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ORIGINAL RESEARCH

mHealth for diabetes self-management in the Kingdom of Saudi Arabia: barriers and solutions

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Purpose: In this paper I present a perspective of mobile health (mHealth) technologies for diabetes in conjunction with an overview of the current status of mHealth technologies for diabetes self-management and the clinical evidence in the Kingdom of Saudi Arabia. In addition, a small survey to identify the barriers to mHealth for diabetes care in the Kingdom and the relevant solutions are discussed.

Participants and methods: In order to study the relevant obstacles for adopting mHealth solutions for diabetes care and to suggest appropriate solutions, a small survey study was conducted with a specific questionnaire deployed to >40 anonymous leading health care professionals and decision-makers of the Kingdom. The survey was distributed by means of a link to the target population through a WhatsApp group. The data were collected during 1 month, and three reminders were sent to the group to complete the survey. Basic descriptive statistics were used to analyze the survey data.

Results: The high percentages of agreement among the participants suggest that mHealth expertise and human shortage; funding and infrastructure investments; legal, privacy standardization and regulatory obstacles; and health care organizational and bureaucracy impediments are barriers to the implementation of mHealth technologies in the self-management of diabetes in this region. However, most of these barriers can be mitigated by the creation of the appropriate leadership and clinical environment in the current health care system.

Conclusion: The mHealth technologies for diabetes self-management have not yet been translated successfully in the Kingdom of Saudi Arabia as it was detected in the literature review carried out in this work. Among other possibilities, the causes of this situation are the existence of human, organizational, funding, bureaucracy, and legal barriers, as shown by the results of the survey conducted among decision-makers and senior clinicians of the Kingdom of Saudi Arabia.

Keywords: mHealth, diabetes self-management, Kingdom of Saudi Arabia, barriers and solutions

Introduction

Diabetes mellitus is a global chronic disease epidemic and a major health and economic burden globally. Furthermore, diabetes prevalence in the Gulf region and in the Kingdom of Saudi Arabia in particular is increasing at an alarming rate among both adult and younger populations. The Kingdom of Saudi Arabia has one of the highest diabetes prevalence levels globally (>24%) with >1.8 million diabetic patients.[1,2] It is estimated that this population is to double with a rate of (105.4%) increase by 2035 compared with the levels in 2013.[2] The highest levels of prevalence are in the northern and eastern regions of the Kingdom accounting to 27.9% and 26.4% levels, respectively.[3] However, a major cross-sectional study (within the capital Riyadh city only) estimated higher

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prevalence levels of 31.6% among 7- to 80-year olds.[4] The Kingdom has also one of the highest incidences globally of type 1 diabetes (T1D) in children.[1] The causes of these alarming statistics are mostly related to increased obesity and body mass index levels; poor diet and unhealthy eating patterns; sedentary and lack of physical activities; increased smoking; and other factors. It is estimated that among 25% and 40% of population aged <18 years and between two-thirds and three quarters of adults in the six Gulf Cooperation Council (GCC) countries including the Kingdom of Saudi Arabia are overweight or obese.[5] There is also increasing evidence of higher rates of diabetes onset in young Saudi women with increased risks of cardiovascular complications.[6,7] These statistics are leading to increasing economic costs of diabetes care in the Kingdom, which is estimated to reach $6.5 billion by 2020.[8] The Saudi Ministry of Health estimates the annual costs of diabetes treatment per patient to be ~$2,600 (for T1D patients without complications) and between $1,300 and $2,100 for type 2 diabetes (T2D) patients annually.[9] These costs are forecasted to increase to >$30,000/patient annually for persons with complications such as renal failure.[9]

In contrast to these health care and economic challenges, the Kingdom is in the midst of the accelerated digitization of its health care economy. The Kingdom is one of the areas with the highest penetration of smart phones, Internet, and social networking usage in the Gulf. Recent statistics indicate that smart phone users in the Kingdom of Saudi Arabia will increase from 21.87 million in 2018 to 24.02 million in 2022.[10] Similarly, the mobile Internet users will increase from 23.77 million in 2018 to 26.44 million in 2022.[11] These unprecedented socio-economic changes are particularly evident in the wider usage of smart phones and social networking tools among the Saudi population, especially among the younger users.[12]

However, this rapid digitization of the society has not yet seen parallel growth and popularity within the health care sector, particularly in the diabetes care areas where such technologies can play a major role in patient support, better outcomes, and improved health care delivery services. Globally, there are numerous mobile health (mHealth) systems in the diabetes care area.[13] However, in comparison with this global trend, there are few clinical studies that address the role of mHealth for diabetes care in the GCC and the Kingdom of Saudi Arabia.[12,13] Moreover, there is no clear mHealth or digital health policy in the Kingdom where the development of such policy is particularly timely, especially with the current drive for the health care digitization and modernization.

In this sense, this article presents an overview of the current status of mHealth technologies for diabetes self-management and the clinical evidence to date in conjunction with some recent mHealth pilot studies for diabetes self-management conducted in the Kingdom of Saudi Arabia. I also present a small survey study of the barriers to implementing mHealth for diabetes care and the solutions to these barriers together with the recommendations for adopting a digital health for diabetes strategy in the Kingdom.

Background

Taking into account the increase in the population of diabetic patients and the clinical and economic benefits perceived by the application (app) of mHealth technologies, the broader incorporation of these systems among the diabetic care sectors within the Kingdom of Saudi Arabia is timely and important. Because of the importance of this issue, I present a brief description about the principles of self-control of mobile diabetes through these technologies and review the clinical evidence presented in this area to date, followed by an analysis of the most relevant studies conducted in this field in the Kingdom of Saudi Arabia and the region of the Gulf.

m-Health for diabetes care: clinical evidence and therapy compliance

mHealth was first defined and introduced as "mobile computing, medical sensor, and communications technologies for health-care."[13] Since 2003, mHealth has become one of the key technological domains that reflected the key advances in the Internet, mobile communications, sensors, and computing for health care delivery. mHealth innovations spanned diverse clinical sectors and apps most notably in the chronic disease management areas such as diabetes, chronic obstructive pulmonary disease, and cardiovascular diseases.

In particular, mobile diabetes remote monitoring and self-management have been one of the early areas of mHealth.[13] Clinically, self-management of blood glucose levels is considered a vital supplementary approach advocated by all the diabetes care standards in providing improved diabetes care and quality of life and is associated in reducing glycated hemoglobin (HbA1C) levels and long-term complications.[14] Furthermore, there is strong clinical evidence that mHealth interventions for diabetes self-management and well-being can assist patients in optimizing their metabolic control, prevent and manage complications, and improve the quality of life and clinical outcomes with cost-effective results. Some of these benefits include the following: 1) the timely access to the individualized diabetes data and relevant information by patients with seamless connectivity to their health care providers (HCPs); 2) the utilization of widely used communication mechanism associated with smart apps and smart phone technologies to facilitate remote monitoring and self-management of diabetes; 3) effective prioritization and delivery of care to diabetic patients by their HCPs and the provision for improved treatment therapy and compliance for better clinical outcomes and reduced complications; and 4) potential cost-effectiveness and economic benefits in diabetes care.[13]

The recent increase in clinical studies together with the proliferation of thousands of commercial diabetes apps and market-driven systems is evident from these benefits. Yet, this global engagement has not yet been translated to any large-scale clinical practice or patient adoption in the Middle East and the Gulf region.

General architecture of mHealth for diabetes care and self-management

The basic architecture of the classical "smart phone center diabetes care and self-management model" usually consists of three basic integrated modules: 1) the mobile patient module; 2) the remote HCP or clinician module; and 3) the remote data servers or cloud module that typically hosts the patient's Electronic Health Record (EHR), together with data analytics, inference engine files (for artificial intelligence [AI] analysis), and data controllers hosted in a secure cloud platform.[13] The mobile patient and physicians' ends are usually connected via either a mobile (cellular) network or any other Internet connectivity link (eg, Wi-Fi). These three modules can be developed either as stand-alone or interconnected depending on the specific monitoring requirements and care management settings. For example, for clinical settings, all these three modules are integrated by the perspective supplier or system developers. While for nonclinical environments (stand-alone patient self-awareness or education), these are usually offered by an app as stand-alone systems for monitoring and education purposes. These are typically downloadable from smart phone platforms such as iOS (Apple Store) or Android (Google Play).

In the mobile patient end, the daily patient data including blood glucose (acquired from the blood glucose meters, insulin pumps, or other diabetes sensors via Bluetooth) together with other biometric, diet, and exercise data that are manually tapped and acquired by the patient's phone using a dedicated smart app. It is estimated that there are >1,400 smart diabetes apps on different smart phone market platforms (iOS and Android). The majority of these are unregulated and developed for diabetes market usage purposes with a few that are clinically validated and approved by the relevant regulatory bodies.[15]

The diabetes app is designed to acquire tracking and to store the patient's daily blood glucose data and other relevant information such as diet and well-being data that are used for the self-management and monitoring purposes. Hypertensive patients may also use additional wireless blood pressure devices and weight scales as required for their particular conditions. These patients are usually required to complete basic training and an educational program on using these systems. Some examples of apps available on the market are the following: Fooducate (iPhone and Android; this app educates users on nutrition), Health2Sync (iPhone and Android; this app documents sugar readings, weight, and other factors that affect diabetes), Glucosio (Android; it monitors weight, HbA1c, ketones, cholesterol, blood pressure, and other variables), MyNetDiary Calorie Counter (iPhone and Android; this app evaluates food intake and weight management), Diabetes Tracker (iPhone and Android; it documents exercise, food and water intake, weight, HbA1c, cholesterol, net carbs, and other health factors), BG Monitor (Android; this app monitors blood glucose and insulin), Glucose Buddy (iPhone and Android; monitor weight, blood pressure, and HbA1c levels), and DiabetesConnect (iPhone and Android; this app inputs your blood sugar, meals, insulin injections, medication, and other values that impact overall diabetes management).[16] Similarly, some apps have been used in various research studies.[17–20] In one of these studies, GlucoMen was developed which is an app that can monitor HbA1c values, blood pressure, weight, nutrition, and medication.[17] In addition, Tulu et al designed a health and wellness smartphone app to support diabetes self-management for advanced T2D.[18] Similarly, Ryan et al proposed an app appropriate for use with a variety of routines, including pumps, insulin scales, glucose levels, and food insulin dosage.[19] In another study, a diabetes self-management mobile app based on a behavioral skills model is designed to provide personalized education, individual information, personal and social motivation, blood glucose trends, and diet and exercise input.[20]

This combination of data is usually transmitted wirelessly and stored in a remote portal hosted in a health clinic or hospital. In the HCP module, a web-based portal that consists of the patient's EHR was supported with intelligent data analytic tools to process the acquired data and produce simple illustrative graphics to assist the clinicians in their care plans for each patient. These can be in a format of graphic representation that displays the appropriate information and decision support messages. The adaptation of any medication and treatment plans required for individual patients can also be included. This is based on the individualized patient self-management history, daily blood glucose profiles, treatment progress, and designated therapy protocol plans assessed regularly at 3-to 6-month follow-up intervals. The other biometric data including the diet, exercise, and sedentary status are correlated with the blood glucose variations to provide the proper clinical feedback and treatment instructions to the patient. The schedule and frequency of taking the blood glucose readings and other medical data are dependent on the individual care plan tailored for each patient by their diabetes specialist and based on their individual diabetes type, complication treatment, and management progress.[13,21] A summary of the functionalities associated with typical smart diabetes apps that are categorized to monitoring or management and support functions is described by Istepanian and Woodard.[13]

Finally, due to the impact of AI on the detection and management of diabetes, it should be noted that AI technologies applied in diabetes health care systems can improve the interactions between patients, health care professionals, and the health care system.[22–24] The algorithms and computer models used in the AI tools are capable of handling and manipulating a vast number of variables of users and the environment that facilitate interactions between patients and mobile apps, assisting in a more effective way the medical treatment. They can also help doctors make decisions about the detection of diabetes and selection of the optimal treatment adapted to the specific characteristics of each patient. In the same way, these technologies have a wider predictive power than conventional mobile technologies and allow interactive actions among users of the health system. In these apps, smartphones or mobile data connections are required to access the cloud.

Clinical evidence and efficacy issues of mHealth interventions for diabetes care

The early clinical studies in this area were conducted more than a decade ago.[13,15,21] However, the introduction of the first generation of smart phone technologies in 2007 resulted in a proliferation of randomized clinical trials and pilot studies worldwide.[13,15,21] This increase is reflected in a recent review and meta-analysis studies in this field.[25] Another overview study of 15 systematic reviews selected from a total of 52 studies of mHealth interventions for both T1D and T2D demonstrated that, on average, mobile phone-based interventions with clinical feedback improve glycemic control (HbA1c) compared with standard care or other non-mHealth approaches.[25] These were on average as much as 0.8% for patients with T2D and 0.3% for patients with T1D, at least in short-term periods (≤12 months).[25] These outcomes are consistent with an earlier meta-analysis study for T2D interventions.[26–28] However, these studies also concluded that mHealth interventions may have limited impact on glycemic control of T1D patients and concur with other traditional behavioral interventions studied in the past.[25,26] In a similar review and meta-analysis study, the outcomes of 14 clinical randomized controlled trials in both T1D and T2D (n=1,360) concluded that all the T2D studies reported a mean reduction in HbA1c levels using mHealth intervention compared with the control group.[27] This review also found inadequate data to support the effectiveness of the mHealth interventions for T1D patients with no statistically significant beneficial outcomes in trials comparing HbA1c between mHealth apps and intervention groups.[27] Likewise, another meta-analysis study of mHealth interventions for T2D that analyzed 13 studies with a total of 1,022 patients concluded that mHealth interventions show moderate benefits on blood glucose control with a pooled effect on HbA1c reduction of 0.40% (4.37 mmol/mol).[28] From these studies and the meta-analysis, it is clear that there are important, if not significant, benefits to controlling blood glucose levels, especially for T2D patients using oral medication or in the context of their lifestyle behavior. In addition to these benefits, the regularity and frequency of the blood glucose measurements are considered important. These studies concluded that the feedback from the HCP and any automated messaging act as important elements in any successful mHealth interventions for diabetes. From the obesity-related diabetes perspective, a recent review of 24 studies concluded that on average a weight loss reduction between 1.97 kg in 16 weeks and 7.1 kg in 5 weeks was achievable with associated reduction levels in HbA1c (0.4% in 10 months to 1.9% in 12 months) using mHealth intermediations.[29] To date, no similar studies have been reported in the Kingdom of Saudi Arabia, considering the importance of this area due to the increasing level in obesity related to diabetes in the Kingdom. In addition, no study on the relevant security, privacy, and ethical issues of mHealth has been done, and these issues remain significantly unexplored in the Kingdom and the Gulf area in general.

mHealth studies for diabetes care in the Gulf and the Kingdom of Saudi Arabia

In relation to the app of mHealth technologies, only a few clinical and experimental studies have been conducted in the Gulf region and the Kingdom of Saudi Arabia.[30] A recent review identified only 15 studies on mHealth for diabetes care in the Middle East area.[30] In addition, some current mHealth pilot studies in the region addressed the effectiveness of mobile text messaging to support education and management of T2D in Iraq.[31] Others addressed the evaluation of text messaging to support antenatal health care in Iraqi pregnant women.[32] The results of these studies indicated the effectiveness of text messaging tools in improving diabetes care and educational outcomes for the patients compared with the usual care.

In the Kingdom of Saudi Arabia, a feasibility pilot study conducted in Dammam region on 20 Saudi patients with a 6-month follow-up period evaluated the effect of mHealth in the intervention group compared with the usual diabetes care group.[33] The primary outcomes of this study were the HbA1c and the diabetes knowledge tests. The mean baseline HbA1c for the intervention group was 8.76% (0.76% tolerance), and it was 8.61% for the control group. The results showed that the mean baseline of the intervention group decreased from 8.76% to 7.85% compared with a slight increase in the mean baseline of the control group from 8.61% to 8.68%. Another study on the effectiveness of social networking for diabetes care in the Kingdom indicated better educational and behavioral awareness outcomes in Saudi diabetic patients after the intervention process.[30]

On the other hand, the Saudi Ministry of Health led several electronic health (eHealth) initiatives in the past.[34] These eHealth initiatives generally aimed to identify and develop plans for strategic health information systems and to introduce different eHealth services such as Electronic Medical Records, Computer-Based Patient Records, Automated Health Records, and Electronic Patient Records in hospitals and clinics throughout the Kingdom.[34] However, these initiatives remain in "silos" format, and their uptake and success levels were geographically limited to specific regions in the Kingdom.[35] However, no study was conducted on identifying the mHealth barriers in the Kingdom, particularly for diabetes care and self-management.

According to this review, I can detect that there are an increasing trend from HCPs and potential acceptance from diabetic patient in the Kingdom for mHealth services. However, there are surprisingly no large clinical studies that can translate the benefits discussed above into the usual diabetes clinical practice within the different health care services in the Kingdom. The reason for this absence is a plethora of social, human, and technical barriers identified, presented, and discussed in the following sections of this study.

Methods

It is pertinent to indicate that, to date, no study has been carried out to identify the mHealth barriers in the Kingdom of Saudi Arabia, in particular, for diabetes care and self-management. In this sense, in order to study the relevant obstacles for adopting mHealth solutions for diabetes care in the Kingdom of Saudi Arabia and suggest the appropriate solutions, a small survey study was conducted to identify the relevant barriers for implementing mHealth for diabetes care and management, in particular, together with suggested solutions for these barriers.

Study settings and participants

The survey was conducted in 2017 with a specific questionnaire designed and deployed to >40 anonymous senior clinicians, leading health care professionals, and decision-makers of the Kingdom of Saudi Arabia. The survey was distributed by means of a link to the target population through a WhatsApp group. I used WhatsApp because most of the decision-makers and leaders in the field of digital health in the Kingdom of Saudi Arabia belong to one group of this app. Furthermore, I employed a scientific professional online survey tool, "SurveyMonkey," and sent the link to anonymous leading health care professionals and decision-makers of the Kingdom of Saudi Arabia in order to guarantee the anonymity of the answers. The data were collected during 1 month, and during this period, three group reminders were sent to the group to complete the survey. The ethical approval was obtained from the Institutional Review Board of the Imam Abdulrahman Bin Faisal University, and the completion of the questionnaire was considered to imply informed consent to participate in the study.

Inclusion criterion

The inclusion criterion was being senior clinicians, leading health care professionals, or decision-makers from the Kingdom of Saudi Arabia.

Exclusion criterion

Senior clinicians, leading health care professionals, and decision makers who are not from the Kingdom of Saudi Arabia

Description of the questionnaire

The design of the questionnaire is based on the existing literature on published research surveys related to eHealth and mHealth technologies.[35–38] From these studies, the appropriate guidelines were obtained to structure and develop the survey questions displayed in Table 1.

According to Table 1, the questionnaire consists of two sections. The first section of the questionnaire is related to the demographic and occupational data of participants and is

Table 1 Questionnaire

Characteristics		
Age (years)		
20–30		
31–40		
41–50		
>50		
Gender		
Male		
Female		
Educational level		
Diploma		
Bachelor		
Master		
Doctorate		
Job title		
Senior clinician		
Health informatics specialist		
IT specialist		
Other		
Years of experience		
1–5		
6–10		
11–15		
16–20		
>20		
Questions	**Yes**	**No**
Do you agree on the following barriers for digital mHealth in the Kingdom?		
1. mHealth expertise and human shortage		
2. Funding and infrastructure investments		
3. Legal, privacy standardization and regulatory barriers		
4. Health care organizational and bureaucracy barriers		
Do you agree on the following causes for these barriers?		
• mHealth expertise and human shortage (eg, diabetes care and management)		
1. Lack of digital health practitioners (eg, diabetes nurse and training opportunities)		
2. Lack of awareness on the importance of mHealth and impact on diabetes management		
3. Lack of differentiation and care benefits between eHealth and mHealth applications (eg, in the diabetes care area)		
• Funding and infrastructure investments		
1. High costs and investment required for the successful implementation of large-scale digital health programs		
2. Absence of large-scale evidence-based clinical trials on digital health that warrant such investments (eg, in diabetes)		
3. Adapting the current information and computing infrastructure toward digital health programs		
• Legal, privacy standardization and regulatory barriers		
1. Lack interoperability standards		
2. Lack of local expertise in these areas		
3. Lack of smart mHealth applications tailored for local needs and cultural norms		
4. Absence of national mHealth plan and strategy		
5. Divergence of opinions and outcomes between the private and public health care sectors on digital health (eg, diabetes care)		
6. Lack of mHealth ethics requirements		
7. Privacy, security, and confidentiality concerns		
• Health care organizational and bureaucracy barriers		
1. Lack of understanding of the importance of mHealth for health care delivery services by decision-makers		
2. The perception of added workload and efficiency issues by health care providers (eg, diabetes)		
3. Lack of mHealth leadership on organizational levels (eg, CIO or their equivalent)		
4. Lack of mHealth initiatives and implementation plans in both private and public health care sectors		
Do you agree on the following solutions for each barrier within each category?		
• mHealth expertise and human shortage		
1. Provide better educational training in digital and mHealth areas of importance (eg, digital diabetes courses for nurses and specialist)		
2. Better public awareness programs on the benefits of mHealth		

(*Continued*)

Table 1 (*Continued*)

Questions	Yes	No
• Funding and investment		
1. Allocation for more funding and strategic plans for digital diabetes		
• Legal, privacy standardization and regulatory barriers		
1. Adoption of interoperability strategy for digital diabetes in the Kingdom		
2. Better resource allocation		
3. National mHealth plan		
4. Development of ethical standards for mHealth		
• Health care organizational and bureaucracy barriers		
1. Training and professional course		
2. Better time allocation and resources		
3. Creation of mHealth leaders		
Any barriers solutions?		

Abbreviations: CIO, Chief Information Officer; IT, information technology; mHealth, mobile health.

aimed to obtain information such as age, gender, educational level, job title, and years of experience of the respondents. The second section presents a set of questions about the barriers and solutions that I identified for the app of mHealth technologies in the Kingdom of Saudi Arabia. In this section, I asked the participants if they agreed with these propositions by answering the words "Yes" or "No." To be more precise, in Table 2, I present the identified barriers and the solutions suggested to suppress each one of the identified barriers. Briefly, the proposed barriers and solutions are the following: barriers: mHealth expertise and human shortage; funding and infrastructure investments; legal, privacy standardization and regulatory barriers; and health care organizational and bureaucracy barriers; and solutions: providing better educational training in digital and mHealth areas of importance such as digital diabetes courses for nurses and specialists; providing better public awareness programs on the benefits of mHealth; allocation of more funding and strategic plans for digital diabetes; adoption of interoperability strategy for digital diabetes in the Kingdom; better resource allocation; the development of a national mHealth plan; the development of ethical standards for mHealth; training and professional courses; better time allocation and resources; and creation of mHealth leaders.

The criterion for selecting the barriers mentioned in the questionnaire is based on the human, organizational, financial, bureaucratic, and legal obstacles that exist to implement health systems in the social, economic, cultural, and political context of the Kingdom of Saudi Arabia.[35,36,39,40] Based on this information and our experience as researchers in the field of digital health, I identified the barriers discussed in this research. The high level of agreement observed in the participants reveals that the barriers proposed in this work are real and important obstacles for the implementation of these technologies in the Kingdom of Saudi Arabia.

Statistical analysis

Basic descriptive statistics using frequencies and percentages were used in the analysis of the survey data. I also estimated the difference in sample proportions, the 95% CI of the difference, and the probability *P*-value.

Results

As described in the "Methods" section, Table 1 presents the questionnaire of the survey carried out in this research. Table 2 describes the identified mHealth barriers and the proposed solutions to suppress them.

Similarly, Table 3 provides the demographic, educational, and occupational information of the survey participants. In this table, it is found that more than half of the participants were men (72. 7%), and 42.4% of the respondents were

Table 2 List of the identified mHealth barriers and suggested solutions

Identified mHealth barriers	Suggested solutions
1. mHealth expertise and human shortage	Provide better educational training in digital and mHealth areas of importance (eg, digital diabetes courses for nurses and specialist) Better public awareness programs on the benefits of mHealth in diabetes
2. Funding and infrastructure investment	Allocation of more funding and strategic plans for digital diabetes
3. Legal practice standardization and regulatory barriers	Development of ethical standards for mHealth Interoperability strategy for digital diabetes in the Kingdom of Saudi Arabia National mHealth plan Better resource allocation
4. Health care organizational and bureaucracy barriers	Training and professional courses Better time allocation and resources Creation of mHealth leaders

Abbreviation: mHealth, mobile health.

Table 3 Demographic data

Characteristics	n (%)
Age (years)	
20–30	2 (6)
31–40	16 (48.4)
41–50	11 (33.3)
>50	4 (12.1)
Gender	
Male	24 (72.7)
Female	9 (27.7)
Educational level	
Diploma	1 (3)
Bachelor	18 (54.5)
Master	6 (18.1)
Doctorate	8 (24.2)
Job title	
Senior clinician	14 (42.4)
Health informatics specialist	12 (36.3)
IT specialist	3 (9.09)
Other	3 (9.09)
Years of experience	
1–5	1 (3)
6–10	3 (9.09)
11–15	15 (45.4)
16–20	10 (33.3)
>20	4 (12.1)

Note: n=33 participants.
Abbreviation: IT, information technology.

Table 4 Respondents rate for the identified mHealth barriers

Respondents rates	n (%)
Yes	30 (90.9)
No	3 (9.09)

Abbreviation: mHealth, mobile health.

Table 5 Respondents rate for each category of the identified mHealth barriers

Identified barrier	Yes (%)	No (%)
1. mHealth expertise and human shortage	90.91	9.09
2. Funding and infrastructure investment	87.88	12.12
3. Legal practice standardization and regulatory barriers	69.70	30.30
4. Health care organizational and bureaucracy barriers	81.82	18.18

Abbreviation: mHealth, mobile health.

senior clinicians. In addition, more than half of them had a bachelor's degree, and the majority had a work experience between 6 and 20 years.

Related to the identified mHealth technology barriers in the Kingdom of Saudi Arabia, Table 4 indicates that 90.91% of the respondents are in agreement with the identified barriers listed in Table 2. Likewise, Table 5 presents the response of the participants for each of the barriers indicated in Table 2. From Table 5, it is clear that the participants believed that the most significant barrier is the mHealth expertise and human shortage (90.91%), followed sequentially by funding and infrastructure investment (87.88%), health care organizational and bureaucracy barriers (81.82%), and legal practice standardization and regulatory obstacles (69.70%).

Similarly, Table 6 presents the opinion of the participants about the solutions proposed to suppress or eliminate the identified barriers listed in Table 2. In relation to the mHealth expertise and human shortage barrier, 93.94% of the respondents think that providing better educational training in digital and mHealth areas and better public awareness programs on the benefits of mHealth in diabetes will contribute to reduce the impact of this barrier. Similarly, 81.83% of the respondents opine that the allocation of more funds and strategic plans for digital diabetes will diminish the barrier of funding and infrastructure investments. Likewise, respondents believe that the development of ethical standards for mHealth (100%), interoperability strategy for digital diabetes in the Kingdom (96.97%), a national mHealth plan (93.94%), and a better allocation of resources (90.91%) will help decrease legalization, privacy standardization, and regulatory barriers. In addition, according to the participants, the health care organizational and bureaucracy barriers can be eradicated by offering training and professional courses (93.94%), making a better allocation of time and resources (90.91%), and creating mHealth leaders (90.91%). Briefly, Table 6 shows the proportion of respondents who agreed to and disagreed with the proposed solutions to each barrier and the statistical comparisons in terms of the percentage of sample proportions, the 95% confidence intervals, and the probability *P*-value.

On the other hand, from the following participant's quotes, I can appreciate other general ideas about mHealth and diabetes:

> mHealth should come up with a plan for how to deal with people of different age as well as their ignorance in technology.
>
> Lack of cooperation between academia and hospitals. No access for fund raising and partnership to support health projects. I tried to work on such topic since three years but lack of cooperation and lack of any opportunity for implementation stopped a valuable idea about diabetic disease management by using personal health record.
>
> Potential resistance by older and more experienced health care professionals. Organizations are more open to new ideas if proper presentation of these ideas is given in terms of benefits e.g., money, time and effort saved.
>
> Lack of academic research on the health organizations to have better decisions from health leaders.

Table 6 Analysis of the respondents for the solutions proposed for each barrier category

Suggested solution against each barrier category	Yes (%)	No (%)	Difference in the simple proportions (%)	95% CI of difference	*P*-value
mHealth expertise and human shortage barriers					
1. Provide better educational training in digital and mHealth areas	93.9	6.1	87.8	22.6–95.2	<0.001
2. Better public awareness programs on the benefits of mHealth in diabetes	93.9	6.1	87.8	22.6–95.2	<0.001
Funding and investment barriers					
1. Allocation of more funding and strategic plans for digital diabetes	81.8	18.2	63.6	19.5–81.0	<0.001
Legal, privacy standardization and regulatory barriers					
1. Interoperability strategy for digital diabetes in the Kingdom	96.9	3.1	93.8	15.3–97.8	<0.001
2. National mHealth plan	93.9	6.1	87.8	22.6–95.2	<0.001
3. Better resource allocation	90.9	9.1	81.8	25.2–92.3	<0.001
4. Development of ethical standards for mHealth	100	0	–	–	–
Health care organizational and bureaucracy barriers					
1. Training and professional courses	93.9	6.1	87.8	22.6–95.2	<0.001
2. Better allocation of time and resources	90.9	9.1	81.8	25.2–92.3	<0.001
3. Creation of mHealth leaders	90.9	9.1	81.8	25.2–92.3	<0.001

Abbreviation: mHealth, mobile health.

These initial results and outcomes of this study are important for further consideration by the relevant decision-makers in the health care sectors within the Kingdom. These can provide the template for further work and better understanding of these barriers and the lack of tangible mHealth initiatives in the diabetes care area in the Kingdom.

Discussion

The introduction of mHealth technologies, more than a decade and half ago, triggered numerous mHealth apps and medical trials in many clinical areas, in particular, for diabetes self-management. However, this global trend and popularity of mHealth have not yet been translated successfully in the Kingdom of Saudi Arabia as was detected in the literature review carried out in this work. mHealth apps for diabetes self-management in the Kingdom remain largely either unknown or at its infancy at the best. Among other possibilities, the causes of this situation are related to the existence of human, organizational, funding, bureaucracy, and legal barriers, as shown by the results of the survey conducted in this research among decision-makers and senior clinicians of the Kingdom of Saudi Arabia.

In this sense, the high percentages of acceptance and agreement among the participants observed in Tables 4 and 5 suggest that there are barriers for the app of mHealth technologies in the Kingdom of Saudi Arabia and indicate that the identified barriers in this research (mHealth expertise and human shortage; funding and infrastructure investments; legal, privacy standardization and regulatory barriers; and health care organizational and bureaucracy obstacles) are real impediments for the app of mHealth technologies in the self-management of diabetes in this region. Likewise, the high percentages of acceptance observed in Table 6 point out that the proposed solutions to overcome the barriers of the app of mHealth technologies are adequate, according to the opinion of the respondents.

Related to the identified barriers and the suggested solutions presented in Tables 5 and 6, I can detect that according to 90.91% of the participants the most significant barrier to the implementation of mHealth technologies is mHealth expertise and human shortage. In relation to diabetes, to overcome this barrier, 93.94% of the participants propose to provide better educational training in digital and mHealth areas and to develop better public awareness programs on the benefits of mHealth in diabetes. Following the declining opinion of the participants, 87.88% of them think that funding and infrastructure investment are barriers to the use of mHealth technologies. In relation to diabetes, 81.83% of respondents consider that the solution to reduce this barrier is to allocate more funding and strategic plans for digital diabetes. Continuing the decreasing order, 81.82% of the surveyed think that health care organizational and bureaucracy are barriers for the app of mHealth technologies. With respect to the identified solutions, 93.94% of the participants believe that training and professional courses represent a possible alternative to reduce these barriers. In addition, 90.91% of the participants ponder that better allocation of time and resources and creation of mHealth leaders can eliminate these obstacles. Finally, 69.70% of the respondents reflect that legal practice standardization and regulatory barriers impede the use of mHealth tools in the Kingdom of Saudi Arabia. To eliminate these barriers, 100% of surveyed persons believe that it is necessary to develop ethical standards for mHealth. Furthermore, 96.97% of them consider that it is pertinent to create an interoperability strategy for digital diabetes in the Kingdom. In the same way, 93.94% of the respondents think that the implementation of a national mHealth plan would be the solution. Similarly, 91.90% of the participants consider that the removal of these barriers requires a better resource allocation. It is relevant to comment that all of the respondents (100%) think that the implementations of ethical standards for mHealth are fundamental to eliminate the legal practice standardization and regulatory barriers. Lastly, the probabilities (*P*-values) shown in Table 6 indicate that the proposed solutions are significant in statistical terms.

In summary, these results suggest that there is a general agreement with the barriers and solutions identified in this study. Obviously, the implementation of the identified solutions requires a great effort and a change in the mentality of the health and medical education sectors to allow these services to be widely used and applied within the different health areas of the Kingdom of Saudi Arabia. However, the high prevalence of diabetes and the exponential increase in the use of digital and intelligent telephones in the Kingdom indicate that the incorporation of mHealth technologies is timely and important to contribute to the solution of health problems created for this disease. These services can bring Saudi patients and government benefits and savings in the costs of treating diabetes.

It is pertinent to point out that the main limitation of this study is the small number of the surveyed HCPs, clinicians, and decision-makers. Another restriction is that I did not include the identifications of the clinical demographics and the geographical distribution of the hospitals and the respondents within the Kingdom of Saudi Arabia.

To overcome these limitations, it is necessary to conduct a study using a sample with a larger number of participants and also to carry out a similar survey from the perspective of the diabetic patient. In addition, the following challenging factors can be analyzed in future studies: 1) the lack of an awareness-raising strategy on the potential benefits of mHealth technologies among users, clinicians, HCPs, and those responsible for policy formulation in the Kingdom; 2) the scarcity of relevant medical educational and training courses on mHealth; 3) the absence of wider dissemination strategies among diabetic patients such as educational programs designed to improve diabetes care; 4) the social and cultural barriers that impose certain restrictions for better utilization of mHealth technologies for diabetes care, education, and lifestyle modifications; and 5) the lack of robust and workable mHealth market plans and business strategies from the local stakeholders interested in the mHealth that can be tailored successfully for the Kingdom's economic conditions.

Based on the findings of this study, I present the following recommendations for the immediate issues to be considered for accelerating the adoption process of mHealth technologies for diabetes self-management in the Kingdom of Saudi Arabia:

1. Development of comprehensive governmental plans for mHealth strategies for diabetes care and self-management. These include the strategic collaborations between the relevant governmental health authorities in the Kingdom with relevant international bodies such as World Health Organization and International Diabetes Federation, to support different mHealth initiatives for diabetes care. These initiatives will aim to provide the necessary regulatory, legal, and relevant efficacy frameworks in this area.
2. Introduction of mHealth educational and training courses within the medical schools with relevant curriculum developments within specialist postgraduate degrees in this important area.
3. Conduction of a large-scale and robust clinical trial within the region to study the wider clinical and economic impacts of mobile phone interventions for diabetes self-management and care.
4. Introduction of a wide educational strategy on using appropriate educational tools (eg, via text messaging and social networking) to provide relevant patient education and behavioral change for diabetes management in the Kingdom.
5. Development of appropriate market-driven public–private health care partnerships tailored for the Kingdom. This alternative aims to provide new and viable mobile diabetes care delivery plans to the Saudi patients. This initiative can, eg, benefit from similar and evolving mHealth service business delivery models that were successfully applied in different parts of the developed world.

A last recommendation can be proposed from the respondents' quotes:

> mHealth should have plans to deal with people of different ages and levels of knowledge. Likewise, it is necessary that there be cooperation between academia, hospitals and health organizations to have better decisions of health leaders. Equally, it is important to have access to fund rising to support projects such as the management of diabetic disease through personal health records. Additionally, to reduce the potential resistance on the part of older and

more experienced health professionals, it is convenient to offer an adequate presentation of the technologies in terms of benefits, money, time and effort saved.

Conclusion

In this paper, a perspective of mHealth for diabetes self-management in the Kingdom of Saudi Arabia was presented. This is a relatively new area within the health care sector in the Kingdom, and an overview of the current status of mHealth for diabetes self-management and clinical evidence with the relevant studies in this region to date was analyzed. Furthermore, a small observational survey study on the barriers for the implementation of mHealth technologies for diabetes care in the Kingdom and the solutions to these barriers was also presented and discussed.

The massive popularity of smart phones and social networking tools and other apps within the Saudi society at large makes the introduction of mHealth for diabetes care among Saudi patients and HCPs timely, if not important. There is an urgent need for further research in this area in which larger clinical trials are required to validate the benefits and the clinical outcomes of using mHealth technologies for diabetes care in the Kingdom.

There are also many barriers to the introduction of such services, and some of these barriers and their solutions have been identified and discussed in this paper. However, most of these barriers can be mitigated by the creation of the appropriate leadership and clinical environment that can accept these changes in the current health care system. Furthermore, the changes and the shift in the diabetic care from the reactive to preventative approaches utilizing these technologies are important and necessary, considering the high level of diabetes prevalence among Saudi population in recent years.

Disclosure

The author reports no conflicts of interest in this work.

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