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REVIEW

The use of telephone monitoring for diabetic patients: theory and practical implications

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Abstract: Over the last 30 years, diabetes mellitus has changed from being seen as a relatively mild ailment associated with aging and the elderly ("just a touch of sugar") to one of the major contemporary causes of premature mortality and morbidity in most countries. In virtually every developed society, diabetes is ranked among the leading causes of blindness, renal failure, and lower limb amputation. Through its effects on cardiovascular disease (70%–80% of people with diabetes die of cardiovascular disease), it is also now one of the leading causes of death. Even diabetes mellitus seems to be dealt with due to innovative information and communication technologies, along with new forms of service delivery organization such as home care and remote monitoring. This paper provides a review of the innovative concept of using mobile phones for diabetes monitoring starting with a brief introduction, continuing with an analysis of health and lifestyle related data that record the patient–health-professional's interaction and decision making, and concluding with a general discussion section followed by an extended bibliography.

Keywords: diabetes mellitus, mobile telephony, remote monitoring, text messaging, internet, coaching

Introduction

There is an ongoing debate on the pros and cons of providing care and support to patients with chronic illness such as diabetes through the use of mobile telephone monitoring. Some of the pros most widely acknowledged include:[1]

- Patient engagement through real time access to their medical records, reminders for various treatment aspects, and provision of instructions and guidelines
- Increased efficiency leading to health care costs reduction, especially where chronic patients are involved, thanks to continuous remote monitoring of vital signs and physiological parameters that the treating physician can access without the patient's physical presence (ie, visit).

As for the cons, though, the most serious concern relates to data security and privacy in general as there are applications that transmit unencrypted sensitive data, hence allowing for data mining strictly for advertising purposes.[2] Lack of physician's involvement during the development cycle can lead to applications not offering optimum relevance and advice to certain conditions. Finally, as many legacy applications and systems are still present in the health care industry, misalignments are observed between existing infrastructure and mobile applications, hence limiting the number of coordinated users, ie, doctors and patients.[3]

It is yet to be questioned whether this practice will produce and "sustain the desired improvements in the health" of these patients[4] such as the physiological blood glucose levels as well as the limitation of the usual comorbidities escorting the condition. The

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quality of the health care provided requires an effective collaboration between clinicians on one hand and patients on the other.[5,6] One way to effectively improve health care is the design of novel methods to enhance communication and, consequently, improve the health condition of those patients with chronic diseases with immediate and up-to-date feedback pertinent to the insulin dose or the intake of certain nutrition. Interventions involving automated telephone message systems have been shown to improve clinical diabetes-related health outcomes, eg, blood glucose levels, by increasing knowledge, hence allowing patients to effectively carry out self-management of their condition.[4–7] Several reviews have documented that telephone-based interventions have had positive results even among patients of low socioeconomic background and at increased risk of cardiovascular diseases, diabetes mellitus type 2, and various ailments characterized by increased mortality.[8,9] Literature also points out the usefulness, potential, and challenges in utilizing mobile phones to generally improve diabetics' health.[9–11] Research to date has indicated that these interventions are able to improve patient outcome.[12] However, some important aspects concerning the design of these mobile applications, such as data transmission[13] and standards/codifications,[14] for diabetes interventions[15] have not yet been examined. The purpose of this paper is to address the importance of using mobile telephones for diabetes monitoring and technological features that will enable these systems.

Recording health-related and lifestyle-related data

According to a review of the federal health monitoring system in the USA,[16] a list of criteria for effective and efficient health monitoring data is identified. It is explained there that frequent updating, separate estimates for key subgroups, adequate precision, provision of estimates at appropriate geographical levels, topical coverage, and easy accessibility by decision makers are some of the factors that need to be taken into consideration.

In another review,[17] the authors proposed the use of electronic health records to support public health. They suggested that the inclusion of a number of different factors like environmental, psychosocial, and economic data into a patient's health record is likely to enable the routine collection of data relevant to broader public health initiatives.

Gravois and Garvin[18] reviewed some of the outcomes of good communication in health settings and they argued that most interactions "are founded on an assumption that information provision to clients/patients is both necessary and sufficient to effect behavior change – despite considerable evidence to the contrary". They also proposed that, instead of information transfer, information exchange systems should be established taking into consideration the factors of social, environmental, and economic context of behavior.

Diaries and logging applications

There has been much interest in using information services to systematically collect, manage, and analyze patients' health care records in electronic form. Electronic health records have been proven to help in reducing medical errors[19] while at the same time improving the quality of care provided to patients. The use of diaries in health recording has been common in nursing practice settings. Practitioners have been using the diary as a means of helping patients to document their symptoms with the aim of modifying their behavior to generate a healthier behavior. Given the tremendous advances in technology and telecommunication, today a digital diary can be used to improve diabetes care. Mobile phones could potentially serve as the tool for collecting information on surveillance, service delivery, evidence-based care, and management and supply systems, thus allowing patients with diabetes from primary care settings to provide information for enhanced diabetes education.[20]

Mobile phones can assist diabetics by serving as a screening/diagnostic tool even in follow-up care. Some smartphone applications may improve diabetes control programs in a number of different ways.[21] According to a review,[20] this method can provide a "long-term tracking of patient data, trends in prescription/management and quality of care, and surveillance data". This review continues to argue that, unlike paper-based systems, a smartphone application may act as a real time information generator that provides high-quality data for planning and monitoring, and live help and assistance to diabetics.

Mobile phone applications can also be effective in remote monitoring of difficult carbohydrate counting. Diabetes Interactive Diary is a program specifically designed for mobile phones and it is capable of facilitating a direct communication between a dietitian and diabetes patients. Both parties will be in touch through Short Message Service (SMS) so that the dietitian can monitor glucose levels and suggest an insulin dose that corresponds directly to the amount of carbohydrate consumed.[22,23]

Recording and monitoring through SMS

SMS (also known as text messaging) is a widely used medium of sending messages as it is easy and quick. Apart from its

accessibility, text messaging has been widely adopted by health technology, mainly for two reasons:[24]

- It is a push technology allowing intervention messages to be delivered without any effort by the recipient
- Text messages can be sent and received by both mobile phones and computers and they can allow patients to log their health-related activities and physiological parameters, like exercise and peak flow in asthma management, while at the same time receiving customized feedback based on the data provided.[25]

In addition, text messages can be automatically processed; therefore, it is possible to have a complete information exchange in an intervention via this medium. For instance users can receive reminders to log relevant data, they can reply to messages, and the system may process this information and have the personal record of each user updated. The diversity of these interactions provides evidence for just how flexible this medium can be in delivering information.

Patient–health care professionals interaction and decision-making

Remote event monitoring

Another application for mobile phones in diabetes care is remote monitoring.[26,27] During a feasibility study[27] of a telemedicine support program and the effects on glycemic control in adolescences with type 1 diabetes mellitus, patients had to send their daily data, such as date, time, and blood glucose, through mobile phones to a central server where these data were received by diabetologists who provided advise using the same route. During this period, it was observed that glycemic control had improved compared to the control phase in which participants used a paper diary for their daily monitoring.

Distant expert advisors/coaches

Distant or remote coaching interventions use data that patients collect on their mobile phones to enable learning interactions. During these interactions, the tracking data are uploaded from the mobile phone to a local server, acting as a repository, through a website where data are reviewed by a member of the patient's health care team. Clinicians then analyze these data and work with patients to help them learn how to manage their condition. The coaching interaction itself typically takes place either over the mobile phone, through SMS exchange, or through a website.[24–28]

In general, mobile phones enable effective remote coaching interventions that have been shown to help chronic disease patients in learning a range of complex skills that they need in order to manage their condition.[9] Using mobile phones, patients are able to collect data about their activities and physiological measurements, while in SMS coaching interventions they are able to receive concrete tailored feedback on how to better manage their illness.[29–31]

In addition to remote coaching, mobile phones are commonly used to monitor patients' health in order to alert the health care team of any serious symptoms that need immediate treatment.[22] Timely detection of such symptoms and worrisome physiological parameters is the key to prevention of likely serious deterioration in a patient's health. Therefore, many of the interventions use data captured with mobile phones in order to look for such indicators and to be able to alert the appropriate health care provider.[32]

Some monitoring applications capable of collecting and analyzing symptoms by sensing, self-report, or a combination of the two, can be beneficial for the patients. According to studies,[33,34] a system was built that combines a mobile phone application and a variety of Bluetooth-connected devices such as a blood pressure cuff, respiration and electrocardiogram (ECG) sensors embedded in an instrumented shirt, accelerometers, and a digital scale, in order to enable chronic heart failure patients to collect data about their condition, which are automatically uploaded to a server and are continuously monitored for signs of decompensation.[24] If there is a decompensation then the patient's physician gets immediately notified. Similar applications can be built for diabetes patients where there is a need for monitoring of their conditions 24 hours a day, 7 days a week.[15–35]

Systems enabling social support from patient's environment and social networks

Probably one of the most important capabilities mobile phones have, and in particular smartphones, from the health interventions point of view is their ability to use the Internet almost anytime. This ability means that user data, such as blood glucose level readings, can be easily uploaded to the corresponding servers as soon as they are captured. This enables early detection and prevention of critical events. These data can be used to update patients' personal records and offer them the option to edit, update, or examine their history. Furthermore, users are able to include web pages, online audio, videos, as part of their phone interventions. In conclusion, the use of online resources makes it easier to keep the content of an intervention up-to-date without asking users to repeatedly install updated versions of the application.[24]

Lastly, a number of different mobile applications make use of social support from and/or competition between friends by linking to social media like Facebook and Twitter.[36]

Discussion

Technological advancements may bring a whole new dimension to many aspects of life and improve it in many ways.[37,38] Mobile technology and especially mobile phones may offer some very exciting possibilities in serving as a tool for diabetes prevention and management. Taking into consideration the positive results from feasibility studies and the increasing acceptance of this technology, mobile phones may improve and further develop existing practices and interventions in diabetes.[20–39] However, effectiveness trials and evaluation of cost-effectiveness of this technology are less documented and need to be further investigated in order to provide robust evidence, which will scale up this technology in the prevention and management of diabetes both in developed and developing countries.[20–27]

In order for an application to be recommended by a health care provider, it needs to have evidence of its effectiveness in improving health outcomes. The number and variety of mobile applications for diabetes disease is large and is a field that is rapidly developing. Although there is a large quantity of applications available, very few of these have been tested, evaluated, and documented in their improvements in health outcomes. Most of these available applications are consumer facing, and although patients could send information and data to their provider, applications – except for the WellDoc application (WellDoc, Inc., Baltimore, MD, USA) – fail to actively engage providers and do not provide any capabilities for integration of data into a provider's workflow or to an electronic medical record. However, diabetes mobile health applications have some great potential for the future. Their seamless integration into "regular clinical care has yet to materialize".[42] Scientists have recently conducted a systematic review[40] on the effectiveness of mobile technology interventions delivered to health care consumers. Based on some preset criteria, they found 75 studies, however most of the studies were described as being low quality. They concluded that there was some evidence that text-message-based interventions can increase "adherence in antiretroviral therapy and smoking cessation studies, but that results were not consistent for other areas". Thirteen of these studies primarily focused on patients; five out of these were focused on diabetes type 1 and three focused on children. These applications only provide text messaging interventions, were all published before 2010, and lack the evaluation functions of some of the features available on current diabetes smartphones applications. Considering, though, the advancement of technology and the increase in the economic investment in mobile Health (mHealth),[41] it is clear that, in the near future, more formal and documented studies will be able to identify the potential health benefits of mobile technology.[36]

Disclosure

The authors report no conflicts of interest in this work.

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