthcare service infrastructure started after 1925 and began developing further after the establishment of the Ministry of Health (MOH) in 1950. Currently, Saudi Arabia has grown to a total of 487 hospitals with approximately 72,981 beds, which is about 2.2 beds per 1000 people (MOH, 2017). The Ministry of Health Care employs 31,516 physicians and 75,978 nurses. The Saudi Arabian healthcare system was ranked 26th (out of 191 countries) by the World Health Organization (WHO, 2018) and was also ranked higher than many other healthcare systems in developed countries such as Canada (30th), Australia (32nd) and the USA (37th) (WHO, 2018).

Today, the healthcare system in Saudi Arabia is made up of a comprehensive public government funded (public) system assessable to all. There is also the private healthcare system which is used by people willing to pay. In the year 2018, the Saudi Arabian government allocated a fund of SAR 146.5 billion (1 US dollar = SAR 3.75) for health services and social development, which is 15% of the government budgetary expenditures (Saudi Arabian Monetary Authority, 2018). Currently, 74.2% of healthcare is funded by Saudi Arabian government and 25.8% is funded by private sector. The private healthcare sector owns 24% of the hospital beds (about 17,622 out of 72,981) and 32% of the hospitals (158 out of 487) (Al-Hanawi, 2019). The private sector is expected to increase to 28.1% by 2025 (Al-Hanawi, 2019) because more people are willing to pay for healthcare which is quicker and more convenient compared to public healthcare.

Healthcare Cost of Diabetes in Saudi Arabia

The cost of diabetes has significantly increased the economic burden in Saudi Arabia (Robert et al., 2020). The cost of a diabetic patient accrues approximately ten times more compared to those without diabetes ($3,686.0 vs. $380.0) (AlMazroa et al., 2018; Robert et al., 2020).The most current report from the Ministry of Health (2017) documented that the cost of diabetic patients was 17 billion Riyals ($4.5 billion USD), including undiagnosed diabetics (many have major co-morbidities from not being diagnosed), the cost increased to 27 billion Riyals ($7.2 billion USD). Pre-diabetic (glucose intolerant) patients, increases the total cost to 43 billion Riyals ($11.5 billion USD). These costs constitute approximately 13.9% of the Saudi Arabian total health budget for this chronic expensive disease. Mokdad et al., (2015) reported the amount diabetes is costing the Saudi Arabian government. It was found that patients not attending their routine visits costs $31,911,495 USD; early-stage diabetics patients cost $130,119,131 USD, normal progression diabetic costs $104,941,646 USD, acute complications costs $232,209,832 USD; dialysis/end-stage costs $71,349,594, and cost for transplants due to diabetic complications $29,755,444 USD. Almutairi & Alkharfy (2013) reported in their study in Saudi Arabia, the greater the severity of the diabetes resulted in greater direct medical cost and patients that are able to maintain better control of their diabetes had a positive effect by lowered direct medical costs. Others reported similar findings (Alhowaish et., 2013)

These data are important as it indicates the challenges of the governmental Saudi Ministry of Health faces with the increasing number of people with diabetes and the effects of subsequent increasing societal cost. Approximately, 30% of the Saudi population has been diagnosed with diabetes with predictions of these numbers doubling effect by 2030 (Robert et al., 2020). It is predicted that an increasing percentage of healthcare expenditures will be for treating diabetics, which the healthcare system will be ill prepared. Interventions are being developed to educate citizens, promote healthier daily habits, and establish more broad-based protocols of healthy lifestyles that would improve and greatly lower healthcare cost.

Non-healthcare Costs

Diabetic non-healthcare costs include the cost from missing work to attend medical appointments, unexpected emergency room visits, self-care management (i.e., medical supplies, prescription medications) amongst others. Non-healthcare cost become greater mainly due to the consequences of an unhealthy lifestyle such as little to no exercise, unhealthy diet, and obesity. Over the past 40 years major socio-economic changes have occurred in Saudi Arabia. The growth and wealth to the people have brought changes to their lifestyle. The greatest changes are with diet and less physical activity. There is an increased consumption of fast foods and sugar-dense beverages (e.g., sodas). Simultaneously, technological advances such as cars, elevators, escalators, fast food availability have led to a decrease in levels of activity and poor diets. These lifestyle changes have resulted in the rapid increase in the incident diabetes and the related non-healthcare costs.

Cost Self-care Management. Diabetes self-care management, and complications from diabetes are considerably more than the cost compared with most others illness (Robert et al., 2020). It is well documented that diabetes is a major cause of health-related complications and extreme financial burdens for the patient, patient's family as well as burdening and overwhelming the healthcare system (Dall et al., 2019). Healthcare providers emphasize to their patients that self-management is critical in preventing and reducing the risk of major health complications. Persons that are non-adherent and/or non-compliant to medication and prescribed self-care is a major issue because of its associated high risk for health complications, early morbidity and increased health costs (MacDonell et al., 2016). The biggest contributors to the increasing self-care costs annually are higher use of prescription diabetes medications ($1,093), higher use of hospital inpatient services medications and supplies to directly treat diabetes ($1,653) and more office visits to physicians and other health providers $11,706, and dialysis /end-stage cost $35,971 annually (Mokdad et al., 2015).

Family Costs. Generally, most Saudi families are one-income families with their income dependent on the father or the male head of household as most of the women are stay-at-home childcare providers. However, there are some families with two incomes in the instances where the women work outside of the home. In most of the families with only one income, the income is enough for the family's basic needs since healthcare is provided by the Saudi Ministry of Health at no cost to the public. However, having diabetes costs the families and affects their budget as an indirect cost. A diabetic who is the sole income provider for the household, there may be a loss of income for the family from lost wages to attend medical appointments or a hospitalization. When the income provider dies early from complications of diabetes, this brings a great financial burden for the family (Baig et al., 2015) losing their families annual income (John, 2019).

Lifestyle. Lifestyle such as diet, exercise, adherence to prescribed medical treatment (medication, self-care) effects the cost of diabetes. Alomar et al., (2019) examined the impact of costs associated with diabetics when not following the prescribed lifestyles. It was reported that more than half of the participants (51.5%) did not adhere to the diabetic diet; 32.7% did not believe exercise decreases blood glucose. Many participants (45.5%) did not adhere their medications; and 34.7% lacked substantial awareness of the disease and self-care and this impacted overall healthcare costs. Those who followed prescribed lifestyles had a mean direct cost of 952,8 Riyal ($2,541 USD);

compared to those who did not had higher costs of 13,346 Riyal ($3,559 USD). Such findings are important to increase awareness and improve on interventions in the healthcare system in Saudi Arabia. These data document that improved diabetic management and education lowered the costs of care and improves health outcomes.

Loss of work. Diabetes self-care management for prevention of complications requires the patients to attend usual routine visits and may have more clinic appointments and emergency room visits compared to non-diabetics. As a result, this extra time needed to attend appointments and emergency room visits, resulting in loss of work and lost wages. Patients attending a public healthcare facility need to take the day off from work due to the commute in traffic and time spent waiting for and receiving services. Many of the public healthcare facilities are not conveniently located where people are living and working, and many have long wait times. A routine appointment for a diabetes patient could cost up to 8 hours of lost wages, adding up to approximately $188 per appointment. On the other hand, other people with higher resources may choose to go to a private clinic that is closer to home and can be seen quicker. For some families with limited resources, lost wages for attending medical care could present a serious financial hardship for their family (Baig et al., 2015).

Doctor visits, Emergency Room visits & Hospitalization. People with chronic illnesses such as diabetes are 4 times more likely to have emergency room visits and hospitalizations. (Alghanim, & Alomar, 2015; Baig et al., 2015). These visits are costly. Almalki et al. (2019) examined emergency room visit rates associated with diabetics in Saudi Arabia between 2011- 2015. The number of diabetic emergency room rates visit increased over the years significantly (*p* = 0.02) from 617,683 cases in 2011 to 748,605 in 2015, costing yearly for the diabetic patients approximately $37 million dollars.

The cost per bed per day for hospitalization for a diabetic patient in Saudi Arabia ranges from is $96 to $170 depending on the severity of the condition resulting in an approximated yearly hospitalization costs to be $56 million (WHO, 2020). It has been well documented that the costs of diabetes are extremely burdensome to the healthcare system and interventions are needed to lower these costs.

Diabetes Supplies. All diabetic supplies are provided from the Ministry of Health without costs to citizens of Saudi Arabia. However, there was no literature found documenting the Ministry of Health costs for diabetic supplies for Saudi Arabian patients. These costs are not broken down and usually 'lumped in' as a direct cost expense along with other expenses. Using a high resource comparable country such as the US, diabetic supplies in the US costs approximate $320 monthly for patients (Lindberg, 2018). At times there is a shortage of equipment such as blood glucose monitors or checkers. When supplies are low, some patients in need may pay out of pocket to buy their own diabetic supplies. The average costs around for out of pocket supplies may be as high as $150 for the month.

In summary, the cost of diabetes impacts the patient, their family and the healthcare system. Many patients are not adherent with their healthcare regimens, and their medical appointments leaving them with fragmented care. Studies indicated these diabetics patients' issues (health awareness, beliefs, how they seek health care, the number of prescribed medications and adherence) have negative effects on their self-care management and their health outcomes. Interventions where there is patient support improves their adherence, health outcomes and costs. In Saudi Arabia, research to develop and test technologic interventions are needed as there were very little data on diabetic patient using these studies.

Diabetes Interventions using technology

Interventions using mobile technology (i.e., texting, apps, and video chats) has enormous potential to improve diabetic patients' outcomes. Studies have shown that by providing diabetics with the tools (ie., monitor, track, receive reminders, couching messages, educational information) they are able to improve their selfcare more easily (American Diabetes Association [ADA], 2020). There is a strong need for further the research with the use of smartphone technology especially in Saudi Arabia. Despite the positive economic conditions in the Middle East and the constantly improving health care system in some areas such as Saudi Arabia, the United Arab Emirates, Qatar, Jordan, Iraq, and Bahrain, all these countries have demonstrated a lack of self-management for diabetes care, and more specifically have limited studies examining the use of mobile technology to improve diabetes self-management. Research has shown that mobile technology interventions motivates diabetes patients to participate in self-monitoring their health and improving adherence (ADA, 2020).

Types of Smartphone Mobile Technology:

There are many types of studies that have been conducted to examine how smartphone mobile technology has been used to improve health outcomes globally. The majority of the studies includes using texting (one-way texting, 2-way texting), video conferencing, and the use of applications (APPS). These studies have focused on the use of smartphone technology for smoking cessation, weight loss, diabetes education, depression and a myriad of different health-related issues (Hassan, 2017; Hussein, 2011; Abaza & Marschollek, 2017). However, there is a paucity of Middle Eastern studies (include Saudi Arabian studies) testing mobile technology interventions with diabetes. Alanzi et al., (2014) documented the majority people of Saudi Arabians, (97%) used/owned Smartphones. Texting and emailing (77%) was the most preferred contact method because of real-time feedback received. Social media (blogs, forums) was the next preferred (73%) followed by education by videos (67%). However, there are limited studies in Saudi Arabia examining the use of mobile technology with diabetics. There are a total eight mobile technology studies found in the Middle Eastern regions including Saudi Arabia. Because of the limited Saudi Arabian studies, Middle Eastern studies are also included with their outcomes. These studies include: 5 texting studies including from Jourdan, Bahrain, Egypt, Turkey, and Iran; 2 Apps studies, and 1 social media study. Currently, there are no Middle Eastern studies found in the literature using video technology. See appendix table 2 for all the studies.

Texting. Globally, 5 billion people use text messaging to communicate daily, which is approximately 65% of the worldwide population, and expected to increase to 77% global population (SlickText, 2020). In the US at least 97% of smartphone owners text regularly (Smith, 2020). According to Grossbard, (2020) 98% of all text messages are opened, and 95% of text messages are opened and responded to within 3 minutes of being delivered.

Texting is used most often for communication, provides connectivity to family, friends, and healthcare providers, among others. It is increasing as a health improvement intervention used by individuals in both wealthy and developing nations (Jones et al., 2014; Urvish, 2017). In the United States, studies using texting interventions for persons living with diabetes have found this intervention is easy, low cost and has shown a greater improvement in diabetic glycemic outcomes and self-management regimens (Fortmann et al., 2017; Greenwood et al., 2017; Hall et al., 2015; Hassan 2017). The studies using mobile technology for texting are used for many types of healthcare issues (ADA, 2020) and have shown positive outcomes including lower mortality rates, improved monitoring of diabetes and quality of life. (ADA, 2020). The use of texting for self-management with people suffering from chronic diseases is an asset to both patients and clinicians.

Texting Interventions Middle East. It is estimated that most Saudi Arabians, (91%) use texting regularly (Insight, 2018). However, Middle Eastern Arabic-speaking countries such as Saudi Arabia, lack of studies using texting interventions with diabetics. The few studies that exist have shown positive outcomes. Most studies using a texting intervention includes a one-way text to the participant which the participants receive a text message but cannot reply back. There is also a two-way texting intervention where the participant receives a text message and can reply back to the sender for questions or more information. The majority of the texting interventions are 1-way texting interventions.

One-way texting Interventions. Bahrain by Hussein et al., (2011) tested a one-way texting intervention with diabetics in the Middle East. The majority of messages were related to home glucose monitoring, healthy diet, physical activity, medication adherence, diabetes knowledge, and lifestyle modifications) and weekly reminders explaining various diabetes self-management behaviors. The result showed a significantly positive outcomes by a reduction in A1c values (p =0.001). Another researcher, Celik et al. (2015) in Turkey, assessed the use of mobile phone messages to improve insulin injection techniques and glycemic control in diabetic participants. The intervention included 12 short text messages related to insulin administration twice a week for six months. Participants' level of knowledge and skills for insulin injection and techniques were measured at the baseline, 3 months, 6 months, and 12 months. The results showed a significant ($p < 0.05$) improvement of the patients' level of knowledge and skills regarding insulin injection techniques at 3 and 6 months. The Hgb A1c levels were also statistically significant; they decreased ($p<0.001$). The Celik et al., (2015) study was an effective one-way texting intervention that improved diabetic outcomes.

Another one-way texting education intervention to improve diabetics self-management Cairo, Egypt, was by Abaza & Marschollek (2017). The researchers examined the feasibility of using daily text messages about a healthy diet, physical activity, medication adherence, diabetes knowledge, and lifestyle modifications with weekly reminders explaining self-management behaviors. The participants received a total of 3,880 messages. Messages content sent by participants included educational, reminders, and greeting messages. Results indicated that the participants had a significant mean decrease in their HbA1c (0.69%; p = 0.003), the mean blood glucose level decreased significantly (p = < 0.01) and participant's knowledge of diabetes was also increased. Overall, Abaza & Marschollek (2017) provided evidence participants had substantial improved outcomes.

Two-Way texting interventions. A study conducted in Jordan (Arabic speaking county) by Hassan, (2017) used a 2-way text message intervention to improve participates foot care practices in a pretest/posttest design over 7 months. The sample included 286 participants in the pretest and 225 participants in the posttest participants (118 women/107 men). There were three primary outcome measures: (1) foot care knowledge, (2) foot care practice, and (3) development of new Diabetic Foot Ulcer (DFU). The intervention included a one-hour foot-care instruction program foot care, general diabetic care, and how to receive and reply to text messages. During the 12-week study period, the primary investigator contacted the participants four times a week using a 2-way text messages. The participants were able to contact the primary investigator if needed. The result of the level of knowledge and foot care practice for pre/post intervention scores indicated that the scores improved significantly (p = .05) in all 3 categories (Good, Satisfactory, and Poor). The use of smartphones for a text messaging intervention was a significantly effective method in educating participants in managing their foot self-care. The Hassan (2017) study suggests that a smartphone texting intervention could inform future Arabic-centered studies in Middle Eastern countries such as in Saudi Arabia.

Another two-way texting intervention includes a study by Hussein et al., (2011), in Bahrain (a middle eastern country). The intervention included the participants with the ability to send text messages to their physician or the clinic educator in between visits. Participants were able to send to their physician their home blood glucose values, ask about sick days, travel days, hypoglycemia and/or hyperglycemia actions, dietary advices and any related issue to their diabetic care. The physician or educator sent a text if no text was received from the participant within 7-day period. A total of 12 participants received the study intervention in addition to usual care (monthly visits for routine checkups and medication refills). There was an average of 17.5 messages sent from the participants per month. The messages were mostly on home glucose monitoring (64.7%), and some were on food related questions (7%), asking about hypoglycemia (6%) or hyperglycemia, (4%) regarding travel advice, exercise, weight loss, and (9%) and unexpected messages such as holiday greetings. Result indicated a significant (p = .001) reduction in A1c values when compared to baseline values. These findings suggested that text-messaging intervention improved their A-1C, supported participants needs, and improved their self-care skills.

Texting intervention compared with telephone follow up. Katalenich et al. (2015), found that using an automated Diabetes Remote Monitoring and Management System (DRMS) that sent text message or phone call reminders prompting the participants to test, then report their blood glucose levels through an automated system, improved diabetics overall health. The results of this study indicated that diabetes could be controlled with an automated remote, telephone-based system, and the system could be scalable and cost-effective. Another study with similar findings includes a study by Zolfaghari et al., (2012). These researchers compared the effectiveness of two methods of follow-up which included a texting intervention and a telephone follow up with diabetics over a 3-month period. The intervention group received texting information about diet, exercising, medication adherence, diabetes self-monitoring, and stress management. The telephone group was provided by telephone call for three months with the same information as the texting group. Following the 3-month intervention period, both the SMS group and the Telephone group showed a reduction in Hb1Ac levels by approximately 1.0%. Despite this finding, there was a significant change in adherence to diet (*p* = 0.00), exercise (*p* = 0.00), and medication (*p* = 0.00) in either of the groups. Researchers concluded that texting is as effective as telephone follow-ups. The results of this study support that texting is less expensive and just as effective as individualized phone calls.

Zolfaghari et al., (2012), an Iranian study (Middle Eastern country), compared the effectiveness of a texting intervention to a telephone follow-up intervention with diabetics over a 3-month period. The goal of the study was to determine which method (text/phone call) would improve blood glucose levels most (HbA1c <7). Both groups (Text group and Telephone group) received a three-day education session on diabetes self-management on educational information about on the nature of diabetes and risk factors, monitoring the blood glucose levels, diet, exercise, and medication adherence, self-managements reminders (i.e., diet, exercise, reminders about medications, self-monitoring blood glucose, and stress managements). The texting group received 6 one-way texts messages per week, every week during the 3-month period totaling 72 messages. The Telephone group received a phone call twice a week the first month, and then one call monthly for the 2nd, and 3rd months. The calls averaged approximately 20 minutes in duration and about 16 calls were made over a three-month period. Results indicated that following the 3-month study period, both the texting group and the telephone group showed a reduction in Hb1Ac levels by approximately 1.0%. Despite this seemingly small change, there were statistically significant changes in adherence to diet (*p* = 0.000), exercise (*p* = 0.000), and medication (*p* = 0.000) in both groups. The researchers concluded that the use of texting was as effective as telephone follow-ups.

The importance that this study that the use smartphones is a promising method to educate and improve diabetic patient's health.

Given the cost benefits of using texting over individualized telephone calls, the results support that the texting intervention a faster and simpler method which can be successfully used when compared to the more labor-intensive and expensive options such as phone calls.

Mobile Phone-Based Video Messages. Mobile phone-based, one-way video messages intervention for diabetes self-care support has shown positive outcomes with diabetics. Bell et al., (2012) examining received self-care video messages from a nurse practitioner daily. The intervention included 540 different self-care video messages (30 to 60-seconds long), developed by six nurse practitioners. Each video message was based on the recommendations by the American Association of Diabetes (Bell et al., 2012). The intervention group received one daily video message via smartphone for one year. The results of the study showed that there was a significant improvement in Hemoglobin A1c (p = 0.002). A study done in Australia by Fatehi et al., (2015) conducted a pilot randomized control trial to evaluate endocrinologists' use of face to face vs. video- with diabetic patients. The face to face group received a consultation enhanced with video consultation, while the usual care group received only face to face consultation. The result indicated that the difference between the two groups on the level of agreement between endocrinologists in changing medications was not statistically significant (0.76 vs. 0.69), and the agreement of changing medications was lower in the video consultation (64%) than in the usual care group (78%). However, the results were not statistically significant.

Mobile Phone App Interventions. Mobile phone apps were first developed in 1993 Sarwar & Soomro (2013) and have become a popular for intervention studies. They provide users with an interactive platform where people can search for information, get linked through chats, and messages. Diabetic patients can easily retrieve information related to their disease and health, and they can easily connect to healthcare providers by sending and receiving information. Apps offer medical professionals and their patients a convenient, continuous, and instantaneous method to communicate with patients. There many studies in the US and other developed countries using App interventions. However, currently in the Middle East including Saudi Arabia, there are only 2 studies examining the use of mobile phone Apps with diabetics.

AlQarni et al., (2016) conducted a mixed-methods retrospective content analysis of the use of the mobile phone app Facebook with an Arabic speaking diabetic group sharing information about the disease. Data was collected between 2010 to 2015. There was a total of 55 Facebook groups screened. The postings from the groups totaled 6,107 and 1,551 were analyzed. These posts included 458 (30%) from Egypt, 311 (20%) from Lebanon, 250 (16%) from Sudan, 120 (8%) from Saudi Arabia, 98 (6%) from Algeria,75 (5%) from Syria, 55 (3.5%) from Iraq, 34 (2.2%) from Morocco, 28 (2%) from Jordan, and no posts from Somalia, Yemen, Comoros, and Djibouti. The majority of the posts were from females 863 (56%), and the focus of the posts were: sharing personal experiences 423 (27%), raising awareness 210 (3.5%), spiritual support 162 (10.4%) and providing education 110 (7.1%) on diabetes mellites. Most of the posts were by participants between 40-60 years old. This study indicated that diabetes patients were willing and able to use appropriate interventions such as education and self-management through and App such as Facebook. The study results confirm that apps such as Facebook, provide an easy way to reach others to convey important information. Users trust the app and feel comfortable sending and receiving information.

Another App study in Basra, Southern Iraq examined the DIAR a smartphone app. The DIAR is a smartphone diabetes self-management system made up of two main components: (1) smartphone self-monitoring of blood glucose (SMBG) and (2) a remote web interface and health management system. The smartphone is linked wirelessly via Bluetooth to the patient's blood glucose monitor. Istepanian et al. (2014) conducted a pilot study using the DIAR system to examine mobile diabetes self-management. The intervention included a smartphone systems APP (The patient's glucose measurement and medical data are sent wirelessly via the internet to the remote server. The DIAR app has information about the diabetes such as diet, exercises, and can be accessed by patients to communicate with health providers. The intervention period was 3 months with a follow-up period of 6 months for each group. The results were statistically significant in decreasing the HBA1c ($p < 0.05$). This study documents the effectiveness of a smartphone app to improve participates with self-management diabetic support.

APPs Interventions – US. Feuerstein-Simon et al., (2018) conducted a pilot study for 12 weeks using the Joslin HypoMap App to reduce hypoglycemia in type 1 diabetics at the Joslin Diabetes Center at SUNY Upstate Medical University. The HypoMap App was designed to improve a user's hypoglycemic awareness. The App provides a platform for users to record their symptoms, contributing factors, and treatments they implemented during their hypoglycemic events. HypoMap app is synchronized with their smartphone allowing a hypoglycemic reading to trigger a reminder from the App to enter their information. In this study, the participants received training on the App, which included how to track and increase their awareness of hypoglycemia**.** The inclusion criteria included that the participants have two or more responses in the Clarke Hypoglycemia Unawareness survey indicating they lacked an awareness of hypoglycemia signs and symptoms. The participants who completed the study had less daytime hypoglycemia minutes with glucose <54 mg/dL (36% of CGM: mean ↓331 minutes) and hypoglycemia minutes with glucose ≤ 70 mg/dL (77% of CGM: mean ↓449 minutes) and they improved greatly on their awareness of hypoglycemia symptoms. A study limitation was the small sample size and some participants had difficulty of using the technology.

Garg et al., (2017) conducted a prospective randomized study over a 6-month period to improve diabetics overall health using the iBGStar App. The iBGStar maintained connected to the researchers by electronic communication such as email, text, or phone call, every 7-14 days. The iBGStar App provided a significant improvement in diabetics self-management and decreased their Hgb A1c is increasing as well as information sharing using social media apps such as Facebook on smartphones.

App Interventions Outside the Middle East. A Canadian study by Ryan et al., (2017) conducted a 4-month pilot study to examine the improvement of A1C levels of diabetes patients using a smartphone app. Ryan et al. (2017) developed an application linked with a website tilted: Intelligent Diabetes Management (IDM). The IDM worked as an insulin calculator and electronic diabetes diary, and the goal of the app was to improve glucose control levels. Participants with diabetes were from the University of Alberta Hospital in Canada. The study was conducted over a 4-month period; the first 4 weeks was for observation, downloading the app, teaching the participants how to use the app, and reviewing the participants' records. At 2, 4, 8, 12, and 16 weeks, records were reviewed online by the clinical team. Participants entered the data and received their results electronically through the Intelligent Diabetes Management App. Glycated hemoglobin (A1c) was recorded by the participants via IDM at the baseline and by the end of the study. A survey was provided to gather data regarding monitoring practices, glucose testing, and recording practices. The result showed participants who used the smartphone app IDM significantly improved their A1c level ($p < 0.001$). The results provide an example of the successful use of the app for diabetes self-maintenance which resulted in the lowering of A1c levels.

Another App intervention in Toronto Canada includes a mobile phone health coach app; The Health Coach (HC). The app is to support health behavior change with the support of an on-line health coach in patients with diabetes (Wayne et al. 2015). The app was able to track blood glucose level, exercise frequency and duration, food intake, and the ability to communicate with a health coach. In the HC app, clients set their goal, which is self-determined leading to improved physical and mental health outcomes and monitored their daily progress. Participants attended an Exercise Education Program (EEP), which included training with weights and bands and cardiovascular exercise, reminders, and use of the app's self-monitoring features. The result of the study showed that initially there was no significant change of HbA1c for either group ($p = .48$). However, a significant reduction at seen 3 months ($p = .03$) and with ($p = .001$) at six months. This study showed that this smartphone apps coupled with human support (health coaches) and reminders contributed to the successful reduction of HbA1c levels for the participants in the intervention group over a six-month period. This study is important because more research must be conducted to determine if the added human component is a determining factor in the successful use of apps for medical self-monitoring and adherence by diabetes patients.

A study in Singapore by Goh et al. (2015) conducted a short-term (8-week) using the Interactive Diet and Activity Tracker APP (iDAT) with diabetic patients. The intervention included weekly self-monitoring glycose control reminders, diet management, exercise tracking (monitored counted steps), fitness workouts, a calorie counter and recorded weight and goals. The participants set their own goal and tracked their progress. The participants were provided with instructions on using the iDAT APP. Results indicated that most of the participants (78.6%) either didn't use iDAT, or they used it only in the first two weeks; only 9.5% of the participants used iDAT for the entire eight weeks of the study. Female participants use was significantly higher (OR 19.55, 95% CI 1.78-215.42). Participants with high exercise motivation scores used the app intermittently (OR 1.82, 95% CI 1.00-3.32). The researchers did not address the possible reasons the participants didn't use the APP. One reason may be due to the participants were higher educated and partnered and not in need of the intervention. This study signifies the importance of considering the target population in most in need for APP use to be successful.

Rasmussen et al., (2015) smartphone use on monitoring diabetes foot ulcer in Europe. The participants uploaded an image of their foot ulcer to the healthcare provider, a written assessment and treatment strategy provided by the healthcare providers, two at home visits and one consultation at the outpatient clinic. The result indicated there were no statistically found in improvement (*p* = 0.42). It was stated that the possible reason for not finding significance was they found it was better for the participants to attend the clinic rather than using an image uploaded by a smartphone for diabetic care.

Gunawardena et al., (2019) conducted a 2-group pilot study for six months of using the smart glucose manager mobile application with diabetics in Sri Lanka with experts from the USA. The intervention was using a Smart Glucose Manager (SGM) App that included reminders to check their blood glucose, medication adherence, exercises, insulin dose calculator, graphs, and were provided a diabetic specialist available for them. There intervention group using the SGM app, and control group received usual care. The result indicated at the 6 months the SGM group had a statistically significant decrease ($p < .001$) in their Hgb A1c than the control group (7.2% vs. 8.17%). Thus, mobile applications showed a significant improvement especially with self-managements with diabetes patients. These findings indicate that the use of Aps can significantly improve patient knowledge and improve health outcomes. Importantly, it was shown that there was a significant improvement of self-care with the use of smartphone apps.

App combined with Social Media Intervention. Alanzi et al. (2016) conducted a study in Dammam, Saudi Arabia to examine a novel design and development of a smartphone system for diabetes patients. The study tested the usability of the Saudi Arabia Networking for Aiding Diabetes (SANAD) system to stimulate social behavioral change and management. SANAD, developed by Alaniz et al. (2016) used smartphone technology combined with diabetes management and a social networking model. The diabetes management and social networking model contained three major components: (1) smartphone diabetes management, (2) social networking, and (3) behavioral management change. The SANAD system allowed patients to message other users, post comments, insert their blood glucose values and send and receive data. It also worked remotely through a web portal hosted in a hospital. The web portal app could be used for scheduling appointments, reviewing patient records and monitoring patient's adherence to medications. There was a total of 33 participants: (17 male and 16 female) whose ages were between 18-65 years. The results indicated that participants accepted the used of the SANAD system. However, diabetic outcomes were not reported. Information sharing using social media apps such as Facebook and other social media platforms on smartphones in increasing. These sites may be used to make connections with diabetic patients in finding novel interventions. However, internet access may be limited for some people in some countries.

App Trackers. The first continuous glucose monitor was developed in 1999. Currently, there are Apps designed for diabetics to function as glucose monitor in the form of sensors and trackers. The majority of these systems allows users to share their glucose results with their healthcare providers (Zimmerman et al., 2019). Having this data quickly assessable to them improves their self-treatments and detects signs and symptoms of glucose issues quicker and easier. The most common Apps having these functions includes Dexcom, HypoMap, iBGStar, and Smart Glucose Manager (SGM). These Apps are a type of platform, which detects their glucose levels, and helps increase the user's awareness of hyperglycemic/ hypoglycemic events. These Apps alert, records symptoms, and helps the user detect the perceived cause, and the user can log in the type of self-treatment given.

According to Gundu (2018), Dexcom G6, the latest model is one of the most recent App trackers. It was approved by the FDA in 2018 as a continuous glucose-monitoring sensor and an insulin dosing system, which does not require blood by a fingerstick. The Dexcom G6 sensor attaches to the user and continuously detects their blood glucose. The sensor can be worn for 10 days and their data can be shared with others through a smart phone App. This App was one of the first developed as a continuous glucose monitor. In a study by Lind et al., (2017) they compared a Dexcom group with an insulin injection group. A total of 161 randomized participants were recruited over a 26-week period. Participants mean age was 43.7 years, 45.3% were women, and mean HbA1c was 8.6. Results indicated that the use of continuous glucose monitoring compared with the insulin injection group for 26 weeks resulted in lower HbA1c. Another common App is the iBGStar App. This App contains a small meter that attaches to an iPhone or iPad to measure the blood glucose. The iBGStar apps is a blood glucose tracker allowing users to enter insulin and carbohydrate information. The data from the App can be shared with the user's healthcare providers, family and friends. In addition, it stores the trends of blood glucose over time and allows users to input personal notes. The Smart Glucose Manager (SGM) App can be downloaded on an iPhone or android phone to assist diabetics in reminding them to check their blood glucose, medications and insulin injection reminders, exercise and eating on time.

These Apps are available globally; however, currently there are no studies done examining their outcomes in the Middle East, specifically Saudi Arabia. The glucose tracking sensor Apps are continuously developing, and hold promise to greatly improve a diabetics overall health. Studies in regions where diabetes is highly in need.

Complications with App interventions: It has been documented that some of the complications found with apps are participants making errors when entering their data into the App (Katalenich et al. 2015). Data entry errors makes the participants results unreliable and questioning the APPs for its usefulness.

Summary

Saudi Arabia has shown a significant and profound barrier to self-management and care for diabetes. While technological enhancements have improved outcomes the Saudi Arabian culture always lags behind innovation (Combi, 2016; Saddik & Al-Dulaijan, 2015). The Saudi Arabian people are open and willing to use technology in the self-management in their health condition despite of all culture barriers (Alzahrani & Alanzi, 2019; Saddik & Al-Dulaijan, 2015). Alzahrani, & Alanzi, (2019) documented in their study the Saudi's perceptions about using smartphone technology. Results indicated that most of the participants (97%) used their smartphone for social media (81%), WhatsApp (96%) followed by Snapchat (68%) amongst others. Hence, 78% found it was useful in raising public awareness and use in health education, 44% found it useful in increasing communication and answering questions between doctors and patients, 25% found it to decreases cost to patients. This important data that indicates the wide range of smartphone technology the Saudi Arabians are using and are able to use despite the cultural barriers and difficulty. Abolfotouh et al., (2019) noted that many (86.8%) of the Saudi healthcare provider used smartphone technology as a medication information source, to help in diagnosis, improve medical access, medical documentation, and patient health education. Thus, in Saudi Arabia, using technology for healthcare delivery, monitoring, and access to care is growing (Abolfotouh et al., 2019). The Saudi Arabian government is advancing the technological innovation by the use of smartphone apps, video calling, and texting. However, these are successfully integrated into other countries, such as the United States, adoption in Saudi Arabia has been slower to manifest (Alanzi, 2018; Khorsheed, 2015). Smartphone technology can be used to efficiently and effectively monitor and guide patient behavior, culture, and adherence to medications. The rapid improvement of Saudi Arabia economy also allowed for the growth and development of modern technologies. Technology is changing the way in which many Saudi Arabians see the world and their culture.

Conclusion

Diabetes numbers are dangerous increasing in Saudi Arabia and is considered a major healthcare challenge. To address this health issue, initiatives are developing in Saudi Arabia to use the most effective methods to educate, motivate, and monitor patients to self-manage for improved health and more efficient costs (Alanzi, 2018). Studies have documented positive outcomes using smartphone technology in the Middle East and other parts of the world. Saudi Arabian researchers, Alzahrani, & Alanzi, (2019) documented the people of Saudi Arabia are receptive to use mobile technology interventions. With the few studies available in the Middle East, texting interventions were the most promising (Ardianti et al., 2020), followed APP interventions (Levine et al., 2019). However, because of the limited amount of studies, there is a significant need to further the research in this area. Studies in Saudi Arabia are needed to gather the knowledge that will be useful in identifying the participants that will benefit most from mobile technology interventions.

The current study proposes to examine a texting intervention with diabetic's patient's for medication adherence, improved self-care, and healthcare costs and use. These study data are important for the Arabic countries, that texting interventions could improve diabetic outcomes in the Middle East. However, in Middle Eastern countries including Saudi Arabia, there is a lack of studies using texting interventions with diabetics. Results are important to develop practice models and health policies by researchers, policy leaders, healthcare systems to improve the outcomes of diabetic patients.

CHAPTER III.

METHODOLOGY

Research Design

This study used a randomized clinical trial to compare the health outcomes and healthcare charges between two groups of participants diagnosed with diabetes in Saudia Arabia attending care the Jazan diabetic center. An intervention group received 3 text messages weekly on diabetic health information (i.e., medication and appointment reminders, educational health information) to their smartphone for 2 months in addition to usual care (routine well-care visits including physical exanimation, health education, possible lab work, and medication refills, adherence, review of correct dosage, frequency of medication) from the Jazan diabetic center. A control group received usual care from the Jazan diabetic center. Both groups followed for 8 weeks including their adherence to their usual care. Data on health outcomes (improved quality of health measured by the *World Health Organization Quality of Life (WHOQOL-BREF)* scale, adherence to their prescribed medication measured by the using the four-item *Morisky Green Levine Medication Adherence Scale (MGLS)* and data collected on the cost of care (i.e., collecting unplanned medical care visit costs, unplanned diabetic supplies, loss of work).

Setting

The study conducted at the Diabetic Center in Jazan, Saudi Arabia with the support of the Institute of the Ministry of Health. The center is the one of the largest centers for diabetic patients in Saudi Arabia and it is affiliated with the Ministry of Health. With over 55 experienced diabetic medical providers attend to the services for diabetic's patients which includes 25 nurses, 10 doctors, 5 laboratories, 5 pharmacologist, and 5 social workers. The center provides its patient's a physical evaluation, diagnosis and treatment, diabetic education, specialty clinics (i.e., clinics: foot, nutrition and eye), on-site laboratories, and collaboration for research. The clinics provide patients with follow-up healthcare, education and a multiple healthcare service. Currently, the diabetic center attends to approximately 22,000 adult and older adult patients. The majority of patients are Saudi Arabian. Most of these patents (60%) meet the study criteria. Patients attending these healthcare clinics receive usual care (routine well-care visits including physical exanimation, health education, possible lab work, and medication refills, adherence, review of correct dosage, frequency of medication).

Prior to any study activities such as recruitment of participants, IRB approval obtained by the Jazan Diabetic Center and Florida International University.

Sample

Using the sample size calculation guided by G power, a convenience sample of 154 participants with type 2 diabetics who meet the inclusion criteria recruited. Power analysis for the sample size determined based on a significance level of $p = .05$ and acceptable power of 80% and above. Using a medium effect, a sample of 128 (i.e., 64 in each group) will be necessary to provide 80% power using a two-sample t-tests answering the research questions for medication adherence and the participants quality of life. The planned sample size (N =154), accounting for 20% attrition, will be sufficient to provide 80% power with a significance level of .05 for the analyses. Another Middle Eastern researcher had a total population of 150 using a 2-group randomized control trial text message intervention (Peimani et al., 2016).

Inclusion criteria of this study. Participants attending the Diabetic Center in Jazan, Saudi Arabia with a diagnosis of diabetes type 2 who are medically stable without other major medical complications (i.e., heart disease, renal failure, blindness) recruited. Participants ages will range from 40-65, taking prescribed diabetic medications; are smartphone owners with the ability to read text messages in English or Arabic. Patients must be living in the Jazan area and attending the Diabetic Center in Jazan for their diabetic care.

Exclusion criteria of this study. Participants who do not own a smartphone; any condition that does not allow the patient to complete the study instruments, any major medical condition; patients not attending the Diabetic Center in Jazan. Participants who are not able to read or speak English or Arabic language. Participants not within the age range criteria.

Retention strategies: Participants in the intervention group received diabetic health information without cost to them which they may find as a possible benefit to be in the study. Both groups will have the opportunity to receive the study results when it is completed. Control group participants will have access to the educational text messages that the intervention group received when the study is completed.

Instruments

Health outcomes

Patient quality of life. This variable measured by the *World Health Organization Quality of Life (WHOQOL-BREF)* instrument (Appendix A). The original WHOQOL instrument developed in 1991 was 100 items. The instrument was then shortened by the World Health Organization (WHO) by international expert members in 1998 to the

WHOQOL-*BREF,* a 26-item instrument. The WHOQOL-BREF has four subscales which contain psychological, environmental, social, and physical aspects of health. The instrument has been translated in over 20 different of languages including Arabic (WHO, 2020). The WHOQOL Arabic version have been shown to have good validity and reliability, with correlations at 0.9 when used with a sample of diabetic Emirati (Arab Gulf region) participants. This study by Bani-Issa, (2011) included 200 participants with mostly equal samples of male to female (44.5% & 55.5%) with most ages (69%) between 40-65 years. The instrument showed good internal consistency (0.95) and reliability (Cronbach alpha $\alpha = 0.85$) for the total scale.

Medication adherence.

This variable measured using the four-item of *Morisky Green Levine Medication Adherence Scale (MGLS)* (Appendix B). The (MGLS) is a 4-item scale originally developed in 1986 by Morisky, Green and Levine. The Morisky, Green and Levine Scale (MGLS) is a structured as Medication Adherence Questionnaire, and self-report medication-taking behavior scale designed to measure medication adherence for patients with chronic illness including diabetics (Alqarni et al., 2019). Morisky et al., (1986) reported the MGLS as a reliable ($\alpha = .61$) and valid scale showing significant correlations with each item in the scale (Morisky et al. 1986). The scale has been used in many different languages including Arabic language especially with Saudi Arabia patients measuring medication adherence of diabetic participants (Alqarni et al., 2019). The (MGLS) Arabic version have been shown to have good validity and reliability, with a sample of diabetic Saudi Arabian participants (Alqarni et al., 2019).

Text messages

Text messages for use in this study were developed by the American Association of Diabetes Educators (AADE7, 2020) and are public domain**.** See Appendix table 1 for the complete texts. The text messages included medication reminders, healthy eating tips, physical activity encouragements, coping and monitoring. These messages have been used in previous studies with positive outcomes (Nepper et al., 2019; Fortmann et al., 2017). However, these messages have not been used with a Saudi Arabian population.

The text messages were translated and back translated in Arabic by 2 bilingual (Arabic and English) doctoral students. After the messages were translated, they were presented to a group of expert healthcare providers in Saudi Arabia to review the messages for content and cultural relevance. There were a total of seven physicians. Their specialties included chronic health illnesses, family medicine, health education, and diabetes specialists. The healthcare providers reviewed the messages individually, then as a group, we meet via Zoom to discuss each of the messages. After the discussion and debate, differences were agreed upon for producing the final messages in Arabic that are culturally relevant for the Saudi Arabian people. The Arabic translated text messages were then given to five other healthcare providers at the Jazan center for their feedback. These healthcare providers included endocrinology, family medicine, internist medicine, and health education. Their responses were consistent with the initial review. These results indicate that the Arabic translated text messages are culturally relevant for Saudi Arabian.

Methods

Data Collection Procedure

IRB approved from Florida International University and from the Jazan Diabetic Center, an informational in-service about the study provided to the healthcare providers at the Jazan Diabetic Center by the Principal Investigator (PI). The study protocol thoroughly and clearly explained to the healthcare providers. The PI provided answers for any questions they may have. The clinical contact person (i.e., nurse manager or other medical staff) at the Jazan Diabetic Center will identify potential clinic participants. The clinical contact person given the potential participants' their names and phone numbers to the PI, or the research assistant (RA) and the potential participant also given the PIs and the RAs contact information. The RA contacted the potential participant and introduced them to the study at a convenient time for the participant. The potential participant may also contact the PI or the RA to ask about the study. The RA assessed his/her willingness to participated and screened them for the inclusion and exclusion criteria.

Participant who agreed to be in the study and meets the inclusion/exclusion criteria, the RA explained the study to them. They informed there is no obligation or any costs to participate. If they decline to participate, they will continue to receive the usual care from the clinic. The RA reviewed with the participants the texting schedule (3 times a week for 2 months), and the study procedures. All willing participants given the opportunity to ask questions. The RA or PI obtained the participant's written consent if they are willing to enroll in the study. After consent is obtained, participants randomized to either the control or the intervention group using a table of random numbers by computer. The RA obtained the demographic data and the baseline data of the MGLS-4 and the WHOQOL-BREF scale. These data documented on the demographic form and the 2 study instruments questtionares; *Morisky Green Levine Medication Adherence Scale (MGLS),* and the *World Health Organization Quality of Life (WHOQOL-BREF)* for both groups. Data collected on day 1 (baseline), weeks 4, and 8, for the 2 study instruments (MGLS-4, and *WHOQOL-BREF)*. The healthcare cost form collected from both groups on weeks 4 and 8.

Intervention Group: Daily Text Messages.

Addition to usual care (routine well-care visits including physical exanimation, health education, possible lab work, and medication refills, adherence, review of correct dosage, frequency of medication) being provided, the intervention group (texting messaging) they received one text message reminders 3 times a week for two months starting 24 hours after enrollment. Based on other studies, positive outcomes were documented sending text messages 3 times a week for 2 months which had the most impact (Nepper et al., 2019; Fortmann et al., 2017).

The control group provided with routine care (monthly patients visit for routine checkup health instructions, medication refill, review of correct dosage, frequency of medication) and will not receive the text message intervention.

In both the intervention and control group, the demographic information, the MGLS-4, and *WHOQOL-BREF* collected at the time of enrollment on day 1. At weeks 4 and 8 both groups completed the MGLS-4, and *WHOQOL-BREF* and the healthcare cost form.

Data Management

The data from each participant contained in an individual file (paper) with a study number on it. Each file included the: 1) demographic data and 2) the questionnaires; the MGLS-4, the *WHOQOL-BREF* and the healthcare cost form. A master logbook tracked the dates when to send the text messages to the intervention group and to collect the data for the questionnaires on weeks 4 and 8 for both groups. All study files kept in a locked cabinet with the participants' names, phone number and their assigned study number. The informed consent (paper) stored in a separate file. Only the PI, the PI's dissertation committee and the research team had access to the data. There was a master contact log with the list of dates the subjects will be contacted. The PI and RA reviewed the contact log daily and the RA contacted the appropriate subjects by sending the text message. Data entered a statistical program, Statistical Package for the Social Sciences 25 (*SPSS*) for Windows. The PI verified data entry to minimize errors. The PI used *SPSS* to examine frequencies and descriptive statistics to look for missing data and possible data entry errors. After correcting any detected errors, the PI merged the *SPSS* file of newly entered data with the already-cleaned data. Data reviewed was ongoing with continuous feedback as needed to maintain data quality.

Data Analysis.

The Statistical Package for the Social Sciences (SPSS) used for data analysis. Analysis such as means, and t-test used to compare the differences between the two groups to assess their statistical difference. The data analysis described and summarized the results between the intervention group; participants received a texting intervention sent to their smartphone compared to the control who did not receive the intervention.

Reaserch Questions

This study, a randomized clinical trial is designed to address the following research questions with diabetic participates.

Research Question 1: When comparing usual care (control) with the texting intervention, is there a difference in participants quality of life at week 4 and 8?

Hypothesis: Participants receiving the texting intervention will have improved quality of life scores compared to the control group. Using the WHOQOL instrument to measure participants quality of life, *t* -test will be used. Total mean scores of the of the two groups (intervention & control) will be compared at weeks 4 and 8. Paired *t*-test will be used to compare means across the 2 timepoints (weeks 4 and 8) for differences within the intervention group compared to the control group.

Research Question 2: Comparing the control and the text messages intervention group, are their differences in medication adherence on weeks 4 and 8?

Hypothesis: Participants receiving the text intervention will have improved MGLS-4 scores compared to the control group. Using the MGLS-4 instrument to measure participants medication adherence, *t* -test will be used. Total mean scores of the of the two groups (intervention & control) will be compared at weeks 4 and 8. Paired *t*-test will be used to compare means across the 2 timepoints (weeks 4 and 8) for differences within the intervention group compared to the control group.

Research Question 3: Comparing the control and the intervention group, are there differences in healthcare costs (i.e., urgent care visits, emergency room visits, rehospitalizations, lost employment time, and texting costs for the intervention group only. **Hypothesis:** The cost of healthcare will be lower for the intervention compared to the control group. Frequencies data analysis will be applied to know the differences in the cost in the two groups. Chi-square and t-tests will be used to compare differences in means across the two groups for the total unplanned healthcare costs.

Conclusion:

Diabetes is an extremely important health concern is Saudi Arabia. This study used texting intervention to improve the outcomes of diabetes participants in Saudi Arabia. The results of this study added important data that may crucially facilitate the use of mobile technologies for this high-risk group. Medical professionals are knowledgeable about the importance of adherence to routine follow-up, diabetic medication, diet, and exercise to the health of their patients. The use of the smartphone text messages has been used to improve health services in many countries. However, there are some limitations on the data.

Chapter IV.

Results

The purpose of this randomized clinical trial was to compare the health outcomes and healthcare charges between two groups of participants diagnosed with diabetes in Saudi Arabia attending care at the Jazan Diabetic Center. A control group (*n*=80) received usual care from the Jazan Diabetic Center. An intervention group (*n* =74) received three text messages weekly on diabetic health information (i.e., medications, appointment reminders, diabetic educational health information) to their smartphone for two months (8 weeks) in addition to usual medical care (routine well-care visits including physical exanimation, health education, possible lab work, medication refills, adherence, review of the correct dosage, and frequency of medication) from the Jazan Diabetic Center. See appendix for the text messages. Both groups were followed for 2 months including data on their adherence to their usual care and on their health outcomes (improved quality of health, adherence to their prescribed medication, and data on the cost of care. Results from this study are reported in this chapter.

Sample

A total sample of 154 adults, ages ranged from 40 to 64 years, participants with type 2 diabetics were recruited from the Jazan Diabetic Center, Saudi Arabia. There were 74 participants in the intervention group and 80 participants in the control group. The total number of participants recruited was 165, however 154 participants completed the study. Eleven participants were not able to be contacted to complete the study. The intervention and control group had total of 80 and 74 respectively.

Characteristics of the sample are presented in Table 1. The participants' age ranged from 40-64 with a mean age of 52.5 (*SD*= 6.5), and the mean number of years diagnosed with diabetes was 8.5 (*SD*=3.7) ranging from 40 years to 65 years (Table 1), most of the participants were male (60.4%) and married (83.1%). The majority (82.5%) had a monthly income of 5,000 SR or more. The participants were divided between working (55.2%) and not working (44.8%). Most of the participants used smartphones and texted routinely (91.6%). However, most participants reported they did not receive health information by their smartphones (85.1%). Over half of the participants (53.8%) had an educational background of completing a Bachelors' degree or higher, and (46.1%) were completed secondary education or less (less than college or no bachelor's degree). The majority of the participated (81.2%) reported attending their routine visits. Almost, most of the participants did not have health insurance (97.4%), and all the participants were Saudi and speak the Arabic language. Characteristics of the intervention and control groups are presented in Table 1. The two groups were almost similar, showing no significant differences in their demographic or background characteristics. However, the control group had more working participants than not working (62.5% vs 37.5) and more working compared to the intervention group (47.3 vs 52.7). However, these differences were not significant.

Table 1.

Demographic and Background Characteristics

	Total sample (*n* =154)	Intervention (*n* =74)	Control (*n* =80)	Statistics
Mean Age Years	52.5 (*SD* =6.5)	52.2 (*SD*=6.5)	52.8 (*SD*=6.6)	*p* =.873
Years Diabetes	8.5 (*SD*=3.7)	8.7 (*SD*=4.2)	8.6 (*SD*=3.1)	*p* =.850
Gender	*n* (%)	*n* (%)	*n* (%)	
Male	93 (60.4%)	44 (59.5%)	49 (61.3%)	
Female	61(39.6%)	30 (40.5%)	31(38.8%)	
Marital status	*n* (%)	*n* (%)	*n* (%)	χ^2 =.444
Single	13 (8.4%)	8 (10.8%)	5 (6.3%)	
Married	128 (83.1%)	61 (82.4%)	67 (83.8%)	
Divorce	10 (6.5%)	3 (4.1%)	7 (8.8%)	
Widowed	3 (1.9%)	2 (2.7%)	1 (1.3%)	
Working status	*n* (%)	*n* (%)	*n* (%)	χ^2 =.058
Working	85 (55.2%)	35 (47.3%)	50 (62.5%)	
Not working	69 (44.8%)	39 (52.7%)	30 (37.5%)	
Income RS	*n* (%)	*n* (%)	*n* (%)	χ^2=.133
<5000	27 (17.5%)	18 (24.3%)	9 (11.3%)	
5000-10,000	55 (35.7%)	21 (28.4%)	34 (42.5%)	
10.000-15000	49 (31.8%)	24 (32.4%)	25 (31.3%)	
15000-20000	22 (14.3%)	10 (13.5%)	12 (15%)	
> 20000	1 (0.6%)	1 (1.4%)	0 (0%)	
Education	*n* (%)	*n* (%)	*n* (%)	χ^2 =.443
Primary	1 (0.6%)	1 (1.4%)	0 (0%)	
Secondary	70 (45.5%)	31 (41.9%)	39 (48.8%)	
Bachelor’s	82 (53.2%)	41 (55.4%)	41 (51.2%)	
Graduate	1 (0.6%)	1 (1.4%)	0 (0%)	
Insurance	*n* (%)	*n* (%)	*n* (%)	χ^2 =.937
Insurance	4 (2.6%)	2 (2.7%)	2 (2.5%)	
No insurance	150 (97.4)	72 (97.3%)	78 (97.5%)	

Table 2.

Smartphone Sample Characteristics

	Total sample (*n*=154)	Intervention (*n*=74)	Control (*n*=80)	Statistics
Smartphone Using	*n* (%)	*n* (%)	*n* (%)	χ^2=.662
Using smartphone	141 (91.6%)	67 (90.5%)	74 (92.5%)	
Not using smartphone	13 (8.4%)	7 (9.5%)	6 (7.5%)	
Health information	*n* (%)	*n* (%)	*n* (%)	χ^2=.182
Receive health information via smartphone	23 (14.9%)	14 (18.9%)	9 (11.3%)	
Not Receiving health information via smartphone	131 (85.1%)	60 (81.1%)	71 (88.8%)	

Effects of the texting Intervention on Health Outcomes

Patients Quality of Life:

The quality-of-life variable was measured by the *World Health Organization Quality of Life (WHOQOL-BREF)* instrument (Appendix A). The original WHOQOL instrument was developed in 1991 with 100 items. The instrument was shortened by the World Health Organization (WHO) by international expert members in 1998 which became the WHOQOL-*BREF,* a 26-item instrument. The WHOQOL-BREF has four subscales which contain psychological, environmental, social, and physical aspects of health. WHOQOL-BREF has 26 questions each question has a Likert scale range from 0-

5, and the subtotal scouring range as Physical Health (7-35), Psychological (6-30), Social Relationships (3-15), and Environment (8-40).

The instrument has been translated in over 20 different of languages including Arabic (WHO, 2020). The WHOQOL Arabic version have been shown to have good validity and reliability, with correlations at 0.9 when used with a sample of diabetic Emirati (Arab Gulf region) participants. This study by Bani-Issa, (2011) included 200 participants with mostly equal samples of male to female (44.5% & 55.5%) with most ages (69%) between 40-65 years. The instrument showed good internal consistency (0.95) and reliability (Cronbach alpha $\alpha = 0.85$) for the total scale.

Patient Quality of Life Result.

The overall patient's quality of life was collected from Jazan Diabetic Center using the WHOQOL questionnaire. Both groups received usual care which was (routine well-care visits which included a physical exanimation, health education, possible lab work, and medication refills, adherence, review of correct dosage, frequency of medication) from the Jazan Diabetic Center. The intervention group received usual care in addition to 3 text messages weekly on diabetic health information (i.e., medication and appointment reminders, educational health information) to their smartphone for 2 months in addition to usual care from the Jazan diabetic center (see appendix table 1 for the text messages).

Result indicated the score for the subscale of the WHOQOL questionnaire at the Time 1 had similar overall total scores and for the four subscales for both groups (Physical Health $Mi = 20.12$, SD = 3.40, vs. $Mc = 20.23$, SD = 4.40, $p = .856$; Psychological Health $Mi = 17.9$, SD = 2.14, vs. $Mc = 17.7$, SD = 2.82, $p = .684$; Social

Relationship *Mi*= 8.68, SD = 1.62, vs. *Mc* = 8.47, SD =2.35, *p* = .516; Environment *Mi* = 22, SD = 3.30, vs. *Mc* = 20.9, SD =4.32, *p* = .098) See table 3.

However, at Time 2 (1 month) the intervention group had a significantly higher mean scores (*p* = .000*) for the 4 subscales: physical health (*Mi* = 24.32, SD = 3.36, vs. *Mc* = 20.95, SD = 4.07), Psychological health (*Mi* =21.56, SD = 2.66, vs. *Mc* = 18.07, SD = 2.92), Social relationship (*Mi* =10.02, SD = 2.10, vs. *Mc* = 8.65, SD = 2.31), and Environmental quality of life (*Mi* = 27.39, SD = 3.83, vs. *Mc* = 21.65, SD = 4.58) than control group.

At Time 3, (2 months), the intervention group had significantly higher scores than control group (*p* = .000*) for all 4 subscales; physical health (*Mi* = 31.16, SD = 2.61, vs. *Mc* = 21.62, SD = 3.84), Psychological health (*Mi* = 24.13, SD = 2.25, vs. *Mc* = 18.75, SD = 2.63), Social relationship (*Mi* = 12.04, SD =2.14, vs. *Mc* = 8.95, SD = 2.11), and Environmental quality of life (*Mi* = 33.41, SD = 3.42, vs. *Mc* = 22.21, SD = 4.58).

The overall total score of the patient quality of life at the Time 3 was statistically significantly higher than at Time 1 and Time 2 and increased at a higher rate compared to the control group. The total score for the intervention group patient quality of life had a higher mean at time 2 (Mi=90.29, SD=9.72, vs. Mc=75.70, SD=12.23), and time 3 (Mi= 109.52, SD=8.94, vs. Mc=78.20, SD= 11.70). The increase in scores over time (T1; T2; T3) for the control group may be attributed to the participants knowing they were in a study as the rate of increase in scores was much greater in the intervention group. (See table 3).

Table 3.

Patient Quality of life

	Total sample *n*=154	Intervention *n* = 74	Control *n* = 80	Statistic
Physical Health	M (SD)	M (SD)	M(SD)	
Time 1	20.18 (3.94)	20.12 (3.40)	20.23 (4.40)	*P* = .856
Time 2	22.57 (4.10)	24.32 (3.36)	20.95 (4.07)	*P* = .00*
Time 3	26.20 (5.80)	31.16 (2.61)	21.62 (3.84)	*P* = .00*
Psychological Health				
Time 1	17.79 (2.51)	17.9 (2.14)	17.7 (2.82)	*P* = .684
Time 2	19.75 (3.29)	21.56 (2.66)	18.07 (2.92)	*P* = .00*
Time 3	21.33 (3.64)	24.13 (2.25)	18.75 (2.63)	*P* = .00*
Social Relationship		M (SD)	M (SD)	
Time 1	8.57 (2.03)	8.68 (1.62)	8.47 (2.35)	*P* = .516
Time 2	9.31 (2.31)	10.02 (2.10)	8.65 (2.31)	*P* = .00*
Time 3	10.43 (2.62)	12.04 (2.14)	8.95 (2.11)	*P* = .00*
Environmental QOL				
Time 1	21.46 (3.88)	22 (3.30)	20.9 (4.32)	*P* = .098
Time 2	24.40 (5.11)	27.39 (3.83)	21.65 (4.58)	*P* = .00*
Time 3	27.59 (6.92)	33.41 (3.42)	22.21 (4.58)	*P* = .00*
Total Score Time 1	73.95 (10.22)	74.38 (7.86)	73.55 (12.03)	*P* = .617
Total Score Time 2	82.71 (13.26)	90.29 (9.72)	75.70 (12.23)	*P* = .00*
Total Score Time 3	93.25 (18.85)	109.52 (8.94)	78.20 (11.70)	*P* = .00*

*p value <0.05 ^ QOL Quality of Life

Medication Adherence

This variable was measured using the four-item of *Morisky Green Levine Medication Adherence Scale (MGLS)* (Appendix B). The (MGLS) is a 4-item scale originally developed in 1986 by Morisky, Green and Levine. The Morisky, Green and Levine Scale (MGLS) is a Medication Adherence Questionnaire, and a self-report medication-taking behavior scale designed to measure medication adherence for patients with chronic illness including diabetics (Alqarni et al., 2019). Morisky et al., (1986) reported the MGLS as a reliable ($\alpha = .61$) and valid scale showing significant correlations with each item in the scale (Morisky et al. 1986). The scale has been used in many different languages including Arabic language especially with Saudi Arabia patients measuring medication adherence of diabetic participants (Alqarni et al., 2019). The (MGLS) Arabic version have been shown to have good validity and reliability, with a sample of diabetic Saudi Arabian participants (Alqarni et al., 2019).

The result showed that the medication adherence for the intervention group and control group at time 1 was not statistically significant (*Mi*= .93, *SD* = .689, vs. *Mc* =.99, *SD* =.771) with $p = .642$. However, the intervention group had a higher mean medication adherence at time 2 (*Mi* =1.96, *SD* = .689, vs. *Mc* =1.15, *SD* = .797) and was statistically significantly higher (p =.000) than control group. Also, the intervention group had a higher mean medication adherence at time 3 (Mi =3.38, *SD* = .542, vs. *Mc* =1.50, *SD* = .842) and was statistically significantly higher (p =.000*) than control group (See table 4). Medication adherence scores increased over the 2 months to higher rates than the control group. The controls group scores increased over time at a much lower rate.

Table 4.

Medication Adherence

	Total Sample *n* =154 M (SD)	Intervention *n* = 74 M (SD)	Control *n* = 80 M (SD)	Statistic
Total Score Time 1	.96 (.731)	.93 (.689)	.99 (.771)	*P* = .642
Total Score Time 2	1.54 (.833)	1.96 (.650)	1.15 (.797)	*P* = .00*
Total Score Time 3	2.40 (1.174)	3.38 (.542)	1.50 (.842)	*P* = .00*

Summary

Study findings indicate that intervention group benefited from the texting intervention as reflected in their health outcomes, and quality of life and medication adherence. Intervention group had higher scoring in physical health, psychological health, social relationship, environment, and medication adherence compared to the control group. These study results indicate that an educational texting intervention this sample of diabetic Saudi Arabian was culturally receptive by them and was an effective, safe, improved the quality of life, and increase the medication adherence, easy to apply intervention which improved their health outcomes, quality of life, and increase the medication adherence.

Healthcare Visits

Routine healthcare visits were similar in both groups. The majority of the participates attend their regular scheduled routine visits, however close to 30% were not attending their routine visits. See table 5. Unscheduled healthcare visits included unplanned visits to their physician, any emergency room visits or hospitalizations. Results indicated that the intervention group had a significant fewer number of visits in each of the 3 healthcare categories and across each time points (Month 1 and Month 2) compared to the control group ($p = < 0.5$). The overall number of visits of unscheduled visits was $n = 42$ (42.3%) for the intervention group and $n = 74$ (74.7%) for the control group. The intervention group had fewer number of emergency visits, ($n = 13$ vs. $n = 30$) and fewer hospitalization ($n = 1$ vs. $n = 4$). One participant from each the intervention and control groups had one unscheduled repeated visit at Month 1& 2.

Table 5.

Healthcare visits

	Total $N = 154$	Intervention $n = 74$	Control $n = 80$	Statistic
Routine visit	n (%)	n (%)	n (%)	$\chi^2 = .700$
Attend	125 (81.2%)	61 (82.4%)	64 (80%)	
Not Attend	29 (18.8%)	13 (17.6%)	16 (20%)	
Unscheduled HC visits				
Month 1	50 (32.5%)	19 (25.7%)	31(38.8%)	$\chi^2 = 2.997$
Month 2	36 (23.4%)	9 (12.2%)	27 (33.8%)	$\chi^2 = 10.002$*
Emergency Room				
Month 1	26 (16.9%)	9 (12.2%)	17(21.3%)	$\chi^2 = 2.262$
Month 2	17 (11%)	4 (5.4 %)	13 (16.3%)	$\chi^2 = 4.604$*
Hospitalization				
Month 1	3 (1.9%)	1 (1.4%)	2 (2.5%)	$\chi^2 = .266$
Month 2	1 (0.6%)	0 (0%)	1 (1.3%)	$\chi^2 = .931$*
Total visits	133	42	91	$P = .000$

*p value <0.05

Saudi Arabia Healthcare Cost

Saudi Arabian employees per Saudi Labor Law work 8 hours daily and 48 hours per week. (Ameen, 2020). The annual income for the Saudi Arabian employee is $54,100, the monthly income is $4,509, weekly income of $1,127, and the average wage per hour of $23.50 (John, 2019). Generally, most Saudi families are one-income families with their income dependent on the father or the male head of household as most of the women are stay-at-home childcare providers. In most of the families with only one income, the income is enough for the family's basic needs since healthcare is provided by the Saudi Ministry of Health at no cost to the public. However, having diabetes costs the families and affects their budget as an indirect cost and cost the country. The participants in this study were considered lower income by Saudi Arabian standards. With a diagnosis of diabetes, the cost of care for unscheduled healthcare visits (unscheduled healthcare clinic visits, emergency room visits and hospitalizations) greatly impact the family's budgets.

Healthcare Cost Result

The overall health care charges for unscheduled visits, emergency room visits, and hospitalizations were collected from Jazan Diabetic Center by asking participants for their charges for health services. The intervention group had a lower total unscheduled visit charge at month 2 (Ti = $1.066, vs. Tc= $3.973) and was statistically significantly lower (p =.000*) than the control group. See tables 6 & 7. Also, the intervention group had lower total emergency charges at month 2 (Ti =$533 vs. Tc = $1.893) p= .024*compared to the control group. The total hospitalization for the intervention group at month 2 was lower than the control group but was not significant (p =.320).

The intervention group received additional text messages charges which the control group did not receive. The Research assistant (RA) time was calculated to cost $35 per hour ($70,000/year). This amount was based on the average full-time salary plus benefits for an RA (i.e., the general nurse with either bachelor's or master's degree in nursing) working in Saudi Arabia as reported by the Ministry of Health. The hourly rate was calculated by dividing the annual salary and benefits by 48 weeks and again by dividing by $35hours/week.

The total mean charge for RA text messages for the intervention group was $27 per participant with a total charge of $2000. Overall, the total intervention group charges of $8,533 were significantly lower (t = -4.92*, p = <.0001) compared to the control group's total health care charges of $13,746, a difference of charge savings for the (RA) intervention group.

The results indicated a statistically significant overall lower healthcare cost for the intervention group compared to the control group at both time points; Month 1 (t = -2.06* p=.04) and at Month 2 t =-4.92* p=.000 (See Table 6 & 7). The table below 1a is in Saudi Riyal (SR) monies and table 7 is in US dollars.

Table 6.

Texting Intervention: Effects on Health Care Charges by Saudi Riyal (SR)

	Total charge T (SR)	Intervention T (SR)	Control T (SR)	Group difference (SR)	Statistic
Unscheduled					
Month 1	30,200	12,450	17,750	5,300	*p* =.277
Month 2	18,900	4,000	14,900	10,900	*p* =.000*
Emergency					
Month 1	14,950	5,550	9,400	3,800	*p* =.235
Month 2	9,100	2,000	7,100	5,100	*p* =.024*
Hospitalization					
Month 1	1,900	500	1,400	900	*p* =.445
Month 2	1,000	0	1,000	1,000	*p* =.320
Intervention Cost	7,500	7,500	N/A		
Total M1 *M* (SD)		250 (369)	357 (364)		*t* = -2.06*
Total M2 *M* (SD)		81 (179)	288 (357)		*t* = -4.92*
Total	83,550	32,000	51,550	27000	

1 USD = $3.75 SR. *p value <0.05.

Table 7.

Texting Intervention: Effects on Health Care Charges by USA Dollars ($)

	Total charge T ($)	Intervention T ($)	Control T ($)	Group difference ($)	Statistic
Unscheduled visit					
Month 1	8,053	3,320	4,733	1,413	*p* =.277
Month 2	5,040	1,066	3,973	2,906	*p* =.000*
Emergency					
Month 1	3,986	1,480	2,506	746.6	*p* =.235
Month 2	2.426	533	1,893	1,360	*p* =.024*
Hospitalization					
Month 1	506	133	373.3	240	*p* =.444
Month 2	266	0	266	266	*p* =.320
Intervention Cost	2000	2000	N/A		
Total M1 *M* (SD)		66.6 (98.4)	95.2 (97)		*t* = -2.06*
Total M2 *M* (SD)		21.6 (47.7)	76.8 (95.2)		*t* = -4.92*
Total	22,280	8,533	13,746	7200	

1 USD = $3.75 SR. *p value <0.05. Ti, Tc (total charge for the intervention, and control group).

Summary

Study findings indicate that intervention group benefited from the texting intervention as reflected in their health outcomes, and health care charges. Intervention group fewer emergency room visits: had fewer urgent care visits and 1 hospitalization compared to four hospitalizations in the control group. These study results indicate that an educational texting intervention this sample of diabetic Saudi Arabian was culturally receptive by them and was an effective, safe, low cost, easy to apply intervention which improved their health outcomes and reduced healthcare costs.

Chapter V

DISCUSSION

Studies examining the use of mobile technology and its effects on diabetic health outcomes and health care costs in the kingdom of Saudi Arabia are very limited. However, investigators analyzing interventions for diabetes self-management have shown that the most effective intervention to improving diabetic patients' health outcomes target physiologic, behavioral, and psychological outcomes with the highest improvements seen in interventions using peer support/coaching and technology-based interventions such as Smartphones for texting health promotion messages (Carpenter et al., 2018). Studies using text-messaging interventions with diabetic patients have shown increased patient satisfaction, changes to their diet, improved hemoglobin HbA1c levels and many other health behavior changes by improved knowledge in self-management (Arambepola et al., 2016; Fortmann et al., 2017; Dobson et al., 2015). In this era of technology, numerus studies have documented that texting interventions with chronic illnesses including diabetes, have shown positive outcomes (Fortmann et al., 2017; Hassan, 2017; Hussein, 2011; Abaza & Marschollek, 2017). However, data on texting interventions with diabetics in Saudi Arabia are very limited. Saudi Arabia lacks behind in the research using texting interventions to improve diabetic health outcomes. As diabetes is increasing in extremely high rates in Saudi Arabia, a texting intervention has the potential in improving the health outcomes for this population. This intervention would provide them with texts messages that would include such health behavior reminder messages such as: medication adherence, medical appointment reminders, health information, educational information, community support information amongst others. This data is needed in

Saudi Arabia to improve the outcomes with diabetic patients and to guide the development of practice models with the aim to improve diabetics non-adherence to medically prescribed treatments and their complex self-management plans. This chapter compares the present study findings with those of other research in this area.

Interventions and Samples

In this study, and all the participants were from Saudi Arabia and speak the Arabic language. Participants ages ranged from 40 to 65 with an average age of 52 year and the mean number of years diagnosed with diabetes was 8.5 years. Most of the participants were male (60.4%) and married (83.1%). The majority (82.5%) had a monthly income of 5,000 SR ($1,333) or more which consider as low income. The participants were divided between working (55.2%) and not working (44.8%). Most of the participants were used the smartphone and routinely use text messaging (91.6%). However, most participants reported they do not receive health information through smartphones (85.1%). Over half of the participants (53.8%) had an educational background of completing a Bachelors' degree or higher, and (46.1%) were completed secondary school or less. The majority of the participated (81.2%) reported attending their routine visits. Almost, most of the participants did not have health insurance (97.4%), however, they receive coverage for medical expenses through the Saudi government. This profile is consistent with the demographic profile of residents living in Jazan Diabetic Center, Saudi Arabia. Other texting studies have been conducted but with different sample characteristics and study interventions. A study conducted in Jordan (Arabic speaking country) by Hassan, (2017) used a 2-way text message intervention to improve participates foot care practices in a pretest/posttest design over 7 months. This sample was included 225 participants (118 women/107 men). The result of the level of knowledge and foot care practice for pre/post intervention scores indicated that the scores improved significantly (p = .05). The use of smartphones for a text messaging intervention was a significantly effective method in educating participants in managing their foot self-care.

Another study by Katalenich et al. (2015), conducted a study in New Orleans the sample was 98 participants. The majority were female (60%), African American (65%), with an average age of 59. The majority had less than high school or high school education (55%) and college education or greater (45%). Katalenich et al. (2015), found that using an automated Diabetes Remote Monitoring and Management System (DRMS) that sent text message or phone call reminders prompting the participants to test, then report their blood glucose levels through an automated system, improved diabetics overall health. The results of this study indicated that diabetes could be controlled with an automated remote, telephone-based system, and the system could be scalable and cost-effective. Another two-way texting intervention includes a study by Hussein et al., (2011), in Bahrain (a middle eastern country). The study sample had 34 participants, and the mean age was 46 years. The intervention included the participants with the ability to send text messages to their physician or the clinic educator in between visits. Result indicated a significant (p = .001) reduction in A1c values when compared to baseline values. These findings suggested that text-messaging intervention improved their A-1C, supported participants needs, and improved their self-care skills.

Another study with similar findings includes a study by Zolfaghari et al., (2012) in Iran. The sample was 38 participants, (n =18) males, and (n =20) females, (30%)

employed, (38%) house worker, and (32%) retired. The financial income of the participants was (34%) sufficient, (45%) semi-sufficient, and (21%) non- sufficient. These researchers compared the effectiveness of two methods of follow-up which included a texting intervention and a telephone follow up with diabetics over a 3-month period. Following the 3-month intervention period, both the SMS group and the telephone group showed a reduction in Hb1Ac levels by approximately 1.0%. Despite this finding, there was a significant change in adherence to diet ($p = 0.00$), exercise ($p = 0.00$), and medication ($p = 0.00$) in either of the groups. Researchers concluded that texting is as effective as telephone follow-ups. The results of this study support that texting is less expensive and just as effective as individualized phone calls.

The majority of studies that used a texting intervention for diabetic participants used mixed method interventions including texting (1 way), 2-way texting and texting with telephone follow up. These study samples participants were also from different countries including Jordan, Iran Bahrain (a middle Eastern country) and New Orleans. These studies using a texting intervention were in different regions of the world, while demonstrating improved outcomes. However, studies using this intervention have not been implemented in Saudi Arabia. In this study, all the participants were from Saudi Arabia. The texting intervention, in comparison to other studies, used a texting intervention. This intervention was low cost, and easy to apply. The intervention provided participants with educational health information and medication reminders and was effective in improving health outcomes. To date, studies reported testing a texting intervention with a Saudi Arabian sample having the characteristics in this study are limited.

Health Outcomes

Quality of Life

Diabetes a rapidly growing chronic disease, is a global medical epidemic and is a major health problem (Alzahrani & Alanzi, 2019). According to the literature, diabetics quality of life is much lower than healthy individuals (Abedini et al., 2020; Chew et al., 2015; Gebremedhin et al., 2019). This is also true for diabetics living in Saudi Arabia. A major contributory factor resulting in diabetes is their way of life. As documented in other studies, this includes their culture, beliefs and customs which substantially influence how people understand and manage their health, their health seeking behaviors and their related to their health decisions (Abedini et al., 2020; Alzahrani & Alanzi, 2019; Gebremedhin et al., 2019). Their lack of health awareness about diabetes, their health beliefs, attitudes, and lifestyle increase their risk substantially for this chronic illness (Alanzi, 2018). Studies using self-management interventions such as texting have been used to improve the outcomes of patients living with chronic illness including diabetes (Al-Qahtani, 2020 & Alanzi, 2018). In this study, the texting intervention improved the participants quality of life scores over time as measured by the *World Health Organization Quality of Life (WHOQOL-BREF)* instrument. Result showed the scores for the four subscales of the WHOQOL questionnaire were significant at Time points 2 and 3 for the intervention group. The control groups Quality of Life scores also increased at Time 2 and 3 however at a much lower increase compared to the control group. This may be attributed to the control group knowing they are in a study or experiencing the Hawthorne effect. Other studies with diabetes reported similar findings with the control group and the Hawthorne effect (Abraham et al., 2018; Peterson et al., 2021). These findings strengthen the validity of including a control group in a research design with diabetics when examining behavioral and quality life health outcome.

Medication Adherence

Non-adherence to medication with diabetics includes a myriad of causes that have been reported in the literature such as: forgetfulness, inconvenience, using traditional medicine, medications side effects, and especially cultural barriers and beliefs (Alatawi et al., 2016; Hussein et al., 2019). In addition, when diabetics are not adherent to their medication their health is gravely impacted as seen with poor glycemic control resulting in increased morbidity and mortality (Huang et al., 2020; Jamal, et al., 2018; Polonsky, & Henry, 2016). In this study, medication adherence was measured using the four-item of *Morisky Green Levine Medication Adherence Scale (MGLS).* The intervention groups medication adherence was improved at Times 2 and 3 indicating the texting intervention had an effect these subjects. These results were similar the other studies using a texting intervention also to improve medication adherence. As seen in a study in Bahrain by Hussein et al., (2011) using a one-way texting intervention with diabetics in the Middle East. They received messages on lifestyle modifications, weekly reminders, and medication adherence and had significantly positive outcomes by a reduction in A1c values.

Another one-way texting education intervention to improve diabetics self-management was carried out in Cairo, Egypt, by Abaza & Marschollek (2017). The researchers examined the feasibility of using daily text messages about medication adherence, diabetes knowledge, and lifestyle modifications with weekly reminders for self-management behaviors. Results indicated that the participants had a significant mean decrease in their HbA1c (p = < 0.01) and participant's knowledge of diabetes and medicating adherence was also increased. In this study, the participants medication adherence improved, and this may be attributed to their increased knowledge and self-management behaviors they gained from the text messages they received as seen in the Abaza & Marschollek (2017) and the Hussein et al., (2011) studies.

Healthcare Cost Result

Diabetes is a long-term disease which constantly incurs significant healthcare costs. Globally, it is estimated to cost $1.31 trillion which is 1.8% of global gross domestic product, and 11% of the total health care expenditure (Alotaibi et al., 2017; Bommer et al., 2017). The cost of diabetes has significantly increased the economic burden in Saudi Arabia and interventions are needed to be developed to improve the Saudi Arabians health, lifestyle and economic outcomes (Robert et al., 2020). Studies in Saudi Arabi have documented the tremendous cost of diabetes in their country. Almutairi & Alkharfy (2013) conducted a retrospective observational analysis to assess the direct medical cost of diabetes in Saudi Arabia. They reported that the greater the severity of the diabetes resulted in greater direct medical cost. The total annual cost for the controlled diabetes (HbA1c < 7) was $1.384.19; the less optimally controlled (HbA1c 7-9) was $2,036.11, and the uncontrolled (HbA1c > 9) was $3,104.86.

Another study by Alomar et al., (2019) conducted a prospective descriptive study with Saudi Arabian diabetic patients to examine the impact of costs associated with diabetics when not following the prescribed lifestyles. The results indicated that participant awareness of prevention and treatment modalities impacted overall healthcare costs. Differences between those who did and did not believe that diet mattered were significant. Those who believed that a healthy diet could lower blood glucose levels had a mean direct cost of ($2,541 USD); those who did not believe that a healthy diet can lower blood glucose levels had a higher annual direct mean cost of ($3,559 USD). Furthermore, patients who adhere to treatment had an annual mean direct cost of ($2,604 USD); those who did not adhere to the oral hyperglycemic medicines had a higher annual direct cost of ($3,224 USD) with ($p = 0.046$). While it is documented the escalating healthcare cost of diabetes, this study documents a health cost savings intervention with a Saudi Arabian sample.

The results of this study showed the intervention group had less unscheduled visit charges at time 2 (Mi= $14.4, vs. Mc= $49.6) had lower mean emergency room charges at time 2 (Mi=$7.2 vs. Mc = $23.66) and had a lower mean hospitalization. The overall lower healthcare cost for the intervention group compared to the control group at both time points were also significantly lower (T 2; $t = -2.06$* p=.04 and T3 t = -4.92 p=.000). These results indicate that an educational texting intervention in this sample of diabetic Saudi Arabians is an effective cost savings in providing a smartphone intervention which has the potential to their health outcomes and reduced healthcare costs.

Similar finding documented in other studies. Islam (2020) using a cost-effectiveness analysis randomized controlled trial in Bangladesh examined diabetes participants who received a text messaging for 6 months encouraging healthy lifestyles. They also had improved health outcomes and lowered cost of care.

Watterson et al., (2016) reported lowered health cost and improved outcomes in their texting study results. Their texting intervention cost was $42.03 per participant while the texting intervention had considerable improvement in preventing or delaying the onset of diabetes in some participants, it had lowered health costs considerable compared to the cost of the intervention. These results were similar in other texting intervention studies which have shown improvement in health outcomes with diabetic patients (McGill et al., 2020; Fortmann et al., 2017; Hassan, 2017; Hussein, 2011; Abaza & Marschollek, 2017).

Limitations of the Study

While the Saudi Arabian culture has many factors that affect their control of diabetics, this sample was receptive to the texting intervention. However, for these results to be generalized in Saudi Arabia, it would need a larger sample and the intervention to be over a greater period. Another limitation includes that all the participant responses in this study were self-reporting, and the data were collected from one site only.

Implications

Diabetes, a common chronic illness requiring long-term management has risen globally from 108 million in 1980 to 422 million in 2014 (WHO, 2018) and the healthcare provided to diabetic patients most often do not meet the established diabetes clinical guidelines (American Diabetes Association, 2019). Saudi Arabia is currently facing major healthcare challenges. With the rapid development of wealth and growing resources, diabetes is increasing as at dangerous rate. Because of this severity, the Saudi Arabian government has taken the initiatives aiming at lowering diabetes and lower societal healthcare costs. These initiatives are to develop and use the most effective methods to educate, motivate, and monitor patients to self-manage for improved health and more efficient costs (Alanzi, 2018). The use of the rapidly developing health technology intervention studies (i.e., text/short messages (SMS), video messages, APPs), have indicated improved patient outcomes by improved in an individual's overall health, decreased healthcare costs, and improved access with their healthcare providers (Ashrafzadeh, & Hamdy, 2019). Additionally, along with other technological advancements (i.e., mobile phone technology, telehealth monitoring, and SMS) patients also have a higher expectation and a greater demand for healthcare efficiency, information access, and more effective healthcare delivery (James, 2018; Mayberry et al., 2019). Given the widespread distribution of diabetes globally, research on the effectiveness these interventions are needed especially in Saudi Arabia as research in this area is lacking.

Clinical Nursing

In countries such as Saudi Arabia where diabetes rates are higher compared to other wealthy countries, there is a significant need for interventions to improve diabetic rates. This study indicated that the use of text messages intervention was helpful to increase their quality of life, medication adherence, and decrease the cost for the diabetic patients in Saudi Arabia. Healthcare providers in Saudi Arabia are in a unique position to provide texting interventions for diabetic patients.

In this study, the intervention group had significantly lower health care charges, and fewer emergency room visits and rehospitalizations compared to the control group. These findings highlight the ability of healthcare providers to apply low cost, easy to apply interventions to diabetics especially during times the Saudi Arabians are in need to improve their self-management of their health for a better health outcome.

Future Research

Findings from this study have provided valuable information on the effects a texting intervention with Saudi Arabian diabetic participants. Findings indicated that the text messages had a significant effect on healthcare charges and health outcomes in a sample of diabetic patients seeking health from Jazan Diabetic Center. The intervention group benefitted from 2 months text messages intervention. Future research could target diabetics using 1) a larger, diverse sample, 2) a longer period of time in the study up to 6 months, 3), 2-way texting intervention and 4) testing the A1C of the participants.

Summary

The purpose of this randomized clinical trial was to examine the effects of a texting intervention with diabetic participants in Saudis Arabia. Results of this study indicate that the texting intervention had a significant effect on health outcomes and a decrease in healthcare charges. Participates the intervention group had significantly higher quality of life scores and improved medication adherence which improves their health outcomes. Outcomes for the intervention group had fewer emergency room visits and rehospitalizations compared to control. Additionally, health care charges for intervention group were significantly lower compared to control group charges. Study findings indicate that this study results indicate that an educational texting intervention this sample of diabetic Saudi Arabian was culturally receptive by them and was an effective, easy to apply intervention which improved their health outcomes and increased the patient medication adherence.

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Appendices

A. The World Health Organization Quality of Life (WHOQOL-BREF)

WHOQOL-BREF

The following questions ask how you feel about your quality of life, health, or other areas of your life. **Please choose the answer that appears most appropriate.** If you are unsure about which response to give to a question, the first response you think of is often the best one.

Please keep in mind your standards, hopes, pleasures and concerns. We ask that you think about your life **in the last four weeks.**

	Very Poor	Poor	Neither Poor Nor Good	Good	Very Good
1. How would you rate your quality of life?	1	2	3	4	5

	Very Dissatisfied	Dissatisfied	Neither Satisfied Nor Dissatisfied	Satisfied	Very Satisfied
2. How satisfied are you with your health?	1	2	3	4	5

The following questions ask about **how much** you have experienced certain things in the last four weeks.

	Not at All	A Little	A Moderate Amount	Very much	An Extreme Amount
3. To what extent do you feel that physical pain prevents you from doing what you need to do?	5	4	3	2	1
4. How much do you need any medical treatment to function in your daily life?	5	4	3	2	1
5. How much do you enjoy life?	1	2	3	4	5
6. To what extent do you feel your life to be meaningful?	1	2	3	4	5

	Not at All	A Little	A Moderate Amount	Very Much	Extremely
7. How well are you able to concentrate?	1	2	3	4	5
8. How safe do you feel in your daily life?	1	2	3	4	5
9. How healthy is your physical environment?	1	2	3	4	5

The following questions ask about how completely you experience or were able to do certain things in the last four weeks.

	Not at All	A Little	Moderately	Mostly	Completely
10. Do you have enough energy for everyday life?	1	2	3	4	5

11. Are you able to accept your bodily appearance?	1	2	3	4	5
12. Have you enough money to meet your needs?	1	2	3	4	5
13. How available to you is the information that you need in our day-to-day life?	1	2	3	4	5
14. To what extent do you have the opportunity for leisure activities?	1	2	3	4	5

	Very Poor	Poor	Neither Poor Nor Good	Good	Very Good
15. How well are you able to get around?	1	2	3	4	5

	Very Dissatisfied	Dissatisfied	Neither Satisfied Nor Dissatisfied	Satisfied	Very Satisfied
16. How satisfied are you with your sleep?	1	2	3	4	5
17. How satisfied are you with your ability to perform your daily living activities?	1	2	3	4	5
18. How satisfied are you with your capacity for work?	1	2	3	4	5
19. How satisfied are you with yourself?	1	2	3	4	5
20. How satisfied are you with your personal relationships?	1	2	3	4	5
21. How satisfied are you with your sex life?	1	2	3	4	5
22. How satisfied are you with the support you get from your friends?	1	2	3	4	5
23. How satisfied are you with the conditions of your living space?	1	2	3	4	5
24. How satisfied are you with your access to health services?	1	2	3	4	5
25. How satisfied are you with your transport?	1	2	3	4	5

The following question refers to how often you have felt or experienced certain things in the last four weeks.

	Never	Seldom	Quite Often	Very Often	Always
26. How often do you have negative feelings such as blue mood, despair, anxiety, depression?	1	2	3	4	5

WHO, (2020)

Appendix B. Morisky Green Levine Medication Adherence Scale (MGLS)

Item no	**Questions**		**Frequency (n)**	**Percentage**
Q1	Do you ever forget to take your diabetic medication?	Yes NO		
Q2	Are you careless at times about taking your diabetic medication?	Yes NO		
Q3	When you feel better, do you sometimes stop taking your diabetic medication?	Yes No		
Q4	Sometimes if you feel worse when you take diabetic medication, do you stop taking it?	Yes No		

Morisky et al., (1986)

Table 1. Contents of educational text messages for diabetic patients.

AADE7 Handout Titles/Topics	Contents of Text Messages
Healthy Eating	1. Healthy Eating is one of the self-management behaviors for people with diabetes, prediabetes or cardiometabolic disease. 2. Eat breakfast every day! 3. There are only three main types of nutrients in foods: carbohydrates, proteins, and fats. A healthy meal will include all three of these", 4. Do not skip meals! Remember to eat regular meals and snacks every day. *For more info: https://www.diabeteseducator.org/patient-resources/aade7-self-care-behaviors/healthy-eating*
Healthy Coping	1. Think positive! Feeling down? Remember your successes and feel good about your progress with diabetes. 2. Build healthy relationships. You are not alone when you have diabetes. 3. If you are sad, anxious or stressed, go for a walk or stand up and stretch. 4. Attending diabetes education classes or a diabetes support group can help you both manage your diabetes and better cope with your feelings. *For more info: https://www.diabeteseducator.org/patient-resources/aade7-self-care-behaviors/healthy-coping*
Monitoring	1. Checking your blood sugars gives you vital information about your diabetes control. 2. Monitoring your blood sugars helps you know when they are on target. 3. Call your doctor or diabetes educator if you are concerned about your blood sugars. 4. Weight and activity monitoring can also provide you a more complete picture of how you are progressing toward your self-care goals.

	For more info: https://www.diabeteseducator.org/living-with-diabetes/aade7-self-care-behaviors/aade7-self-care-behaviors-monitoring
Being Active	1. Being active has many health benefits, like improving blood pressure and blood sugars. 2. If you haven't exercised for a while, start with a five-minute walk and increase gradually. 3. Break activity into three ten-minute sessions. 4. Find a friend to exercise with. *For more info: https://www.diabeteseducator.org/living-with-diabetes/aade7-self-care-behaviors/being-active*
Taking Medication	1. Take notes when you visit with your doctor about your medication. 2. Learn what causes your blood sugar to go above or below target. 3. Talk to your doctor about how to improve your blood sugar. 4. Take your medication at the right time. *For more info: https://www.diabeteseducator.org/living-with-diabetes/aade7-self-care-behaviors/taking-medication*
Reducing Risk	1. See your eye doctor at least once a year. 2. Keep a wallet card that lists all of the tests you should be regularly getting and the targets for each. 3. Lowering your cholesterol can decrease your risk for a stroke. Talk to your doctor about what you can do. 4. Take care of your feet. *For more info: https://www.diabeteseducator.org/living-with-diabetes/aade7-self-care-behaviors/reducing-risks*

(AADE7, 2020)

Table 2. Studies used Technology with Diabetics Patients

Name/year	Type of study	intervention	Country	Outcome
Hassan (2017)	pretest - posttest study	SMS	Jordan	After 12 weeks <1% reported poor foot care practices. Statistical testing showed significant gains in knowledge (by score and level) and nearly unanimous compliance with daily foot examination.
Hussein, Hasan, & Jaradat (2011)		SMS	Bahrain	The result showed both groups had a significant reduction in in their A1c compared at the baseline; however, the intervention group had a significantly greater reduction in A1c (p=0.001).
Abaza & Marschollek (2017)	randomized controlled trial	SMS	Egypt	The result of the primary outcome did not differ significantly. Three months later there was a mean drop HbA1c of -0.69% and -1.05% in both groups. The target, a 1% HbA1c reduction, was achieved by 16 intervention groups and 6 control groups. A secondary outcome was achieved after three months; the mean blood glucose level decreased by 19 mg/dl in the control group, and 61 mg/dl in the intervention group.
Celik, Cosansu, Erdogan, Kahraman, Isik, Bayrak, & Olgun (2015)	pretest-posttest design study	SMS	Turkey	significant ($p < 0.05$) improvement at 3 and 6 months, and the A1c levels showed a statistically significant decrease.
Katalenich Et al., (2015)	randomized controlled study	DRMS Diabetes Remote Monitoring and Management System	USA	HbA_{1c} was similar be- tween the DRMS and control groups at 3 months (7.60% vs 8.10%) and at 6 months (8.10% vs 7.90%). Changes from baseline to 6 months were not statistically significant for self-reported medication adherence and diabetes-specific quality of life, with the exception of the Daily Quality of Life–Social/ Vocational Concerns subscale score (P 1⁄4 0.04).
Zolfaghari, Mousavifar, Pedram, & Haghnai, (2012)	a quasi-experimental study	SMS	Iran	both interventions had significant mean changes in glycosylated hemoglobin. For the telephone group ($p < .001$), a mean change of -0.93 and for the short message service group ($p < .001$), a mean change of -1.01. There was no significant difference in diet adherence (p = 0Æ000), physical exercise (p = 0.000) and medication taking (p = 0.000) adherence in either groups.
Bell, Fonda, Walker, Schmidt, & Vigersk (2012)	prospective randomized trial study	Mobile Phone-Based Video Messages	USA	was a significant improvement p<.001in the group which received mobile phone-based, one-way video messages, Hemoglobin A1c decrease was greater in the video message group. The results show that using a smartphone with one-way

				intervention video self-care messages improved A1C for diabetic participants.
Alanzi et al., (2016)	mixed method design study	Saudi Arabia Networking for Aiding Diabetes (SANAD).	Saudi Arabia	The preliminary results of the usability study indicated general acceptance of the patients in using the system with higher usability rating in patients with type 2 diabetes
AlQarni, Yunus, & Househ (2016)	mixed-methods retrospective	App	Saudi Arabia	They found 6107 posts in Arabic related to DM of which 1551 posts were included for further analysis. There were 458 (30%) FB posts from Egypt with no posts from Somalia, Yemen, Comoros, and Djibouti. The majority of the posts, 863 (56%), were from females. The focus of the posts was on sharing personal experiences (*n* = 423, 27%), raising awareness (*n* = 210, 3.5%), providing spiritual support (*n* = 162, 10.4%), sharing latest research (*n*=147, 9.5%), and providing education (*n*=110, 7.1%) on DM. A large number of the posts by people in 40—60-year age group were around finding out diagnosis related information due to limited access to care in their home countries.
Istepanian, Mousa, Haddad, Sungoor, Hammadan, Soran, & Al-Anzi (2014)	feasibility study	App (DIAR),	Iraq	Outcome of this study indicated the lowering of HbA_{1C} levels in the mobile health group indicating the potential of deploying such technologies in these regions where health resources are limited and challenging.
Goh, Tan, Malhotra, Padmanabhan, Barbier, Allen Jr, & Østbye, (2015)	short- term (8-week) trajectories study	iDAT app	Singapore	Three iDAT app use trajectories were observed: Minimal Users (66 out of 84 patients, 78.6%, with either no iDAT use at all or use only in the first 2 weeks), Intermittent-Waning Users (10 out of 84 patients, 11.9%, with occasional weekly use mainly in the first 4 weeks), and Consistent Users (8 out of 84 patients, 9.5%, with weekly use throughout all or most of the 8 weeks). The adjusted odds ratio of being a Consistent User, relative to a Minimal User, was significantly higher for females (OR 19.55, 95% CI 1.78-215.42) and for those with higher exercise motivation scores at baseline (OR 4.89, 95% CI 1.80-13.28). The adjusted odds ratio of being an Intermittent-Waning User relative to a Minimal User was also significantly higher for those with higher exercise motivation scores at baseline (OR 1.82, 95% CI 1.00-3.32).

Ryan et al., (2017)	a pilot study	App (IDM) Intelligent Diabetes Management	Canada	participants who used smartphone app IDM had improved A1C level and fell from 8.1% (7.5 to 9.0 IQ range) to 7.8% (6.9 to 8.3; p<0.001).
Wayne et al (2015),	Randomized controlled trial (RCT)	App	Canada	there were no significant between-group differences in change of HbA1c at 6 months using intention-to-treat (last observation carried forward [LOCF]) (*P*=.48) or per-protocol (*P*=.83) principles. However, the intervention group did achieve an accelerated HbA1c reduction, leading to a significant between-group difference at 3 months (*P*=.03). This difference was reduced at the 6-month follow-up as the control group continued to improve, achieving a reduction of 0.81% (8.9 mmol/mol) (*P*=.001) compared with a reduction of 0.84% (9.2 mmol/mol) (*P*=.001) in the intervention group. Intervention group participants also had significant decreases in weight (*P*=.006) and waist circumference (*P*=.01) while controls did not. Both groups reported improvements in mood, satisfaction with life, and quality of life.

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PUBLICATIONS AND PRESENTATIONS

1. Ahmad, R., Aboshaiqah, E., & Cruz, J., (2019). The Use of Smartphones among Nurses during Clinical Practice: A Multi-Hospital Study (in review /Journal of Nursing Management).

2.Ahmad, R. (2015) The Morse Falls Scale: An Evidenced Based Intervention for a Medical Center in the South of Saudi Arabia (in progress).

3.Ahmad, R. (2018). Medication Adherence Through Technology for Diabetic Type 2 Patients in the Kingdom of Saudi Arabia (in progress).

4. Ahmad, R., Gaillard, T., (2019). A Review of the Literature on Metabolic Syndrome Among Older Adults (in progress).

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Ahmad, R., Alexander, P., Alharbi, M., & Dunbar-Milledge, M. "The Morse Fall Scale: An Evidence-Based Intervention at a Saudi Arabian Hospital." March 2019. Poster presentation. 44th Annual Spring Seminar by the Broward County Chapter of the American Association of Critical-Care Nurses. Fort Lauderdale, Florida.USA. Supported by FIU

Ahmad, R., Alexander, P., Alharbi, M., & Dunbar-Milledge, M. "The Morse Fall Scale: An Evidence-Based Intervention at a Saudi Arabian Hospital." April 2019. Poster presentation Graduate Student Appreciation Week. Florida International University. Supported by FIU

RESEARCH
2019 Ahmad, R., PI. Aboshaiqah, E., & Cruz, J. The Use of Smartphones among Nurses during Clinical Practice: A Multi-Hospital Study. This study investigated the utilization of smartphones for work-related purposes among nurses