Designing a Social Mobile Platform for Diabetes Self-management: A Theory-Driven Perspective

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Abstract. Diabetes mellitus (DM) is increasingly being accepted as a lifelong public health problem with profound consequences on the worldwide healthcare system. Self-management, therefore, has been long suggested as an integral solution of diabetes treatment [1] which requires patients to adopt strained lifestyle modifications (e.g., balancing diets and frequent monitoring of blood glucose) [2, 3]. With the proliferation of smart devices, this study proposes a theoretical framework as an important guideline for designing and prototyping a life-changing mobile platform for a next-generation diabetes self-management. It revolutionises the interaction between patients and their smart phone with a high degree of media richness and social connectivity for better health management success.

Keywords: Diabetes mellitus · Self-management · mHealth · Social support · Social presence

1 Introduction

The prevalence of diabetes mellitus (DM) has been growing rapidly on a global scale in recent decades. The International Diabetes Federation estimates a tremendous rise in cases diagnosed with diabetes to 592 million by 2035 [4] which suggests a huge economic burden of DM. In order to meet the public expectations on healthcare services within resource constraints, self-management, therefore, has been long regarded as an integral part of clinical treatment of DM [1]. It involves a considerable amount of strained tasks for patients, such as balancing diets, increasing physical activity, frequent monitoring of health status, and obtaining diabetes knowledge as well as adherence to treatment regimen and advice [1, 2].

Mobile applications (mobile apps) have been studied as viable tools for diabetes self-management [5–9] which empower patients with great advantages of usability and mobility [10, 11]. Moreover, the ubiquitous mobile technology promisingly brings patients closer to their friends and family members for social support thus creating persuasion power and generating sufficient motivation for patients to comply with their diabetes treatment protocols [12]. Nevertheless, it was unclear whether existing mobile apps in the market were designed based on behavioural science theory capable of modifying self-care behaviours [13]; hence, this research aims to fill the existing gaps in

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literature and practice to propose a theoretical framework for designing and prototyping a life-changing mobile platform for a next-generation diabetes management.

In this research, we have conducted systematic searches using the keywords: "Diabetes" and "Glucose" across different app stores, such as Apple AppStore, Google Play, and Windows Store; and there are over 2,000 mobile apps related to diabetes management. Similar to the findings from Holtz & Lauckner [6], and El-Gayar et al. [13], the majority of the apps offer health tracking capabilities including blood glucose, insulin treatment, and dietary intakes. However, there are only a handful of apps with family support features which are limited to the use of social blogs, forums or e-mails for disseminating patients' health status to their supporters.

In this study, the design of a social mobile platform for diabetes self-management brings social support to the next level of mobile social presence through the innovative use of loved ones' voice messages which will stimulate patients to self-manage their conditions. It also provides an effective mean of using social networking sites (SNS) for family members and friends to help patients with distributed inputs which will reduce the burden of manually entering data and will enhance the experience and accuracy of tedious self-care tasks like dietary tracking. Based on a strong theoretical foundation, it is capable of reshaping the interaction between patients and their smart phone with a high degree of media richness and social connectivity for effective diabetes management.

The structure of our paper is as follows. In the following section, we review the relevant literature background of diabetes self-management, behavioural theories, and mobile apps. Section 3 discusses our theoretical framework and the design of our social mobile platform. The last section concludes the paper with our direction of forthcoming research.

2 Literature Background

2.1 Diabetes Self-management

Diabetes is a chronic disease resulted from insulin deficiency (Type I Diabetes), insulin resistance (Type II Diabetes), insulin receptor problem in pregnancy (Gestational Diabetes Mellitus), or genetic defects (other specific types of diabetes) so that the plasma glucose level is above the normal range [14]. Self-management has been recognised as an important part of clinical treatment, which requires patients to adopt lifestyle modifications [1, 15]. According to the most recent Standards of Medical Care in Diabetes [16], patient self-monitoring of blood glucose level (SMBG) plus medication, nutrition therapy, and physical activity are the key elements required for both type I and type II diabetes patients. In addition, studies have shown that while many patients require 6-8 times of testing per day, SMBG frequency and timing should be adjusted by individual and proper SMBG correlates with a lower glucose level [17, 18]. While physical exercise and diet control also help to improve glycaemia and cardiovascular risk factors [19], individually tailored interventions are required in order to make a change towards healthy, low-fat eating [20]. The success of self-management, as social cognitive theory describes [21], is strongly influenced by various personal factors and environmental factors, in which the behavioural change theory plays a critical role [22, 23].

2.2 Behavioural Change Theory for Diabetes Self-management

As diabetes self-management requires changes in individuals' self-care behaviours (e.g., blood glucose testing, dietary management) [3], the effect of self-management is strongly understood by the behavioural change theory. This section reviews previous literature and summarizes relevant theories for self-management of diabetes.

Self-efficacy. Self-efficacy, defined as the strength of one's ability to carry out a behaviour to reach a desired goal, is fundamental to behavioural change interventions in social cognitive theory [23]. Self-management interventions need to attach importance to developing self-efficacy [22]. In addition, Bandura's behavioural change study [24] postulates that individuals' past performance accomplishments harden their belief leading to improvements in health-related behaviours. In terms of diabetes glucose control, which requires habitual diet and glucose tracking, the process of goal setting increases patients' self-efficacy [25]. More specifically to SMBG, which offers day-to-day information of glucose level in response to diet, exercise and medical treatment, outcome expectation also helps to improve the efficacy of diabetes self-management [25–27].

Social Support. The success of diabetes self-management essentially involves ongoing collaborative efforts of family members and friends [16, 28]. Social support empowers patients' self-care behaviours, such as adherence to the treatment regimen and acts as a protection layer against impact of stressful events [29]. Furthermore, studies on social support of diabetes care indicated the evidence of informal social support in improving health outcome, and diabetes care teams should encourage informal support from family members before the formal clinical support interventions [2, 30], especially in dietary management, which is vulnerable to social influences [3].

Social Presence. Social presence theory indicated that communication is more effective through the medium with higher social presence, such as motional, audio and visual, comparing to text-based medium [31]. In the newly published book, Social Media and Mobile Technologies for Healthcare [32], it was pointed out that there had been very few models integrating social network elements into mHealth, although mobile social presence has been newly discussed as an extension of virtual social presence with collaborative technologies like transmitting photos, videos, and local-based statuses [33]. According to Cialdini & Goldstein [12], higher mobile social presence strengthens the effect of social support by generating sufficient motivation for patients and their supporters to accomplish diabetes management tasks thus leading to increased levels of health related outcomes.

2.3 Mobile Apps for Diabetes Self-management

With the advancements in mobile technology, attempts of mobile diabetes support as well as related publications have increased rapidly since the early 2000s [5, 34]. Early efforts were mainly about giving lifestyle interventions through mobile text messages, so that patients' awareness, knowledge, and control of disease could be improved [35, 36]. With the increasing storage capacity as well as Wi-Fi accessibility, the majority of mobile apps

nowadays offer health tracking capabilities of one or more areas in glucose, diet, exercise and medication [7–9, 13, 37, 38]. Personalisation and decision support are also heated topics in the existing market and research [11, 39, 40]. The mobile capabilities of communication and self-management education have been studied to show positive impacts on various health outcomes [13, 41, 42]; nevertheless, there are only a handful of apps with family support features and explorations in social media support are also limited [6, 13].

3 Social Mobile Platform for Diabetes Self-management

3.1 Theoretical Framework

We propose the following theoretical framework (Fig. 1) as an overarching design guideline of our social mobile platform for effective diabetes self-management.

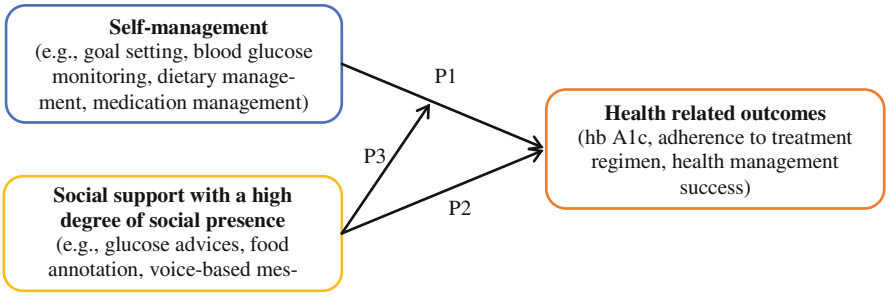

Fig. 1. The theoretical framework for self-management mobile app designing

Self-management interventions attach importance to developing self-efficacy [22, 23], which postulates that individuals' past performance accomplishments harden their belief leading to improvements in health-related behaviours [24]. The process of goal setting increases patients' self-efficacy [25]; which promotes their sense of responsibility and accountability in managing their own health thereby improving their health related outcomes. We propose Proposition 1 as enabling factors of a diabetes self-management mobile app, such as goal setting, blood glucose management and physical activity tracking.

Proposition 1. Individuals can achieve higher levels of health management success thus resulting in improvements of health and medical status progress by facilitating their self-management activities, such as goal setting of diabetes management, and management of blood glucose levels, dietary, physical activities, and medications.

The success of diabetes self-management essentially involves an ongoing supporting role of family members and friends [28]. According to the social support theory, it influences patients' self-care behaviours, such as adherence to the treatment regimen and acts as a protection layer against impact of stressful events [29]. With mobile technologies, mobile social presence [31, 33] has been newly discussed as an extension of virtual social presence with collaborative capabilities like transmitting voices, photos and videos, and local-based services, which strengthen the effect of social support by

generating sufficient motivation for patients and their supporters to accomplish diabetes management tasks thus leading to increased levels of health related outcomes [12]. We, therefore, posit a direct effect of social support in Proposition 2 and an interaction effect between self-management and social support in Proposition 3 which in turn allow us to design a comprehensive feature set of our mobile app in the Table 1.

Table 1. The theory-driven feature set

Theory	Feature
Self-care [6, 15, 20]	• Glucose monitoring
	• Dietary tracking
	• Physical activity and medication management
Self-efficacy [23–26]	• Goal setting
	• Reporting and advice
Social support [2, 3, 27, 30, 36]	• Social glucose monitoring
	• Social dietary tracking
Social presence [31, 33]	• Voice-based reminders

Proposition 2. Individuals can achieve improved health management success thus resulting in increased levels of health and medical status progress by facilitating social support for them and their supporters to access diabetes management activities and to engage in a high degree of social presence.

Proposition 3. By facilitating both self-management and social support for individuals and their supporters to access diabetes management activities and reports, they can achieve improved health management success thus resulting in increased levels of health and medical status progress.

3.2 User Interface Design

This study aims to design a patient-centric minimalistic mobile platform for diabetes self-management. The following sections describe the comprehensive set of theory-driven features in great details.

Glucose Monitoring. Our design offers an important function of glucose self-monitoring at patients' convenience (Fig. 2 - the left screen). A patient can set the blood glucose level using a scrollbar of the input circle after taking fingerstick blood tests. The date and time of record will be automatically captured, and, further edit is allowed by scrolling the time picker. The target range of blood glucose for different people before and after meals are different. Hence, the design allows users to have a personalized target range for both before meal glucose level and after meal glucose level.

Fig. 2. Self-care features

Dietary Tracking. A patient simply needs a few steps to log their diet (Fig. 2 – the middle screen). The first step is to take a photo of the meal by clicking "Capture Meal" in the home page. The second step is to enter the type of food which allows the app to know the carbohydrate count for diabetes management. The last step is to indicate the amount of finished food. These steps can even be shorter with the use of Social Support Features. Patients could also select the time frame of the diet record that he or she would like to review. Both the starting date and end date could be edited through scrolling the date picker at the top part of "Diet Record" screen.

Physical Activity and Medication Management. Other than glucose monitoring and diet tracking, physical activity and medication are two other important aspects of diabetes self-management. Our design caters for a minimalistic way of capturing users' inputs on physical activities and medication like jogging and insulin treatment (Fig. 2 – the right screen). It facilities the selection of different types of activity or treatment therapy together with the amount of work done or treatment dosages. Integration with fitness devices and location-based services are yet to be explored.

Goal Setting. This features the process of goal setting which breaks major target into concrete and manageable objectives within a desired timeframe (Fig. 3). For instance, a goal of glucose monitoring can be "from Jan 10, 2015 to Jan 24, 2015, having a minimum glucose level of 4 mmol/L". Once the user accesses this feature, the fulfilment ratio will be updated based on glucose input, diet log, physical exercise log, and medication records within the time range indicated at the top of the screen. This design provides users with useful feedback about their efficacy of achieving goals.

Reporting and Advice. For reporting purposes, the user could select the time range they want to view data logs as shown in Fig. 4. The functionality displays the period

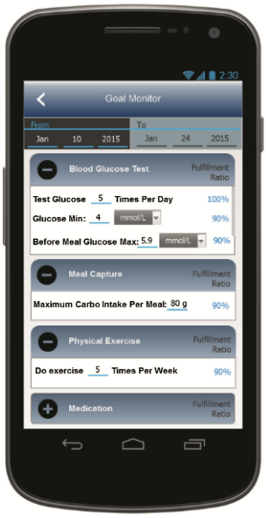

Fig. 3. Goal setting

average as well as each day's test results in the bar form. The daily average is shown as an orange line, and each meal's intake time and carbohydrate exchange amount are indicated as orange triangles. The design is capable of motivating users by displaying friendly status related to their health-related outcomes.

Fig. 4. Reporting and advice

Social Glucose Monitoring. Our design allows the ability to connect with family and friends based on the Facebook's friend list (Fig. 5 – the left screen). Once connected, various reports of the patients will be sent to their supporters for information exchange and advices including glucose charts and health-related status messages. The app also reports the adverse events, such as hyperglycemia and hypoglycemia to supporters who can act in time to prevent life-threatening consequences. The interactions between users and the mobile app, therefore, are enhanced for frequent usage and healthier lifestyle.

Fig. 5. Social support features

Social Dietary Tracking. The design further simplifies the tediousness of food tracking by sending requests to connected family members and friends for distributed inputs as shown in Fig. 5. When a patient takes a photo of their food, it will be sent automatically to their loved ones on Facebook. And it is important to guide the supporters through a series of steps to tag the food based our calories count database. Two hours later, the mobile app will prompt the patients to complete their dietary tracking tasks based on the collected inputs.

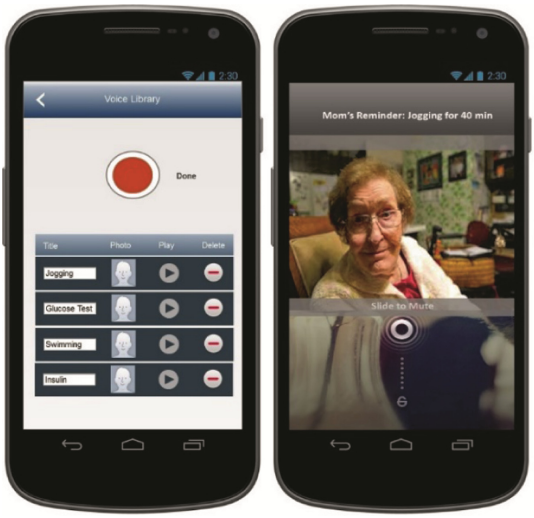

Fig. 6. Voice-based reminders

Voice-Based Reminders. Rather than using the traditional notification or alarms, the design implements voice-base reminders with a family member or a friend's photo shown in Fig. 6. This aims to facilitate effective interventions for lifestyle changes, as well as long term efforts in self-management because the reminders will be based on physical exercise schedules, glucose testing schedules, medication schedules, etc. Family members and friends can record their voices based on certain event triggers. After the setup, the mobile phone will start to notify patients through the voice selected for the reminder, and the screen will show the profile photo of the voice's owner at the same time.

4 Conclusion

Our study has established forceful contributions to the literature and practice of mobile diabetes management in two folds. First, based on the behavioural science theory, our research proposed the theoretical framework capable of reshaping the current generation of diabetes management towards a more active and supportive direction. Second, we designed and prototyped a next-generation mobile app for diabetes self-management through the use of voice-based reminders and collaborative features. It provides a solid mean to promote the practice of self-management amongst patients and their social networks which is exceptionally valuable for healthcare professionals to impart necessary interventions to patients with diabetes.

The paper is not an end; but rather a beginning of forthcoming research. In the future, we are looking into ways of further simplifying our mobile app by interfacing with devices, such as glucose meters, fitness devices, and insulin pumps. Furthermore, we are in the process of conducting an experimental design study to assess the impact of the mobile app on apprising and predicting the user behaviour and on understanding how contextualized social support should be given to increase the likelihood of behaviour change and improvements in health status.

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