We are IntechOpen, the world's leading publisher of Open Access books
Built by scientists, for scientists

5,600
Open access books available

138,000
International authors and editors

175M
Downloads

Our authors are among the

154
Countries delivered to

TOP 1%
most cited scientists

12.2%
Contributors from top 500 universities

CLARIVATE ANALYTICS
BOOK CITATION INDEX
INDEXED

WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com

Novel Health Mobile Technology as an Emerging Strategy in Diabetes Management

Satish Kumar David and Mohamed Rafiullah

Additional information is available at the end of the chapter

Abstract

Advances in mobile phone technology and its applications coupled with equally robust growth of telecommunication technology can serve to give patients a better access to the healthcare. More and more healthcare providers and patients started using these applications. Mobile applications are useful in handling various aspects of healthcare namely, health promotion and disease prevention, diagnosis, treatment, monitoring and supporting health services. Clinical studies evaluating mobile applications often come up with mixed results. In this chapter, application of mobile health technology or mHealth in diabetes management is presented as a case study. We have reviewed 25 articles from pubmed database that fulfilled our selection criteria which included original clinical studies that evaluated mobile health technology in the management of diabetes mellitus. Most studies (88%) reported positive outcomes after use of the mobile health applications in various aspects of diabetes treatment such as disease management, behavioural monitoring and patient education. Educational SMS were effective but inferior to Smartphone Apps or teleconsultations. User-friendliness of the systems influenced patient compliance and outcomes. Smartphone/web applications offer significant benefits for patient care, education and behavioural modifications. As providing continuous patient support would require adequate infrastructure and personnel, cost effectiveness of such interventions need to be studied.

Keywords: smartphone apps, mHealth, health informatics, diabetes management, mobile health

1. Introduction

The huge developments and advances in mobile phone technology and its applications coupled with equally robust growth of telecommunication technology can serve to give patients a better access to health care information, which can make their life easier and enable efficient self-care. Electronic health services or eHealth is the use of information and communication technologies for health which continues to grow rapidly worldwide. It can also make the web-based health services easier, quicker, accurate, and cost effective. Chronic diseases need to be addressed in every possible way to contain their growth through awareness, education, and implements that enable self-management of the disease by patients. In this aspect, IT technologies together with mobile handsets can play a pivotal role in facilitating the dissemination of information and hence help better management of the disease. The rate by which mobile technology grows is something that cannot be overlooked; for example, a recent study has shown that there will be 11.5 billion connected mobile devices on use worldwide, and the global mobile data traffic will increase 10 times by the year 2019 [1]. Thus, the health care delivery can ride on this growth to reach the patients with innovative health care solutions.

The ever-expanding computing ability of smartphones together with the increasing footprint of the communication network, and the ever pervasive IT can be exploited to bring health care services to the patient's doorstep. Mobile technology can be used by both the health care service providers and the patients equally [2]. For example, doctors are adopting smartphone apps to seek clinical knowledge and case studies while patients are utilizing the same to have access to health information that will improve their understanding and management of their diseases [3, 4].

2. mHealth

Mobile health (mHealth) is a part of the broader field of eHealth that employs mobile phones as the base of health care–related solutions. mHealth services can also make the health services easier, quicker, accurate, and cost effective. WHO defines mHealth as "mobile health (mHealth) is an area of electronic health (eHealth), and it is the provision of health services and information via mobile technologies such as mobile phones and personal digital assistants (PDAs)" [5]. mHealth intends to enable the patient to self-care and helps the health care professionals to remotely follow-up their patients. For supporting the self-care, it would require the device to collect the data and provide advice automatically using embedded software that analyzes the data. On the other hand, remote care would require in addition to data collection, data transmission also. The device will collect the data and transmit it to a portal which the health care professional can access. Any decisions or advices from the health care professional after reviewing the patient data can be automatically communicated to the patient device using the same gateway. While the data can be entered manually by the patients using an appropriate interface, there are already devices available that can communicate the data wirelessly to the mobile phones. However, integrating various biosensors into mobile phones has not been widely followed yet. This may be possibly because of perceived prolonged regulatory approval process, which may be longer than the shelf life of many mobile phone models themselves.

3. mHealth in health care

With the emergence of electronic health records (EHRs), digital health services started increasing rapidly. EHRs are the database of patient health information stored in digital form that can be retrieved anytime using a secure access. mHealth systems which are part of digital health can be effectively integrated into hospital-based EHR systems with controlled access given to both patients as well as health care providers. With advances in mobile phone technologies, the functionalities of mobiles phones have increased tremendously. The new generation mobile phones also known as smartphones have several features such as voice calls, video calls, SMS, apps, and web access. These functionalities can be utilized to provide the access to mHealth. Smartphones also can be connected to certain medical devices. The mHealth applications used commonly in disease management programs are smartphone apps. Other features of smartphones can also be utilized for improving the health care. Voice calls, SMS, web/e-mail access through smartphone browser, and third party applications such as WhatsApp are other functionalities that have been explored to mHealth.

Smartphone application, popularly known as app, is a dedicated application developed using the mobile operating software. It provides the user with all the options that are usually available in a desktop computer when accessing a website. Apps use the Internet connection to access database, hospital information system, or even a web portal. Patients enter their daily activities as input data, which will be saved in the phone memory or in a web database. The database may be in the cloud or in the hospital itself depending on the service provider. Apps may provide the automated feedback based on the patient data. There are some apps which provide access to health care worker to review the patient entered data and provide feedback.

The availability of mHealth apps has been increasing rapidly. Presently about 165,000 mHealth apps are available [6]. Various dedicated mHealth applications have been developed for the chronic diseases management recently. Several health care organizations started already using these applications to improve patient awareness. Simplest use of such mHealth application is the follow-up of clinic visits of patients. Patient-centered applications are designed to be used by patients to enhance the patient awareness about their condition, track their health parameters, and help self-management. These apps utilize the GPS tracking, accelerometer, and connectivity features available in most of the smartphones to provide specific functionalities. Common examples of patient-centric applications are diet apps, physical activity monitoring apps, behavior modification apps, and smoking cessation apps.

Clinical decision support systems are apps that are exclusively meant for health care providers. These apps provide access to patient history, current data, and clinical decision support. Clinical decision support systems assist the health care workers in interpreting patient reports and prescribe medications. This will greatly enhance remote treatment and monitoring of patients and will help to decrease the frequency of hospital visits. They also have alerts, reminders, and customized data entry forms for documenting patients' health information. mHealth applications aim to realize an improved health care system by targeting various aspects of medical care such as health promotion and disease prevention, diagnosis, treatment, and monitoring and supporting health services [7]. **Figure 1** illustrates the simplest possible framework of implementation of a mHealth setup in a hospital.
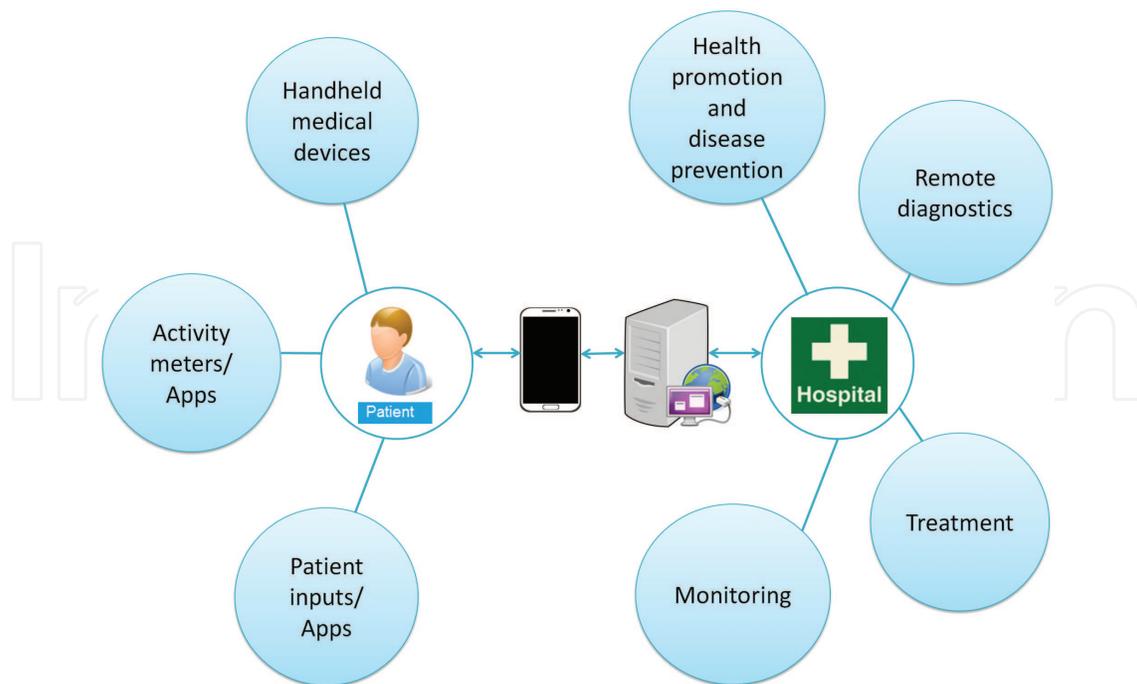
Figure 1. Schematic diagram of implementation of mHealth in a hospital setup.

3.1. Health promotion and disease prevention

Health promotion and disease prevention target the modifiable risk factors that contribute to the development and worsening of chronic diseases. These are mostly behavior modification strategies intending to change the poor eating habits, tobacco usage, and lack of physical activity. Behavior modification has been the key target of health promotion and disease prevention strategies. These interventions are meant to promote healthy behavior among patients. With the ability to reach individuals en masse, mHealth apps can address the communities with health promotion and disease prevention strategies and provide strong thrust in initiating healthy behavior. With wireless self-tracking sensors and activity monitors, behavior of the patients can be monitored. This will help in inducing the behavioral change among patients. In addition to the behavior monitoring, patients can be provided with personalized feedbacks that can influence the effect of healthy behavior.

In a meta-analysis, to examine the efficacy of mobile devices to influence the physical activity, it was concluded that mobile technology is an effective platform for influencing the physical activity [8]. The studies included SMS, mobile software, and personal digital assistants (PDAs) as means of intervention. The effect was larger for pedometer step counts. Mobile phone intervention yielded a significant effect while with the PDA, the effect was not significant.

When the effect of mobile apps to promote weight loss and increase physical activity was evaluated in a systematic review, it was found that use of mobile phone apps resulted in a significant weight loss when compared with control group. However, the physical activity did not differ significantly between the groups [9]. A report from Sax Institute, Australia, analyzed seven systematic reviews on physical activity and/or weight loss outcomes and concluded with mixed results [10]. Despite the improvements in healthy behavior after using

mHealth, sustaining the changes were often faced with difficulty. Patients tended to drop-off once the intervention was removed. Long-term interventions are limited by the cost of such implementations. Patient behavior monitoring systems should be integrated with the disease management systems to lessen the cost of such interventions. However, patients and care providers may find it too much for every day routine as these systems might require too many data entries and feedbacks. Automated systems can be used to tackle this burden but at the cost of a higher budget.

3.2. mHealth in diagnosis

With the increased use of handheld point of care diagnostic devices, it has become possible to decentralize the diagnostic procedures. Many of these devices are user friendly and can be operated by patients at their home. There are web-connected devices which can capture the patient health data and communicate to the designated portal. If these devices can be integrated with smartphones, it can used to analyze, interpret, and also communicate the data. This will help the patients to carry out the self-diagnosis but still under the monitoring of a health care worker even without having to visit the health care facility.

These connected devices can also be used in primary health centers of remote locations in developing countries where the reach of expert medical care is not easy. The data can be communicated in real-time to receive an expert opinion. This will also help the care providers with more time to review the data and make informed decisions. With the rapid increase in the screen resolution of mobile devices, using mobile screens for viewing diagnostic images has also been explored. Owing to their handy and connectable nature, these devices will be very valuable in remote diagnosis. Kumar et al. [11] used an iPhone-based specific image archiving and forwarding program (i2i telesolutions) to view and report the diagnosis on diabetic retinopathy fundus images in the mobile phones. It was found that the diagnosis using mobile phones matched with that of computer-based technique, and the quality of images on the iPhones was reported high by the ophthalmologists. In a review on smartphones, tablets, and mobile applications for radiology, 11 applications were identified as diagnostic reading applications [12]. It was concluded that the use of smartphone or tablet screens resulted in comparable outcome to the respective gold standards. It may be noted that the mHealth applications that are intended for diagnostic purposes are considered as medical devices by the USFDA and therefore will require prior approval for the clinical use [13]. This could be the reason behind the lower utilization of mHealth for diagnostic purposes when compared to the other forms of mHealth usage. Even some mHealth apps carry the label "not for diagnostic use" to avoid the tougher regulatory journey.

3.3. mHealth for treatment of chronic diseases

Treatment of chronic diseases requires continuous follow-up and monitoring of the progress. By implementing mHealth, patients can be kept in the loop for appointment reminders, medication reminders, or any other important alerts. Apart from these general service, patient-specific treatment follow-up can be done using specific applications. Patients will report the health information to a designated portal using the point care of care devices connected to web directly or through a smartphone. The health care team will review the

patient data and make the necessary changes in the treatment with or without the help of clinical decision support systems. This will greatly help in reducing routine and emergency hospital visits. Dose adjustment of medications while initiating new treatments will require frequent visits to hospital or even frequent phone calls. If web-connected devices are used in such situations, checking the patient health status and adjustment of treatment can be carried out remotely.

Several attempts have been made to study the impact of mHealth technologies in the management of chronic diseases. Diabetes, cardiovascular diseases, chronic lung diseases, osteoarthritis, and mental health are the commonly studied chronic conditions where the mHealth intervention was found to be useful. De Jongh et al. assessed the effects of mobile phone messaging applications designed to facilitate self-management of long-term illnesses, in terms of impact on health outcomes and patients' capacity to self-manage their condition in a systematic review [14]. The phone messaging interventions provided benefit in supporting the self-management of long-term illnesses. They concluded that the long-term effects, acceptability, costs, and risks of such interventions needed further investigation. mHealth tools facilitated adherence to chronic disease management, but the evidence supporting its current effectiveness was found to be mixed in another systematic review [15]. A review by Sax Institute found that meta analyses and systemic reviews conducted to study the effect of mHealth interventions on cardiovascular disease, chronic lung disease, and mental health produced mixed outcomes [10]. Interestingly, majority of the studies that evaluated the mHealth interventions in chronic diseases included diabetes. Therefore, we decided to focus on effect of mHealth interventions on the various aspects of managing diabetes mellitus.

4. mHealth in diabetes

Diabetes mellitus has been the most common chronic disease affecting human beings as reported by the International Diabetes Federation with more than 366 million people currently affected and is expected to reach 552 million by the year 2030.The high mortality and morbidity as a result of chronic complications which make diabetes the leading cause of blindness, renal failure, ischemic heart disease, and limb amputation [16]. Diabetes mellitus is considered to be costly disease in terms of economic burden since the health care expenditure for diabetes in United States during 2011 was 7.7 billion US dollars with direct costs of 3.4 billion US dollars and indirect costs of 4.3 billion US dollars [17].

Treatment of diabetes needs self-management by patients to achieve stable control of the disease. Diabetes management is often cumbersome and demanding as it requires the patients to do regular home-based glucose monitoring and apply continuous lifestyle modifications. Typical diabetes management plans always include diabetes education and regular follow up of patients in order to achieve the treatment goals. Evolvement of smartphones and their wide reach has paved way for development of various mobile health applications. This has attracted a lot of attention from diabetes health care researchers as it aptly suits for implementing various aspects of diabetes management plans such as patient remote monitoring, data collection, patient education, and medical intervention.

5. Case study

The case study was intended to review the effectiveness of mobile health applications in management of diabetes mellitus using original articles that were published in ISI indexed journals from PubMed database. About 209 scientific articles were captured from the PubMed database starting by the year 2007 till 2014. The search key phrases were "clinical study on use of mobile phones for diabetes," "clinical study on use of smart phones for diabetes," "clinical study on use of cell phones for diabetes," and "clinical study on use of mobile applications for diabetes." The search resulted in 66, 64, 62, and 17 articles, respectively. From these 209 articles, 131 were found to be duplicate. Of the remaining 78 articles, 25 fulfilled our selection criteria which included original clinical studies evaluating mobile health technology in diabetes mellitus management. These articles were grouped under three categories such as applications used for diabetes treatment, applications used for modifying patient behavior, and applications used for patient education.

5.1. Mobile applications for diabetes management

5.1.1. Mobile-based diary applications

A paper-based diary is provided to the patients by diabetes clinics to ensure patients record their blood glucose readings and hypoglycemia events. This is done in conjunction with regular phone calls by the clinical team to support the self-management of patients. Advances in mHealth comes in handy to help the patients to record their data and communicate it to the health care team. A mobile phone–based diabetes digital diary that can be accessed by the health care team via web is a reality now. However, use of such mobile phone–based diabetes diaries resulted in mixed outcomes in clinical studies. When a mobile diary app was used in type 2 diabetes patients for self-titration of insulin dose, there was a significant decrease of Hemoglobin A1c (HbA1c) [18]. However, there was no significant reduction in HbA1c and other glycemic parameters such as Fasting blood glucose (FBG) and Postprandial glucose (PPG) in type 1 diabetes [19].

5.1.2. Web-based diary applications

Smartphone apps can be used to collect the data and upload it to a web-based server. This will make it simpler to integrate the mHealth applications with the web-based health information systems already available in the health care organizations. Effect of web-based patient monitoring and intervention in diabetes management was explored in different studies. Even though the web-based diary intervention improved the patient self-care, many patients expressed frustration over using the app multiple times every day [20].

When patients were given access to online web diary and received optimal recommendations through e-mail or mobile phone after uploading their daily blood glucose readings, there was a significant improvement of HbA1c and postprandial glucose levels after 12 weeks [21], 6 months [22], and 1 year [23]. Hee-Sung [24] evaluated a web-based patient monitoring and nurse's education through SMS in type 2 diabetic patients. HbA1c levels were found to be

significantly decreased. It should be noted that despite having improvements in glycemia after using these mHealth interventions, patients reported frustration with the intervention. Hence, necessity of frequent use of smartphone and websites may lead to a decreased compliance among patients in long term.

5.1.3. Other applications

A smartphone app (Diabeo) for insulin dose adjustment improved the HbA1c among the patients who used that app along with teleconsultation [25]. When a telehealth system with real-time graphical feedback and remote nurse monitoring through mobile phones was implemented for the dose adjustment of oral hypoglycemic agents in type 2 diabetic patients, it lead to a decrease in the HbA1c levels [26]. The telemonitoring of patients with mobile phones provides a closer and real-time support to the patients. It seems that access to the health care team and timely feedback facilitated the treatment optimization and increased patient compliance.

5.2. Mobile applications for patient behavior modification

Treatment of diabetes includes lifelong lifestyle modifications. To successfully implement the lifestyle modifications, continuous patient monitoring strategies are required. However, these strategies often fail to bring the desired lifestyle changes due to the lack of efficient patient monitoring systems. Wide availability of smartphones has brought the patient remote monitoring possible. Patient behavior modification includes monitoring the patient behavior, adherence, and self-care.

5.2.1. Patient behavior monitoring

Patient behavior monitoring will help the care providers to plan the effective intervention strategy for individual patients. A cellphone-connected glucometer along with telephone and SMS communication was used to monitor the behavioral pattern of adolescent type 1 diabetic patients, resulted in a significant improvement in the self-management profile and a reduction in HbA1c [27]. A telehealthcare program was used to monitor self-management behavior in adult type 2 diabetic patients [28]. They used an online diabetes self-management system with teleconsultant service, in addition to a cell phone–connected glucometer. This improved healthy behaviors, increased glucose monitoring, and a significant reduction in HbA1c. Behavioral monitoring of the patients with the cell phone–based applications was beneficial in inducing lifestyle modifications that lead to a better glycemic control.

5.2.2. Patient adherence monitoring

Diabetes treatment requires multiple medications and lifestyle changes. This is a huge challenge for both patients and care providers in terms of patient adherence. Diabetic clinics closely follow the patients to make sure that they adhere to the instructions. mHealth technology can be applied effectively for such patient follow-up programs. It is very interesting to note that despite the conventional telephone-based patient follow-up and the SMS communication resulted in similar adherence, the SMS-based follow-up was more effective in

decreasing the HbA1c [29]. Mobile phone–based ecological momentary assessment tool to measure the patient adherence behavior [30] was comparable to the traditional self-reported data. This supports the use of mHealth interventions for improving patient behavior and adherence.

5.2.3. Applications supporting patient self-care

Self-care and self-efficacy are the two important patient behaviors that have a direct influence in the diabetes treatment. mHealth applications can be utilized to develop patient support systems to promote self-care and self-efficacy behaviors in patients. When an interactive cell phone technology in which patients would receive recommendation messages after uploading their data were used, the self-care and the self-efficacy scores were significantly improved. However, there was only a negligible decrease in HbA1c levels. This was attributed to the low patient adherence arising out of the lack of user-friendly system [31]. Most of the patients reported positive lifestyle changes when they were asked to record their daily self-care activities in a web-based diary using their mobile phones and received feedback messages [32]. Remote monitoring of the patient activities with care provider feedback is supportive in improving patient self-care.

5.3. mHealth in patient education

As patients with diabetes are required to take multiple medications, check their blood glucose levels, and implement lifestyle modifications, awareness about their disease and understanding of the care providers instructions are very important. Lack of awareness about the disease will impact the diabetes treatment by affecting the self-care activity. This is often the reason for treatment failures in many cases. Clinical guidelines on diabetes management include patient education. Patient education using the mHealth technology can prove to be highly useful as the patient can carry the mobile handsets and apply the informational tips whenever needed.

5.3.1. SMS-based patient education

With the availability of audiovisual communications, mHealth technology offers better ways to deliver the patient education effectively. SMS is the simplest form of communication that mHealth technology can utilize for patient education. When unidirectional educational text messages were sent to patients using a specific messaging program (TExT-MED), it increased medication adherence, quality of life, and decreased emergency visits [33]. But there was no improvement in glycemic control. Lack of patient interaction in the unidirectional messaging might have been the reason behind the ineffective glycemic control. However, sending educational SMS according to the patient preference increased the adherence and improved the HbA1c and lipid profiles [34].

5.3.2. Smartphone apps for patient education

Smartphone applications can be a valuable tool in the patient education programs as it can engage the patients more effectively than the unilateral SMSs. Patient specific data are collected through the app, and the educational content is tailored to suit the patient requirement.

"Glucose Buddy," a freely available iPhone diabetes management application, was used in type 1 diabetic patients. It collected patient information and send educational SMSs based on the patient data. Despite a significant improvement in HbA1c, the quality of life and self-care activities were not improved [35]. However, it may be noted that the self-care activities and quality of life do not always correlate with HbA1c in type 1 diabetic patients [36].

A smartphone-based diabetes diary "Diab-Memory" was used to collect and transmit patient data to a remote monitoring center in patients with type 1 diabetes. The app sent reminder messages to patients with analyzed data output and statistical trends. It was well accepted by the patients, and the glycemia improved significantly. 'Ubiquitous Chronic Disease Care' (UCDC) system for a Smartphone app for diabetes care was investigated in type 2 diabetic patients [37]. Patients received alarms to remind about daily self-care activities. They also received educational messages after sending their data. This intervention improved the clinical parameters such as HbA1c, Blood Pressure (BP), and lipid profile. The educational messages and reminders supported the patient self-care, whereas the use of smartphone app engaged the patients and helped increasing the patient adherence.

A patient coaching system using mobile diabetes management software was evaluated in diabetes patients. The system sent automated, real-time, educational, behavioral, and motivational messages to patients. The messages were tailored to suit the patients by reviewing the patient entered self-care data. Care providers were either given access to only patient data or patient data along with decision support. Patients showed greater improvement in HbA1c when the care providers with given access to decision support [38]. This study has showed the decision support system when integrated with mHealth can enhance the clinical outcomes in chronic diseases.

6. Limitations

Care should be exercised while interpreting the results of these clinical studies, as many of them reported that the patient entered data without any validation. Age could be a significant factor which can influence the effect of mHealth interventions especially in chronic diseases. Educational level and the experience of using smartphones among patients are other important factors that can affect outcome of the implementation of mHealth. These factors also should be taken into account before interpreting the results of studies that evaluated the mHealth-based interventions.

7. Conclusion

Results of many systematic reviews and meta-analyses indicate that intervention of mHealth applications for most of the chronic diseases resulted in mixed outcomes. However, in our case study, to review the use of mHealth for diabetes has shown positive outcomes from most of the studies (88%) after use of the mobile health applications in various aspects of diabetes treatment such as disease management, behavioral monitoring, and patient education. Even many of the studies have shown that the simple text messages are very effective in improving the clinical and behavioral outcomes. The reason may be that the text messages are easier to

handle and can be read by the user whenever they have convenient time. Even though the text message–based interventions were found to be effective in improving clinical outcomes, they were inferior to the relatively complicated smartphone apps. Sending such unidirectional messages by the health care organization may not be able engage the patients effectively as there is no active interaction between the patients and care providers. To overcome this, several smartphone apps with integrated messaging system have been developed. Patients enter their data using the app which then goes to a dedicated repository which the care provider has been given secured access. After reviewing the patient data, the care provider can send instructional or recommendational messages to patient's mobile using the same app. Some apps even automate this feedback messages; in such cases, the software will analyze the patient data and provide automated feedback.

Patient compliance will be an important factor in long-term mHealth interventions. Many patients may not be comfortable with being monitored remotely. Hence, patient privacy–related issues can be another hurdle in the way of mHealth. However, the biggest challenge is in providing continuous patient support with this technology. This would require adequate infrastructure and trained personnel in place. Cost of such interventions needed to studied with respect to the available options. Cost benefit and cost-effectiveness analysis studies with mHealth technologies are therefore necessary before implementing these systems on large scale.

Acknowledgements

Author details

Satish Kumar David[1]* and Mohamed Rafiullah[2]

*Address all correspondence to: skumar@ksu.edu.sa

1 Department of Information Technology, Strategic Center for Diabetes Research, King Saud University, Riyadh, Kingdom of Saudi Arabia

2 Department of Pharmacology, Strategic Center for Diabetes Research, King Saud University, Riyadh, Kingdom of Saudi Arabia

References

[1] Cisco. Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update 2014–2019 White Paper. 2015. Available from: http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white_paper_c11-520862.html

[2]   Serkan GS. Mobile learning in medicine. Proc SPIE [Internet]. 2013;8667:866715–6. Available from: http://dx.doi.org/10.1117/12.2013833

[3]   Atienza AA, Patrick K. Mobile health: The killer app for cyberinfrastructure and consumer health. Am J Prev Med. Netherlands; 2011 May;40(5 Suppl 2):S151–3.

[4]   Blumberg SJ, Luke JV, Ganesh N, Davern ME, Boudreaux MH, Soderberg K. Wireless substitution: State-level estimates from the National Health Interview Survey, January 2007–June 2010. Natl Health Stat Report. United States; 2011 Apr;(39):1–26,28.

[5]   World Health Organization. mHealth: New horizons for health through mobile technologies. Observatory [Internet]. 2011;3(June):66–71. Available from: http://www.webcitation.org/63mBxLED9

[6]   Powell CA, Torous J, Chan S, Raynor SG, Shwarts E, Shanahan M, et al. Interrater reliability of mHealth app rating measures: Analysis of top depression and smoking cessation apps. JMIR mHealth uHealth [Internet]. 2016 Feb 10;4(1):e15. Available from: http://mhealth.jmir.org/2016/1/e15/

[7]   Ali E, Chew L. Evolution and current status of mhealth research: A systematic review. BMJ Innov [Internet]. 2016;2(1):33–40. Available from: http://innovations.bmj.com/content/2/1/33.full.pdf\nhttp://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=emed13&NEWS=N&AN=20160124900

[8]   Fanning J, Mullen PS, McAuley E. Increasing physical activity with mobile devices: A meta-analysis. J Med Internet Res [Internet]. 2012 Nov 21;14(6):e161. Available from: http://www.jmir.org/2012/6/e161/

[9]   Flores Mateo G, Granado-Font E, Ferré-Grau C, Montaña-Carreras X. Mobile phone apps to promote weight loss and increase physical activity: A systematic review and meta-analysis. J Med Internet Res [Internet]. 2015 Nov 10;17(11):e253. Available from: http://www.jmir.org/2015/11/e253/

[10] Laranjo L, Lau A, Oldenburg B, Gabarron E, O'Neill A, Chan SCE. mHealth technologies for chronic disease prevention and managament. An Evid Check Rev brokered by Sax Inst Heal Aust [Internet]. 2015 Dec:1–90. Available from: http://www.saxinstitute.org.au/wp-content/uploads/mHealth-Technologies-for-Chronic-Disease-Prevention-and-Management-1.pdf

[11] Kumar S, Wang E-H, Pokabla MJ, Noecker RJ. Teleophthalmology assessment of diabetic retinopathy fundus images: Smartphone versus standard office computer workstation. Telemed e-Health. 2012;18(2):158–62.

[12] Székely A, Talanow R, Bágyi P. Smartphones, tablets and mobile applications for radiology. Eur J Radiol [Internet]. Elsevier Ireland Ltd; 2013;82(5):829–36. Available from: http://dx.doi.org/10.1016/j.ejrad.2012.11.034

[13] FDA. Mobile medical applications. US Department Heal Hum Serv Food Drug Adm [Internet]. 2015;44:1–44. Available from: http://www.fda.gov/downloads/MedicalDevices/DeviceRegulationandGuidance/GuidanceDocuments/UCM263366.pdf

[14] De Jongh T, Gurol-Urganci I, Vodopivec-Jamsek V, Car J, Atun R. Mobile phone messaging for facilitating self-management of long-term illnesses. Cochrane database Syst Rev. England; 2012 Dec;12:CD007459.

[15] Hamine S, Gerth-Guyette E, Faulx D, Green BB, Ginsburg SA. Impact of mHealth chronic disease management on treatment adherence and patient outcomes: A systematic review. J Med Internet Res [Internet]. 2015 Feb 24;17(2):e52. Available from: http://www.jmir.org/2/e52/

[16] International Diabetes Federation. IDF Diabetes Atlas [Internet]. 5th ed. Brussels, Belgium: International Diabetes Federation; 2011. Available from: http://www.idf.org/diabetesatlas

[17] Arredondo A, Reyes G. Health disparities from economic burden of diabetes in middle-income countries: Evidence from México. PLoS One [Internet]. Public Library of Science; 2013 Jul 12;8(7):e68443. Available from: http://dx.doi.org/10.1371%2Fjournal.pone.0068443

[18] Larsen ME, Turner J, Farmer A, Neil A, Tarassenko L. Telemedicine-supported insulin optimisation in primary care. J Telemed Telecare. 2010;16(8):433–40.

[19] Rossi MCE, Nicolucci A, Pellegrini F, Bruttomesso D, Di Bartolo P, Marelli G, et al. Interactive diary for diabetes: A useful and easy-to-use new telemedicine system to support the decision-making process in type 1 diabetes. Diabetes Technol Ther. United States; 2009 Jan;11(1):19–24.

[20] Lyles CR, Harris LT, Le T, Flowers J, Tufano J, Britt D, et al. Qualitative evaluation of a mobile phone and web-based collaborative care intervention for patients with type 2 diabetes. Diabetes Technol Ther. United States; 2011 May;13(5):563–9.

[21] Kim HS. A randomized controlled trial of a nurse short-message service by cellular phone for people with diabetes. Int J Nurs Stud. 2007;44(5):687–92.

[22] Kim H-S, Jeong H-S. A nurse short message service by cellular phone in type-2 diabetic patients for six months. J Clin Nurs. England; 2007 Jun;16(6):1082–7.

[23] Kim S-I, Kim H-S. Effectiveness of mobile and internet intervention in patients with obese type 2 diabetes. Int J Med Inform. 2008;77(6):399–404.

[24] Hee-Sung K. Impact of web-based nurse's education on glycosylated haemoglobin in type 2 diabetic patients. J Clin Nurs. 2007;16(7):1361–6.

[25] Franc S, Borot S, Ronsin O, Quesada JL, Dardari D, Fagour C, et al. Telemedicine and type 1 diabetes: Is technology per se sufficient to improve glycaemic control?. Diabetes Metab. [Internet] Elsevier Masson SAS; 2014;40(1):61–6. Available from: http://dx.doi.org/10.1016/j.diabet.2013.09.001

[26] Nagrebetsky A, Larsen M, Craven A, Turner J, McRobert N, Murray E, et al. Stepwise self-titration of oral glucose-lowering medication using a mobile telephone-based telehealth platform in type 2 diabetes: A feasibility trial in primary care. J Diabetes Sci Technol. [Internet] 2013;7(1):123–34. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3692224&tool=pmcentrez&rendertype=abstract

[27] Carroll AE, DiMeglio LA, Stein S, Marrero DG. Contracting and monitoring relationships for adolescents with type 1 diabetes: A pilot study. Diabetes Technol Ther. 2011;13(5):543–9.

[28] Chen L, Chuang L-M, Chang C-H, Wang C-S, Wang I-C, Chung Y, et al. Evaluating self-management behaviors of diabetic patients in a telehealthcare program: Longitudinal Study over 18 months. J Med Internet Res [Internet]. 2013;15(12):e266. Available from: http://www.jmir.org/2013/12/e266/

[29] Zolfaghari M, Mousavifar SA, Pedram S, Haghani H. The impact of nurse short message services and telephone follow-ups on diabetic adherence: Which one is more effective? J Clin Nurs. 2012;21(13–14):1922–31.

[30] Mulvaney SA, Rothman RL, Dietrich MS, Wallston KA, Grove E, Elasy TA, et al. Using mobile phones to measure adolescent diabetes adherence. Health Psychol. United States; 2012 Jan;31(1):43–50.

[31] Faridi Z, Liberti L, Shuval K, Northrup V, Ali A, Katz DL. Evaluating the impact of mobile telephone technology on type 2 diabetic patients' self-management: The NICHE pilot study. J Eval Clin Pract. 2008;14(3):465–9.

[32] Nes AA, van Dulmen S, Eide E, Finset A, Kristjánsdóttir ÓB, Steen IS, et al. The development and feasibility of a web-based intervention with diaries and situational feedback via smartphone to support self-management in patients with diabetes type 2. Diabetes Res Clin Pract. 2012;97(3):385–93.

[33] Arora S, Peters AL, Burner E, Lam CN, Menchine M. Trial to examine text message-based mhealth in emergency department patients with diabetes (TExT-MED): A randomized controlled trial. Ann Emerg Med [Internet]. American College of Emergency Physicians; 2014;63(6):745–54.e6. Available from: http://dx.doi.org/10.1016/j.annemergmed.2013.10.012

[34] Shetty AS, Chamukuttan S, Nanditha A, Raj RKC, Ramachandran A. Reinforcement of adherence to prescription recommendations in Asian Indian diabetes patients using short message service (SMS)—A pilot study. J Assoc Physicians India. 2011;59(11):711–4.

[35] Kirwan M, Vandelanotte C, Fenning A, Duncan JM. Diabetes self-management smartphone application for adults with type 1 diabetes: Randomized controlled trial. J Med Internet Res [Internet]. 2013;15(11):e235. Available from: http://www.jmir.org/2013/11/e235/

[36] Charpentier G, Benhamou P-Y, Dardari D, Clergeot A, Franc S, Schaepelynck-Belicar P, et al. The Diabeo software enabling individualized insulin dose adjustments combined with telemedicine support improves HbA1c in poorly controlled type 1 diabetic patients: A 6-month, randomized, open-label, parallel-group, multicenter trial (TeleDiab 1 Study). Diabetes Care [Internet]. Department of Diabetes, Centre d'Études et de Recherche pour l'Intensification du Traitement du Diabète, Sud-Francilien Hospital, Corbeil-Essonnes, France. kerbonac@free.fr; 2011;34(3):533–9. Available from: http://europepmc.org/abstract/MED/21266648

[37] Yoo HJ, Park MS, Kim TN, Yang SJ, Cho GJ, Hwang TG, et al. A Ubiquitous Chronic Disease Care system using cellular phones and the internet. Diabet Med. 2009;26(6):628–35.

[38] Quinn CC, Shardell MD, Terrin ML, Barr EA, Ballew SH, Gruber-Baldini AL. Cluster-randomized trial of a mobile phone personalized behavioral intervention for blood glucose control. Diabetes Care. 2011;34(Sept):1934–42.