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Conformity of Diabetes Mobile apps with the Chronic Care Model

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ABSTRACT

Background Despite the growing use of mobile applications (apps) for chronic disease management, the evidence on the effectiveness of this technology on clinical and behavioural outcomes of the patients is scant. Many studies highlight the importance of the theoretical foundations of mobile-based interventions. One of the most widely accepted models for the management of chronic diseases, such as diabetes, is the Chronic Care Model (CCM). In this study, we investigated the conformity of the selected diabetes mobile apps with CCM.

Method We searched online journal databases related to diabetes mobile apps to find common features. Then considering the components of the CCM as a reference model, features of some popular and top-ranking apps were compared with CCM.

Results Among 23 studied apps, 34 per cent of them had medium conformity and 66 per cent of these apps were in weak conformity. The self-management support component is covered by 100 per cent of them. Ninety-five per cent of apps have covered the proactive follow-up component.

Conclusions App conformance with CCM is generally weak. App developers are recommended to give greater consideration to established theoretical models in their design and implementation.

INTRODUCTION

Diabetes mellitus (DM) is a major public health concern worldwide.[1] The difficulties of living with diabetes, with its multipart regimen and need for behaviour change, are challenging and good self-care is difficult to achieve.[2] Moreover, the management of diabetes complications is a multifaceted process that requires frequent interactions and collaboration among patients and physicians to address clinical issues and lifestyle change.[3] To overcome these difficulties, mobile health (mhealth) has shown potential to help healthcare providers and support patients for improving diabetes care. There are different reports for patient-centric mobile apps applied for different diseases and condition in routine care[4] such as chronic obstruction pulmonary disease (COPD),[5 6] diabetes,[7–9] cardiac disease[10 11] physical activity and nutrition management.[12 13]

There has been an extraordinary increase in the number of health mobile apps over the past several years.[14] In spite of the abundance of available apps, little has been published about how to design mhealth interventions to achieve a desirable and sustainable effect in the long term.[15]

To overcome this situation, researchers suggested that mhealth apps should be developed based on guidelines or theoretical models.[16] One of the most popular and comprehensive models for the management of chronic care diseases such as diabetes is the chronic care model (CCM). It is reported that planned care within a managed care system could improve the care delivery system for people with diabetes.[3 17 18] This model consists of six major components: delivery system design; self-care strategies; decision support and expert system; information support; community linkages; and health systems' support.[19] It is focused on resources, improvement of the quality of care and patient self-care capabilities. Several studies have demonstrated that if the model of diabetes care is appropriate and consistent with the CCM elements, quality of life and healthcare planning would be improved.[20–22] This model could be used as a suitable framework for covering the gap between the healthcare provider advice and practical care implementation especially as self-care oriented by patients.[23] As a solution, it might be concluded that healthcare providers need to plan new connections between mhealth apps and healthcare professionals in the frame of guidelines such as an integrated and consistent strategy according to CCM components.[17] Therefore, the aim of this research was to investigate the extent to which the features of diabetes mobile apps, as a new solution for patients' self-care improvement, conform to the components of CCM.

METHODS

Identification of the features of diabetes mobile apps

First, a review of the literature was performed to identify the most common features of

diabetes mobile apps. We searched major biomedical databases including Web of Science, PubMed and Science Direct using the following English keywords: 'diabetes', 'blood sugar', 'mobile health', 'mobile apps', 'smartphone' and 'mobile app', in a period from 2012 to 2017. Also, the references of the included articles were explored for additional relevant articles.

We did not consider diabetes life-style apps such as those targeting solely diet and physical activity. We considered just diabetes self-care apps. In the next step, we tried to provide a definition for each feature in order to determine the area of diabetes care that they address according to CCM components. Some features were well-defined and we extracted their definitions from the literature.[7 24–29] However, the definition of some others was vague, and we tried to provide acceptable definitions based on reviewed apps.

Currently, the only benchmark for rating apps is user's rate (UR).[30] Inevitably, we considered high-rate apps which are more probably embedded with key functions and more likely to be in line with CCM components. For this purpose, the most popular apps which had at least 4 or more rating score on the app store were selected.

Also, the most commonly popular apps based on their rates were chosen which might be in both Google Play and Apple Store too. We also collected the related technical information for all categories and sub-categories apps. In order to ensure a representative analysis despite missing selection criteria, we defined one day (20 July 2017) to record all found apps with title and developer. Therefore, the basis for the systematic and comparative app analysis was defined by the list of Android apps (online supplementary file). Next, due to a high number of available apps, we scanned the most popular apps by names in the Android marketplace and then downloaded just free apps because of cost considerations. We worked with popular diabetes mobile apps (eg, MySugr Diabetes Logbook) to get familiar with features practically. Afterwards, we searched considering all related android apps available in the Google Play Store in December 2017 returned by searching the Store using the aforementioned keywords. We downloaded the top ranking apps based on users' scoring rate.

We applied a number of inclusion and exclusion criteria as follows. The inclusion criteria: free of charge apps; related to diabetes directly; and had at least 4 or more rating score. Exclusion criteria: supporting only a single feature (for example, insulin calculation); not designed for diabetes self-care; provide information source only, such as a journal and magazine; not updated within 12 months prior to the search; and targeting solely fitness, physical activity or diet of diabetic patients only. Using these criteria, we found 23 free apps.

Qualitative analysis

In this step, the elements of each CCM component were identified based on the literature.[31–34] Each component of CCM has some elements that could be realised by their definitions provided by Pearson et al.[33] Next, it was required to investigate the conformity of top-ranking free diabetes mobile apps, which included in this study with the elements of CCM components. Each definition of features was compared with existing capabilities and potentials of the mobile app features. A reference table was developed to compare the conformity level of mobile apps features to elements of CCM components. Finally, the authors used the reference table to compare apps. One of the authors evaluated selected apps based on reference table (online supplementary appendix) and then results of evaluation was discussed with another author. For rating conformity of feature with CCM elements, we considered 0–25 per cent as weak conformity, 26–75 per cent as medium conformity and more than 76 per cent for good conformity. The authors' agreement regarding understudy diabetes apps conformity with CCM was measured by calculating Cohen's kappa coefficient index using SPSS version 22. Cohen's kappa of 0.75 or higher was designated as an acceptable agreement between the authors. Cohen's kappa is a robust statistic for reliability testing and can range from 0 to 1, where closer to 1 represents higher agreement between evaluators and 1 represents perfect agreement.[35]

RESULTS

Definition of diabetes app features and CCM components

Online supplementary table 1 provides the list of 32 features identified in the diabetes apps based on the literature and mhealth apps. This table consists of features' definitions as previously explained.

The components of CCM have been defined[33] as follows:

- Delivery system redesign means some changes in the organisation of care delivery. For example: A) increase physicians' role in care management; B) specify practice team activities; and C) delegate care from physician to non-physician.
- Self-care strategies mean to make some efforts to increase patient's involvement in their own care. For example: A) education materials provided; B) provide psychosocial support; and C) assess self-care skills and needs.
- Decision support means to make some guidelines, education and expertise to inform care decisions. For example: A) guide individualised care planning; and B) facilitate specialty/expert consultation in individual cases.
- Information support means to make some changes to facilitate the use of information about patients, their care and their outcomes. For example: A) provide data collection tools; and B) provide reminders for care planning and management.
- Community linkages mean to do some activities in order to increase community involvement. For example: A) seek community resources or collaborate with the community to meet patient/population

needs; and provide services or programme for members at the community level.
- Health system support means to make some leadership, practitioner and financial support. For example: A) coordinate/communicate among subsystems:; and B) acquire leadership support for chronic care improvement.

Online supplementary table 2 was completed based on conformity between the definition of each element of CCM with the definition of mobile app features. Online supplementary table 2 shows that a limited number of the components related to CCM are considered in the design of the apps. More than 95 per cent of features have covered three components including proactive follow-up, self-care support and information for the management system. The other components of the CCM, in most cases, have been covered by 30 per cent of features. If we compare this situation with the apps that are already available in the Google Play Store, this percentage would be even less, because very few of those available apps have these features.

Comparison of selected diabetes mobile apps with reference table of CCM

According to criteria mentioned in the previous section, 23 apps were extracted and tested one by one to find out their content. Results are shown in table 3. For each app, the authors calculated the number of features that have been covered. Among 23 studied apps, eight apps (34%) had medium conformity and 14 apps (66%) had weak conformity. The self-management support component is covered by all of the apps. Twenty-one apps (95%) have covered the proactive follow-up component. These statistics are also obtained for the component of the information support for care management. The least coverage related to patient registry system, self-management assessment and planned visit elements with only one app (4%).

DISCUSSION

This study aimed to examine the extent to which diabetes mobile apps have conformity with components of the CCM. From online supplementary table 2 it is clear that the 'proactive follow-up' element in 'delivery system design' component has been covered by different features: it might be due to a mobile app's ability to provide necessary services to patients in the absence of doctors and in the patient's private life.[36] The other elements in the 'delivery system design' component may suggest providing team-based services, and since one of the goals of mobile apps is patient-centred care, this feature has been mostly covered in a patient-centered manner.

The second component of CCM includes some strategies that help patients improve their self-care. Applied new technologies empower patients in learning new skills, thus it is supposed that mhealth enhances self-care abilities.[34] Some elements of a self-care strategy's component such as 'collaborative decision making with patients' or 'patient activation/psychosocial support' can be satisfied by special feature including colour coding or messaging. Hence, the 'delivery system design' and 'self-care strategies' are two components that have almost been implemented in diabetes mobile apps.

In the features of studied mobile apps, almost none of the component of 'decision support and expert system' were considered. Fundamentally, the CCM's decision-making is based on guides, evidence-based guidelines, protocols and standards; usages to provide the required care.[17] Despite the importance of this issue, however, many mobile apps did not apply even elementary proposition of guidelines in their design.[31]

The fourth component, 'information support', has three elements which correspond to the collection, integration and distribution of information. Institutional and personal information would be used to make a proper decision and treatment. As a result, it is better that an app has specific capabilities such as synchronisation with some tools such as social network, electronic registries and electronic health/medical records. The rate of adoption of these registries and records is less than what was expected in mobile apps, this issue partially could be related to usability issues such as national infrastructure, security and privacy considerations, and other obstacles.[37] Having a personal health record (PHR) that can be kept by the patient and his family can support the maintenance of more complete and accurate health information. These personal files can also be kept on the mobile device, but there are various challenges. Patients or their family may find it difficult to understand the medical terminologies. Another challenge is to provide support and assistance to patients as real- time support might be very costly. Another challenge is security and privacy of the data and ensuring that the data is entered correctly by users in such systems. On the other hand, the creation and maintenance of these cases is a partnership of patients and care providers, while patients are not specialised in medical matters.[38]

However, it should be taken into consideration that the use of electronic tools such as electronic health record (EHR) in gathering, storing and sharing data can be helpful to cover this component and it is better to invest in these facilities as soon as possible.[39]

'Community linkage' would provide information about community resources to support patients' needs or provide services or programmes for the community. There is still a research gap to examine the effectiveness of online communication systems to support self-care.[40] More studies are needed in this regard.

Regarding the last component, 'health system support', there is little information about how to design mhealth interventions that integrate with healthcare systems in the field of chronic care disease.[17] It seems that the essential features such as personalisation and decision support features in apps have important effects

on care improvement and these features are also recommended in the guidelines.[31]

Many researchers suggest involving innovative and inclusive technologies and tools for their positive impact on self-care diseases such as diabetes due to their direct effects on lifestyle. Mobile phone interventions provide an inexpensive and effective role in encouraging patients to promote self-care[41 42] and better interactions between the patient and the physician through the effective integration of patients' daily monitoring.[43–46] This will increase the patients' awareness about their condition.[47] Therefore, these possibilities make an opportunity to record disease-related information and transfer it to healthcare professionals. Another reason for the use of these technologies is the inherent characteristics, such as powerful technical capabilities, availability in all locations, people's dependency on, and the possibility of, customisation. Technical functions of mhealth can provide access to customised intervention based on different parameters such as age, sex, and health status of patients at both individual and social level. Also, it can be used for short message services (SMS), software applications and multimedia, such as image and video. These technologies provide direct interaction between the patient and the healthcare and provide real time and immediate assistance when needed by the patient.[48 49]

Health mobile apps can provide cost-effective foundation for caring for patients affected by chronic disease such as diabetes.[28] For example, it can be available in low-income areas and even a large number of people to monitoring and healthcare.[48] Also it can be useful for adherence to drug prescriptions, encourage them to have healthy lifestyles, and improve their knowledge and self-management abilities.[50] Reports of the cost effectiveness of health mobile apps like these, have been proven in some studies, but not in all of them.[51]

Nevertheless, in spite of all of these potential advantages regarding mhealth, the role of mhealth and apps in diabetes management has not yet been widespread.[52 53] This is not only due to the lack of CCM consideration in apps development, as far as we know, other requirements are also needed to implement the optimal usage of health mobile apps to diabetes care. These requirements which are shown in CCM may include constructive interaction between the informed and active patient, and the experienced and prepared healthcare team. These factors, in addition, to consider CCM's components in the mobile app architecture, are effective and important to achieve the desired results. If we design a diabetes app architecture along with all CCM's components' consideration, the data may not be still forwarded completely and accurately to be monitored by the service provider and the ultimate goal of the CCM, which is improving the patient ability to manage her/his own chronic illness truly, would not be covered.

The data produced in the process of interaction between the provider and the patient can be collected, analysed and retrieved in a database. Statistical and mathematical algorithms might be used in order to develop intelligent modelling and provide a prediction of diabetes-related outcomes such as blood glucose, weight, calorie intake and even HbA1c levels to achieve the ultimate goal of the CCM. This is possible when data are collected longitudinally and build a rich database. Therefore, to achieve such an ideal output, cost and time are needed, but ultimately, when the system reaches the degree of automatic operation, can improve outcomes and processes of care smartly based on the CCM approach.

Despite the advantages of many mobile-based systems for improving healthcare, if not properly understood and used, could lead to misdiagnosis and increased risk. The US Food and Drug Administration (FDA) consider the same risk-based approach to mobile phone apps such as other medical devices as well. It even announces a list of apps as an example that has been able to receive FDA approval and describes how to get the confirmation. This file has been edited in its latest version on 8 October 2018.[54] In addition, the security and privacy of the information that patients enter is also another challenge. Although many researchers have suggested state-of-the-art technologies such as the use of intelligent lenses for continuous monitoring of patients, it has always been advised that patients themselves are aware of what information is being collected and for what purpose it is used.[8 55] So, as one of the most crucial aspects of using these tools, it should be resolved by considering secure transmission and secure and private data storage. Therefore, the relevant laws and regulations should consider all of these and show that the patient's safety is a priority.[56] Nevertheless, many medical apps have not passed the necessary regulatory control and might be dangerous for patient safety.[57] Legal frameworks developing to prevent the introduction of unsafe and high-risk programmes also need to allow further innovation.[58] Surveillance should be based on a patient-centred approach, while keeping up-to-date with relevant laws and protecting the safety of the patient.[59]

We considered the date of the latest app update to review and report, but of course, the number of apps and their updates keeps changing. Also, some features are just from published descriptions or articles. There are variances between the explanation in the article and the actual features. We did not have the time and resources to install and test every app. This study was limited to Google Play Store for android apps and can be extended for other app stores in future. Further study may address the trend of apps improvement according to their progress towards CCM conformity.

CONCLUSION

The results of our study showed that conformity of diabetes mobile apps with the CCM is generally weak.

Currently available mobile apps address limited components of the model. Many apps just have focused on some essential options to collect blood pressure, blood glucose, weight and activity tracking. In the future, the ideal apps may have all the suggested features entirely to create an integrated, rich and compatible system. The result of this study can help software developers and intervention designers develop more effective mobile apps for diabetes management according to the recommendations of CCM.

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