e-Health for Diabetes Self-Management in Saudi Arabia: Barriers and Solutions

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Abstract

The need to give support to patients with diabetes through the use of e-health has become increasingly necessary in recent times. This study aims to determine how e-health applications can benefit the self-management of diabetes in patients in Saudi Arabia through a systematic literature review. Barriers and solutions e-health for the self-management of diabetes are the core focus of this study. Google Scholar, JSTOR, PubMed and Research Gate were used to access articles published. Mobile-enabled and e-health applications were consistently found promising in most of the papers. The search yielded 20 usable papers, described then categorised according to the topic and direction of findings. Some barriers found in the study are; integration of patient records at the national level, training of people operating and maintaining the system, etc. The study found that cultural, religious and social practices of the societies significantly affect the effective use of e-health in the study area and everyone including parents need to be educated.

Keywords - Diabetes management, e-health, telemedicine

Introduction

The United States National Centre for Health Statistics defines a chronic disease as any disease which lasts long, typically over three months or more (Shiel Jr, 2018). The long-term care of chronic diseases consists of multiple approaches. This makes many chronic diseases amenable to self-management. One such chronic disease is diabetes. Musaiger (2011) conducted a study in Saudi Arabia (SA) where he found that food intake and the lifestyle of people in SA has contributed greatly to one's propensity of getting the disease and exacerbating it thereafter. He noted that fast food which includes large amounts of sugar and fat, is produced in large quantities and is widely available in the country.

These findings were also supported by Naeem (2012) in the study "Increasing trend of Junk food use in Saudi Arabia and health implications". The study found that diet is a key determinant that can dictate whether an individual will suffer from diabetes or not. Naeem (2012) added that the culture specific diets determine food intake and can aid a chronic disease such as diabetes. It was however mentioned that the increase in the consumption of junk food in Saudi Arabia might be attributed to lifestyle changes owing to work, career, profession etc. Assessing the impact that e-health via self-management can have on diabetes patients is the focus of this study; the barriers, as well as the solutions of effective use of e-health, are also discussed. This study also illustrates how cultural factors play a significant role in disease management and treatment.

Diabetes

Shrivastava, Shrivastava, and Ramasamy (2013) saw diabetes or more precisely, Diabetes Mellitus (DM) as "a chronic progressive metabolic disorder characterised by hyper-glycemia mainly due to absolute (Type 1 DM) or relative (Type 2 DM) deficiency of insulin hormone. The seven essential components of self-management of diabetes include healthy eating, being physically active, monitoring of blood sugar, compliance with medications, good problem-solving skills, healthy coping skills and risk-reduction behaviours.. These were further identified by Shrivastava, Shrivastava, and Ramasamy (2013) in their study. Clearly, all these practices may not be essential for all patients at all times. Some of them may be more critical than others. These include closer monitoring of blood sugar levels when the person already has a high level of blood sugar. To what extent the diabetes patients follow these practices and in what contexts are an important aspect.

Similarly, observations have further shown that diabetes, when not well managed, can lead to other health complications in the patients. Hence, the prevention and self-management of diabetes especially through diet change and fitness is key. Aside from diabetes, hypertension, obesity, mellitus and other coronary heart diseases could be the aftermath of poor dietary intake and a sedentary lifestyle.

e-Health

e-health may be defined in many ways. Eysenbach (2001) defined the term as, "emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies" (Eysenbach 2001:20). E-health is therefore, an online platform that provides healthcare services for people with or without offline activities. E-health remains functional regardless of the location of the patients. Boslaugh (2013) noted that secondary care centres via an online platform should be created for patients so that they can have access to some level of treatment through awareness, knowledge and self-management.

In a broader sense, e-health represents not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology. This is one of the reasons why e-health should be promoted irrespective of culture, religion, tribe and social norms. Stiffler, Cullen and Luna (2014) contend that some patients have difficulty to access e-health services because of the bias that exists in their culture and religion against e-health services and processes. Mayberry (2014) enhanced Stiffler, Cullen and Luna's (2014) argument by stating that for patients who may miss their scheduled clinical appointments, e-health via self-management,would bring about ease for both the patient and their family members catering for them. A vital concern, however, pertains to the level of access that patients may have. This would be access to technology as well as access to the ability to make use of e-health facilities.

e-Health and Self-Management of Diabetes

The relevance of self-management of diabetes in Saudi Arabia arises from the fact that it is a serious demographic threat to the country. In a recent review by Abdulaziz Al Dawish, et al. (2016), it was noted that the WHO established that Saudi Arabia tops the Middle East and is seventh in the world regarding the population affected by diabetes. Therefore, out of a population of 7 million, 3 million have been affected by diabetes. Shara (2010) further noted that the high rate of diabetes in Saudi Arabia may bear a correlation with it being one of the largest producers of red meat, carbohydrates, and sugar. This combination makes the citizens of the country have easy access to food that is detrimental to health and can increase the propensity of an individual to be diagnosed with diabetes. These studies point to the context specific reasons for the high prevalence of diabetes in the country. Understanding this

context is vital as it will pave the way for culturally sensitive and suitable policies and interventions that can address this health concern.

An article by Jennifer Bell in Arab News (2019) cited Colliers International, which estimates that 17.9% of the Saudi population is currently affected by diabetes. In addition, about 35.4% of the Saudi population is obese, which is a predisposing factor for diabetes. Translated into numbers, the Saudi population in 2019 is 34.1 million and 17.9% of this will be about 6 million diabetics and 12 million obese. Thus, Saudi Arabia needs to focus on approximately 20 million of its population. The Saudi Vision 2030 has targets to increase fitness and sports participation of youth by 25%. This strategy will play a vital role in addressing and in reducing diabetes in the country as well.

In order to effectively manage their diabetes, the patients must learn to manage their diabetes on their own and without the constant need for hospital visits. The seven elements of diabetes self-management prescribed by Srivastava et al. (2013) listed above are relevant here. The usefulness of self-management in producing positive outcomes for diabetic patients in Saudi Arabia was demonstrated by AlShareef, (2017) through a survey. However, in another survey by Saad, et al. (2018) it was found that only foot care and medication self-management were practised by the majority of diabetic patients.

In line with the aforementioned, diet control, exercise and blood glucose monitoring were not being practised as a part of self-management by most of them. Since these were the factors which enhanced self-efficacy, it was low in the surveyed population. Low level of self-management practices except medication was also reported by Al Johani, Kendall, and Snider (2015) from their survey. Jackson et al. (2014) added that for e-health and self-management to be effective and successful, there is a need for healthcare providers to create awareness among people regarding its value. In a review of research on self-management of diabetes in the Gulf Cooperation Council or GCC countries, Al Slamah, Nicholl, Alslail, and Melville (2017) mentioned three papers that argue for culturally relevant self-management practices. This may be an important factor in the case of strongly Islamic states like Saudi Arabia. As was discussed earlier, the country has specific reasons that point to a rate of diabetes among its population and so culturally specific interventions may prove to be useful.

The discussions thus far reveal that self-management practices in treating diabetes can produce positive outcomes for patients. However, compliance levels were found to below. Alsomali (2018) listed culture and religion, gender, stigma, social support, and healthcare environment and support from spouse, friends and healthcare professionals as affecting self-management of diabetes. Similar and more detailed factors at micro, meso and macro levels were identified by Alharbi (2018). Different opinions from family, friends, and colleagues have been reported as some of the factors that confuse diabetes patients regarding the use of e-health and self-management.

Considering e-health applications in self-management of diabetes, Aldahmash, Ahmed, Qadri, Thapa, and AlMuammar (2019) pointed out the ability of e-health applications to reach inaccessible and remote localities. It improves access and affordability of diabetes care through self-management. The availability of internet facilities determines accessibility in rural and remote areas. Hospital visits are kept to a minimum, as patients can seek medical advice through remote access when in need. This makes e-health for diabetes affordable and accessible. The use of cloud medical records, online patient records, computer-based health records, and electronic patient records have been noted as some of the advantages of e-health by Al Otaibi et al. (2016). The internet penetration was noted as being high in Saudi Arabia in the year 2018. However, as earlier mentioned in the study, there are limitations to access due to regional, social and religious cultural barriers and other factors. For comparison, the global access figure is 58% for 2019 (Clement, 2019). Except for Africa, Asia and Lain America/Caribbean, all other regions have over 80% internet penetration as per Internet World Stats (2019). The average for the Middle East, however, is 67%. More than 90% penetration has been reported for Bahrain, Qatar, Kuwait, Lebanon, Saudi Arabia and UAE. Thus, Saudi Arabia is well-placed when compared to many other countries in the region as well as the world. Therefore, internet access cannot be a limiting factor for e-health application for self-management of diabetes in the country.

Healthcare is treated as a "right" in Saudi Arabia. So, all the costs to the patients at the point of care are free for Saudi citizens and expatriates. However, increasing costs have forced a review of this issue. Privatisation and insurance schemes are considered to cover the costs to the government. A survey study by Al-Hanawi, Alsharqi, Almazrou, and Vaidya (2018) showed that some dissatisfaction over the quality of care, the availability of appointments, waiting times at the hospitals and the availability of medicines and other materials existed among the patients.

From the discussion so far, it is clear that diabetes and obesity are two major demographic health problems for Saudi Arabia. Self-management of diabetes by patients is a partial solution to the cost burden of both patients and the country. E-health offers scope to reduce this cost further with increased accessibility and affordability within the high internet penetration scenario of Saudi Arabia. However, there are problems and barriers at various levels for the successful implementation of e-health. These problems need to be identified and solutions found. Such solutions would benefit from being context specific and taking into consideration the cultural sensitivities of the country. This systematic review aims to identify and solve the problems of implementing e-health for self-management of diabetes in Saudi Arabia.

Methodology

The study sought to review how e-health applications can benefit the self-management of diabetes in Saudi Arabia using a systematic review. This review made use of key words such as diabetes management, e-health, telemedicine. These keywords were used to narrow down on the pool of useful and relevant articles. A total of 60 articles were obtained by searching the first five pages of Google Scholar, JSTOR, PubMed and Research Gate using articles published from the year 2005 and beyond as time frame. An additional 10 articles were obtained by cross-references. Thus 70 articles were identified. In the next step of screening 30 papers were excluded because they did not have direct relevance to the topic of the review. This step yielded 20 papers for further screening.

Inclusion Criteria

This study was carried out after the following inclusion criteria were met; i. the study identified the essential components of self-management of diabetes in Saudi Arabia, ii. The study ascertained the relevance of self-management of diabetes in Saudi Arabia, iii. The study determined the rate of increase in diabetes in Saudi Arabia, iv. the study examined the usefulness of self-management in producing positive outcomes for diabetic patients, v. the study determined the foot care and medication self-management and vi. the study further examined the healthcare problems for Saudi Arabia. Abstracts that contained useful information were also included.

Exclusion Criteria

Out of the 30 papers yielded for use in the study, 10 papers were excluded because they were not specific to Saudi Arabia or discussed e-health in more theoretical than practical manner. This filtering resulted in the final selection of 20 usable papers for this review.

Search Methods

A systematic literature search was conducted to identify articles, journals and literature about the benefit of self-management of diabetes. The search was comprehensively done through Google search engine, Google Scholar,

JSTOR, PubMed, Research Gate, and several other viable tools. The topic was used as the search term to collect literature from five web pages each for three different time frames. Works in the English language were collected. These papers used are listed and briefly described below categorised in various ways to derive findings and conclusions.

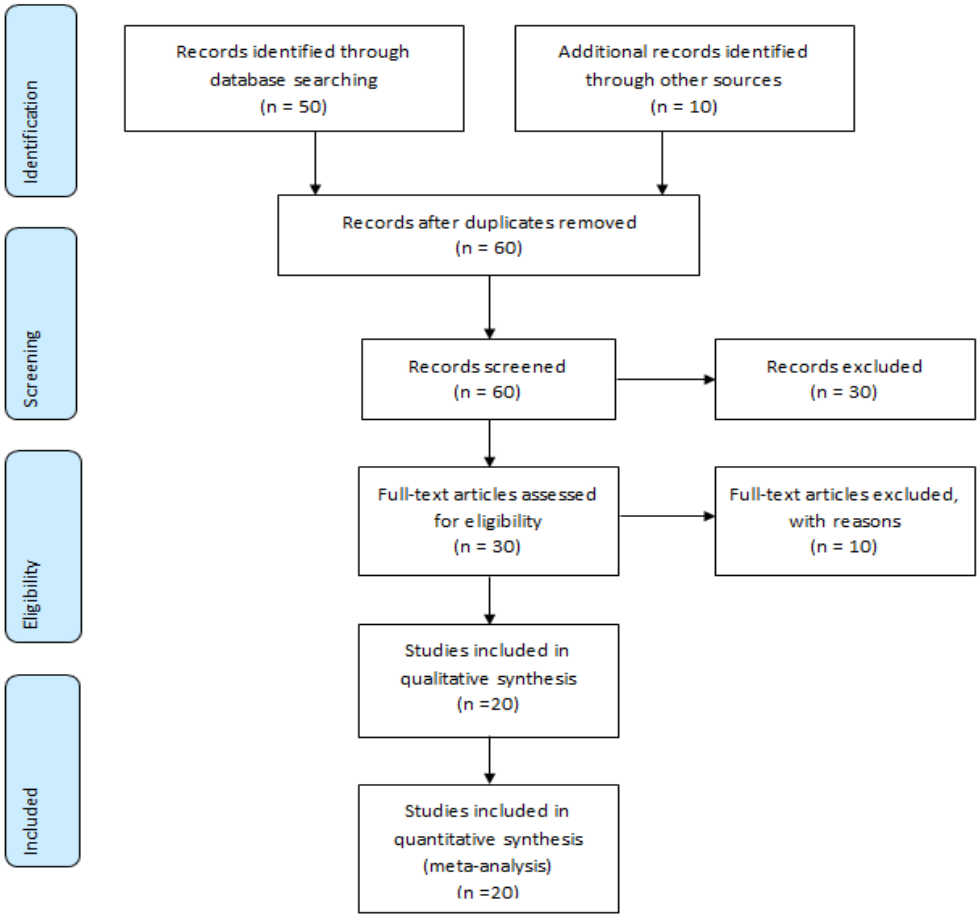

Fig 1: PRISMA diagram

Results

Mobile/smartphone

An intelligent mobile application for diabetes management and educational system for patients in Saudi Arabia with type 2 diabetes, SAED, was developed by Alotaibi, Istepanian, Sungoor, and Philip (2014). It has a patient/healthcare component and an intelligent diabetes management component. The first of these has two units, one for the patient and the other for the diabetes specialist unit. In the intelligent management system, there is a database module, intelligent decision support based on fuzzy logic, an SMS reminder module and a diabetes education module. Stored clinical data like test results, medication and other interventions, along with the decision support system, facilitates monitoring and recommending suitable interventions by clinicians as and when required. Trials to validate the system were to be undertaken. The SAED system was validated for its effectiveness in reducing HbA1C levels in a pilot trial by Alotaibi, Istepanian, and Philip (2016),. Similarly, a six-month study on

the feasibility of mobile messages to control type 1 diabetes in children was conducted by Bin-Abbas, Jabbari, Al-Fares, El-Dali, and Al-Orifi (2014). This study showed a small reduction in the blood sugar glucose level. In the trial, parents of 200 children were sent daily information and weekly interaction messages were sent to the parents. The knowledge of parents about diabetes and its management improved due to this effort. Such mobile messaging serves as a useful intervention between clinical visits.

It was revealed that a high percentage of youngsters favoured the application of mobile technologies and social networking for diabetes self-management in the studies of Alanzi, Istepanian, Philip, and Sungoor (2014). Although there was no significant impact of screen size of mobile phones on the comprehension of content of diabetes related information, small screens reduced the speed of reading the contents. This finding was reported by Alghamdi, Yunus, and Househ (2013). Based on surveys and interviews, Alotaibi M. M. (2015) concluded that there is a high level of support from youngsters for the use of mobile technology for effective management and health awareness of fasting diabetes in Saudi Arabia. The study was done during Ramadan time. Thus, cultural congruence was ensured in this study. A mobile information and education system for gestational diabetes was proposed by Alotaibi and Albalawi (2018). It integrates the patient information and ongoing interventions and their outcomes with the already available information on the topic, so that continuous contextual updating happens. The framework is to be tested through randomised controlled trials on a wide scale in Saudi Arabia.

Problems and predictors of e-health or smartphone applications

The barriers associated with implementation of e-health initiatives were discussed by Almuayqil, Atkins, and Sharp (2015). Absence of systems to connect health information systems available at various levels to integrate at national level was one such barrier. Additionally, the lack of technical and computer skills to use design and use health information systems was also found. The absence of guidelines on using health information records and poor maintenance of networks and computers, slow connections and old terminals were included here. Human barriers such as negative perceptions of healthcare professionals about new technologies, a lack of trust towards computer-based solutions constituted the third barrier. Cultural barriers were also found to stand in the way of virtual contact in favour of physical contact. The possibility of medication safety due to lack of communication or miscommunication is another barrier. Communication gaps among healthcare institutions and limited use of technology to compensate for illegible prescriptions are also included in this barrier. The high cost of transferring paper records into digital records is another barrier. Security and privacy problems of the internet is a major barrier. To solve this problem, the authors proposed knowledge management and knowledge discovery. Alanzi (2018) identified the lack of mHealth expertise and human shortage, inadequacies of funding and infrastructure investments, legal, privacy standardisation and regulatory obstacles, health care organizations and bureaucracy problems, as barriers for implementing m-health for self-management of diabetes. In the same vein, inadequate functional health literacy, overall effective self-care affected by depressed mood were noted from the survey results by Almigbal, et al. (2019). However, functional health literacy was not associated with self-management. Functional health literacy was significantly influenced by age, gender, educational level, employment status and level of the depressive symptoms were significantly.

Alwin Robert, et al. (2016) noted that over the last two decades, there was a 500% increase in the expenses in healthcare and treatment of diabetes in Saudi Arabia. In 2014, out of the total health care budget of SR180 billion, about 25 billion (13.9%) was spent on diabetic care alone. To mitigate the situation, a comprehensive epidemic control program using a multidisciplinary approach needs to be stringently enforced. The authors identified the rising prevalence rate of diabetes and its pre-conditions, increasing prevalence among children and younger population, lifestyle risks, obesity and delayed diagnosis as the major challenges of implementing effective diabetes control programmes. The same obstacles are relevant in self-management and e-health applications for self-management.

Combining the Theory of Planned Behaviour and Technology Acceptance Model, AlBar and Hoque (2018) examined the factors influencing patient acceptance of e-health services in Saudi Arabia. Perceived usefulness and perceived ease of use strongly influenced attitude towards e-health. Attitude and subjective norm highly influenced patient behavioural intention to use e-health services. On the other hand, perceived behavioural control did not affect patient behavioural intention to use e-health services. These findings may be applicable in the case of e-health applications for self-management of diabetes also. Also, Musaiger (2011) conducted a study in Saudi Arabia where he found that food intake and the lifestyle of people in SA has contributed greatly to having the disease. He noted that fast foods which include large amounts of sugar and fat products are greatly produced in the country.

Naeem (2012) on the study of "Increasing trend of Junk food use in Saudi Arabia and health implications" where it was found that diet is a key factor that can dictate if diabetes will come to stay or not. Almalki et al. (2011) noted that the reason for Saudi Arabia has a high rate of diabetes is because the country is the world's biggest extractor and transporter of oil. Shara (2010) further noted that Saudi Arabia is a large producer of red meat, carbohydrates, and sugar- making citizens have access to enough fat and oil.

e-health literacy measuring

An e-health literacy scale (SeHL) was developed by Zakaria, et al. (2018) to facilitate self-management of chronic diseases like diabetes. Four key aspects of e-health literacy were identified for measurement of e-health literacy and implementation of strategies to enhance e-health literacy of chronic patients. These four were – the use of technology/media, information-seeking, usefulness and confidence. Mashi, et al. (2019) found from a survey that health literacy level was high among Saudi diabetes patients, but it was not used for effective glycaemic control. Abdullah (2018) tried to identify predictors of Saudi female diabetic patients' intention to use smartphones for self-management of diabetes. Performance expectancy, effort expectancy, social influence and patient-centred factors were tested as likely predictors. The results showed that Saudi female diabetic patients were using and intended to use smartphones in the future also for self-management of the disease. The current use of such technology by them influenced their intention for future use. Only effort expectancy was a significant predictor of intention to use smartphones in future. The use of cloud medical records, online patient records, computer-based health records, and electronic patient records have been noted as some of the advantages of e-health by Al Otaibi et al. (2016).

Education through RNs in PHCs

Asiri (2015) recognised the importance of diabetic education programmes for diabetic patients to manage their problems better to reduce complications and thereby reduce costs. PHCs can play an active role in this respect through their registered nurses. The author proposed an educational plan for PHC centres in the southern region to meet this objective of Saudi Arabia. AlShareef et al. (2017) found that self-management is a tool for producing positive outcomes for diabetic patients when well monitored via viable knowledge and content. Jackson et al. (2014) found that for e-health and self-management to be effective, healthcare providers should create awareness among people for the need to use e-health.

Social robotics for children

An innovative social robotics system for diabetes management and educational system for diabetic children in the Kingdom of Saudi Arabia was proposed by Alotaibi and Choudhury (2015). The system made use of Aisoy1 v5 robot applicable in mobile health technologies. The system was aimed to improve type 1 diabetes management by empowering them with relevant knowledge about diabetes and its management to create awareness among them. Similar to the social robotics system for children for diabetes management and education (Alotaibi & Choudhury, 2015), a social robotics system for obesity management for children was also proposed by Alotaibi M. (2018). A

systematic review by Alotaibi M. (2017) revealed the usefulness of social robots to improve the diabetic management and awareness among Saudi children.

Knowledge creation and management

The knowledge creation model, Socialization, Externalisation, Combination and Internalisation (SECI) facilitates interaction of tacit and explicit knowledge by applying the four conversion modes implied in the model. Almuayqil, Atkins, and Sharp (2017) proposed a framework to support diabetic patients and healthcare professionals to enable self-manage by patients. It has two components: data mining and the SECI model integrated suitable for this purpose.

Findings from International Studies

In their study, Öberg, Orre, Isaksson, Schimmer, Larsson, and Hörnsten (2018) explored the perceptions of Swedish nurses of using digital e-Health systems to support patient self-management. As per the authors, if nurses are to adapt to the new policies and practices that go with the digitalised development in Swedish primary healthcare, the concept of a nurse's traditional work role needs to be amended. The study highlighted the need for greater research to enable eHealth systems/services to be designed to fulfil multiple requirements. The authors recommend that digitised systems should be a tool for achieving good quality self-management support as well as for giving the primary healthcare nurses adequate resources to support patients' self-management while still maintaining the values associated with person-centred care.

Wake, He, Czesak, Mughal, and Cunningham (2016) explored the evidence for online interventions in diabetes in the context of current and ongoing developments for MyDiabetesMyWay (MDMW), a national electronic personal health record and self-management platform for diabetes patients in Scotland.

The 2017 study by Gao, Zhou, Liu, Wang and Bowers explored the features and contents of Chinese diabetes mobile applications in terms of their suitability for use by older adults with diabetes. Out of a set of 552 diabetes apps, 71 diabetes apps were randomly selected. The results of the study showed that though the usability of all tested apps was rated moderate to good, the features of most apps failed to include content areas of known importance for managing diabetes in older adults.

According to Saha, Riemenschneider, Müller, Levin-Zamir, Van den Broucke, and Schwarz, in their 2017 study, Diabetes Self-Management Education (DSME) is considered as an integral part of diabetes care. Due to this, the study aimed to carry out a comparative analysis of existing DSME programs (DSMEP) implemented in the European Union member states. Comparative analysis of the data indicated that a majority of programs are aimed at adults and only a minority at children and elderly. Only a small percentage of the programs utilise information technology for teaching and learning, and only one out of five programs pay attention to depression. The identified DSMEP aimed primarily to empower patients through increasing knowledge and changing attitudes and beliefs towards diabetes.

Some trends

Topics of the selected papers

Some interesting trends were observable in the selected papers. A large majority of the papers dealt with mobile/smart phones applications as e-health tools. The trend of papers virtually meant that e-health means m-health. More trends on the topics of the papers are given in Table 1.

In the table below, the numbers given in the references are the item numbers in the brief description of the papers. EH-e-health, SM-smartphone/mobile. FHL-Functional Health Literacy.

Table 1. Topics dealt by the selected papers.

Topic	Number	References
Mobile/smartphone	6	1,2, 3, 4, 8, 11
Problems/challenges/barriers/obstacles/factors/predictors of e-health or smartphone applications	11	5 EH, 6EH, 12SM, 13FHL, 14EH, 18SM, 19EH, 23, 24, 24, 26,
e-health literacy measuring	4	7, 16, 18, 27
Education through RNs in PHCs	3	9, 21, 22
Social robotics for children	3	10, 17, 20
Knowledge creation and management	1	15

As Table 1 shows, 6 papers dealt directly with mobile phone or smartphone as e-health tool, often termed as m-health. An additional two papers dealt with problems and challenges related to m-health. Together, out of 20 papers, 8 (40%) were m-health related. The papers are dealing with e-health mostly dealt with problems and challenges. There were 4 such papers. Three papers dealt with functional health literacy, FHL. Out of these, two were related to its measurement and one was related to factors affecting FHL. Thus, only seven papers dealt with e-health topics. Social robotics for diabetes education of children was the subject of three papers, all led by a single author. One of these was a review. Only one paper dealt with knowledge creation and management, although as said above, three papers measured FHL, which is a product of knowledge creation and management.

Direction of findings

Some problems affect generalisability and identifying common trends via meta-analysis of quantitative data across the papers, as discussed below. Instead, a simple method of categorising the direction of the overall findings was done in Table 2. It answers the question: Does this paper support or reject e-health applications for self-management of diabetes as an effective method to control diabetes in Saudi population.

Table 2. Direction of findings for e-health applications in Self-Management

Direction of findings	References	Number of papers
Positive	2, 3, 4, 7, 8, 9, 10, 17, 18, 19, 20	11
Negative	5, 6, 12, 13, 14, 16	6
No trend	1, 11, 15	3

From the table above, it is evident that 11 out of 20 papers are positive towards e-health as a self-management tool for diabetes and more so, with mobile/smartphone applications. Those papers that discussed the predictors came to be classified as 'positive'. Negative findings related to the challenges and barriers for e-health were also found but were outweighed by the positives. These papers focused on the problems, challenges and barriers. It may be inferred, therefore, that once these problems are sufficiently addressed, e-health has the potential to become a positive tool for self-management of diabetes. Only three papers were found to describe some aspects without fully assessing all the components of e-health and hence could not be categorised either way. These were grouped as 'No Trend' papers.

Discussion

The main finding of this review is that e-health for self-management can be implemented successfully using mobile/smart phones in Saudi Arabia. This is evident from the large number of positive findings in the study conducted. Since this paper has already discussed the high internet penetration rate in the country, it follows that problems of connectivity, especially in remote areas, and slow connections can be effectively addressed. This would mean that the majority of the diabetic population can be covered with e-health for diabetes self-management in the country. This can reduce the cost both at the patient side and the government side, ultimately leading to desisting from privatisation of health insurance for reducing cost.

Many challenges, problems and barriers of various types and at various levels (Almuayqil, Atkins, & Sharp, 2016) were identified by many papers. These challenges and problems lead to negative results of e-health applications for diabetes self-management. As long as these barriers are not addressed, the implementation of e-health for diabetes self-management will not be successful. The government and health experts need to consider how these problems and challenges can be tackled and implement the solutions while implementing e-health for diabetes self-management. This review sees the scope for future studies to be conducted on solutions rather than identifying and measuring the challenges and problems are. This is especially the case since the current papers only provide some broad recommendations about addressing the problems rather than specific ones.

The role of cultural factors, especially relevant to countries like Saudi Arabia, cannot be underestimated. Some papers advocated for culturally compatible e-health steps. This would entail matching the e-health strategies with Islamic religious rules. The paper by Alotaibi M. M. (2015) on diabetes self-management during the Ramadan fasting period touched upon this but provided no clear answer on what to do when sugar levels are beyond control during Ramadan fasting, as people tend to overeat after fasting time of the day is over. Not only Ramadan, but other religious observations also need to be researched similarly, but with the aim of finding solutions. Hence, as has been discussed in this paper already, there is a scope for context specific studies and solutions to be found. This too would provide a valuable avenue for future research.

Another crucial aspect for the successful use of e-health for diabetes self-management, is patient awareness so that the patient may be adequately equipped with all the relevant information. Knowledge creation and management of that knowledge for applications in e-health for diabetes self-management should aim at gaining functional health literacy. Thus, the two types of papers are inter-connected. There are two ways of achieving this. One way is using the registered nurses of PHCs as was suggested by Asiri (2015) or training community workers and using them as diabetes educators. In both these cases, e-health is applied when nurses or educators provide round-the clock services through mobile applications, in addition to personal discussions.

The incidence of diabetes and obesity are increasing among the younger population including children in Saudi Arabia. This trend leads to a potential for continued high incidence of diabetes for a long time, resisting any serious attempts to control diabetes at the population level. It may be worthwhile to educate children also about diabetes and obesity and how to control them. Two papers of Alotaibi M. (2017) and Alotaibi M. (2018) deal with these aspects. However, children are often forced by their parents to overeat leading to obesity and diabetes. Therefore, simultaneous education of parents is also required. Although the author did mention this, it was not given sufficient importance in the papers, probably because the papers were about the system architecture and actual validation awaited further research.

Diabetes management of women during pregnancy and self-management of type 1 diabetes among children are two aspects on which only one paper each was seen. The need for more research on these two aspects is evident.

Limitations of this review

The time frame sitting for the selection of papers may restrict selections. An attempt was made to address this by searching with three overlapping time frames. Using only the first five web pages of databases used may miss out papers after the fifth page. To address this, a cross-check was done beyond the 5th page to assess the number of papers not accessed. No significant problem was noted.

Many systematic reviews include meta-analyses across the quantitative data to find common trends and generalise the findings. Being a review related to a single country, meta-analysis of data across the papers might seem to be useful. However, the variety of topics within a small range of only 20 papers lead to too many variations to be accounted for and this means, when applying normal statistical procedures, many basic assumptions need to be diluted and many new assumptions to be made. Hence, meta-analysis was not attempted.

Conclusion and future work

The reviewed papers clearly point to mobile-enabled e-health systems for diabetes self-management as the most effective and efficient route. However, there is a need for patients to be educated through a direct approach, mobile applications and social networking through mobile phones. Internet connectivity and speed need to be improved to reach even remote locations. Other infrastructures need to be provided. Patient information scattered in different provider units at different places needs to be integrated at the national level. People involved in operating and maintaining the system need to be trained, including the nursing staff. Nurses need to learn to adapt around the change in their job descriptions due to the increasing use of e-health solutions for diabetes self-management. All the problems, challenges and barriers need to be addressed.

Future research on the problems and challenges must focus on the solutions rather than just identification of the issues and barriers. There is also a need for further research on the education of children through social robotics along with education of their parents is highlighted. Apart from Ramadan, the impact of other religious practices on adaptation of diabetes self-management needs to be researched. Two other aspects needing attention of researchers are: type 1 diabetes self-management among children and self-management of diabetes by women during pregnancy. The question to be answered may be: How smartphone enabled e-health can serve these two purposes. The study therefore, concludes that several barriers and challenges become the effective use of e-health via self-management for diabetes patients- therefore drafting functional and context specific solutions to make self-management via e-health work is key.

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