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An mHealth Application to Promote Diabetes Self-care Behavior among Medically Underserved Population

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Emergent Research Forum (ERF)

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Abstract

Diabetes is a chronic illness that causes serious health complications such as kidney failure, limb amputations, and often leads to premature death. Adoption of self-care behavior among diabetes patients is known to improve their health conditions and quality of life. Medically underserved populations (MUP) are disproportionately affected by diabetes. In this research we use a design science approach to develop an mHealth app to promote diabetes self-care behavior among MUPs. Using design theories on behavior change and user-centered design we articulated five key design principles. A mobile app based on these principles and AADE7 self-care behavior framework has been implemented using an Android system. We are currently in the process of evaluating its effectiveness. Our research contributes to the discourse on design for behavior change and illustrates the effectiveness of mHealth apps in promoting healthy lifestyles.

Keywords

User-centered design, design for behavior change, mHealth, medically underserved population, diabetes self-management, design science.

Introduction

Diabetes is a chronic illness that afflicts numerous people around the world and results in poor quality of life, loss of limbs, and premature death. According to a report from the World Health Organization, 422 million adults worldwide suffered from diabetes in 2014 (World Health Organization 2016). In US alone, more than 34 million individuals have been diagnosed as diabetic and one in every four individuals is at risk of developing diabetes (CDC, 2020). Prevalence of diabetes is disproportionately high among medically underserved population (MUP), who often are poor, have low educational attainments and limited English language skills (Zach et al. 2012). Their low socioeconomic status combined with their lack of familiarity with the health delivery system limits their access to medical care and this can have serious consequences on the quality of life of these individuals as well as on the economy. Self-management behaviors are a key to managing chronic diseases such as diabetes and limiting their debilitating effects on the patient. The AADE7 self-care behaviors recommended by ADCES (Association of Diabetes Care and Education Specialists) encourages diabetics to practice healthy eating, staying active, monitoring one's vitals, taking medications regularly, resolving problems appropriately, and taking steps to reduce diabetes related complications. Adoption of such self-care behavior is known to result in improved quality of life of diabetes patients. The key challenge is how to persuade people to adopt self-care behavior to manage diabetes.

Extant research has demonstrated that IT artifacts can play a pivotal role in molding patients' behavior. Consolvo et al. (2009)discussed several design strategies that helped people change their behavior and maintain physically active lifestyles. Similarly, a web-based self-management patient portal has been shown to improve quality of life among asthma patients (Ahmed et al. 2016). Ludden et al. (2017) demonstrated that an appropriately designed mobile application can motivate people to lower consumption of sugary beverages, and thus enable them to maintain a healthy diet. Årsand et al. (2012) have demonstrated the effectiveness of an mHealth platform in the self-management of diabetes. Thus, mHealth technology has created an opportunity to deploy applications on mobile phones to assist users in their healthcare. While 36% of smartphone users are known to use some kind of mHealth app (Bhuyan et al. 2016), only 13% of apps that promote diabetes self-care behavior have been found to be useful (Brzan et al. 2016). Most of the diabetes management apps available in the marketplace are unsuitable for use by MUPs, who have limited reading and writing skills (typically less than middle school) and are unable to interpret graphs and charts, and complex language that characterize most diabetes apps. Appropriate messaging is critical to effect behavior change, and AADE (American Association of Diabetes Educators) and ADA (American Diabetes Association) recently formed a task force to address language issues in diabetes care and education (Dickinson et al. 2017). El-Gayar et al. (2013) advocates a user-centered design approach to enhance adoption and use of mHealth applications. Considering the significant benefits offered by mHealth apps to manage diabetes and the lack of appropriately designed apps for MUPs, we endeavor to answer the following research question –

Can diabetes self-management behavior among MUPs be changed by using a mobile phone-based application that has been designed to fit the needs and characteristics of this patient population?

In attempting to address the above research question we not only create a mobile app to help MUPs afflicted with diabetes but also answer a fundamental question: can appropriately designed mobile apps be used to change behavior of it users (Fogg 2009)? We used a design science research method (Peffers et al. 2007) in this research. The app development and testing is complete at this time and we are in the process of conducting a randomized control trial to study its efficacy. The remaining of the paper is organized as follows – the next section describes the design science approach in the context of our study and articulates the design principles underlying the prototype development. We then describe the system architecture and discuss its implementation. The prototype evaluation criteria are then presented, and the paper is concluded with a discussion of our contributions.

Research Method

We used the design science research method, which has been advocated as an important and relevant research paradigm within the IS discipline. In particular, we followed the six step method proposed by Peffers et al. (2007). Figure 1 depicts these six steps as implemented in this project by highlighting key activities performed in the context of this study. The first step in this research method is to identify a problem that needs to be resolved. As elaborated in the introduction section, our goal is to promote self-care behavior among diabetes patients who are medically underserved. We want to develop a mobile app that would help this patient population to change their behavior. While there are numerous mobile apps that promote self-care behavior among diabetes patients, most of these are not suitable for use by MUPs who face various barriers, such as low literacy rate, limited language skills, and others. Thus, our objective is to develop a mobile app that would enable patients from MUPs to adopt diabetes self-care behavior. A key design challenge is to identify design

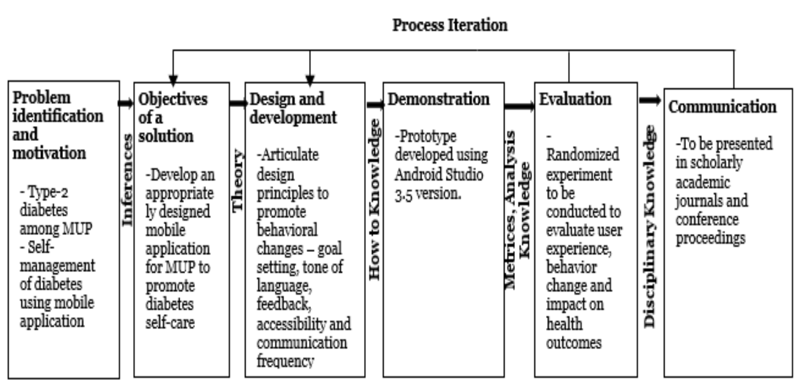

Figure 1: Design Science Process (Adapted from Peffers et.al. 2007)

principles that would lead to behavior change. Another challenge is to adapt the design to suit the characteristics of the target user population, e.g., MUPs. The salient design principles adopted in our app design are described next.

Design Principles

The overarching design principles relied on two relevant theories of persuasion – Elaboration Likelihood Model (ELM) and Fogg's Behavioral Model (FBM). ELM posits that the degree of cognitive engagement experienced by an individual depends on whether he/she uses a central or a peripheral route to process information. High elaboration leads to higher level of engagement and low elaboration results in poor engagement. FBM asserts that individuals with higher ability and motivation are highly prone to reach the target behavior with the presence of proper timing of trigger. Both these have implications for designing the feedback system. The key design principles used in designing the prototype are described in this section.

Goal setting principle:

Specific and challenging goals with appropriate feedback lead to higher task performance (Locke and Latham 2002). Goals also motivate individuals to gauge progress (Consolvo et al. 2009). The goal setting principle involves the user in the decision-making process and enhances psychological engagement to induce behavior change. Our mobile application allows the user to set daily and weekly goals as per his/her needs and abilities. This enhances the probability of user achieving his/her goals.

Feedback principle:

According to feedback intervention theory, feedback makes individuals aware of the gap between goal and accomplishment, and promotes behavior that reduces such gap. A systematic review reveals that mHealth feedback system based on patient-transmitted diabetes related information has a positive effect on diabetes management (Baron et al. 2012). Thus, frequent and regular feedback is likely to promote adoption of self-care behavior by encouraging the user to interact with the app on a regular basis.

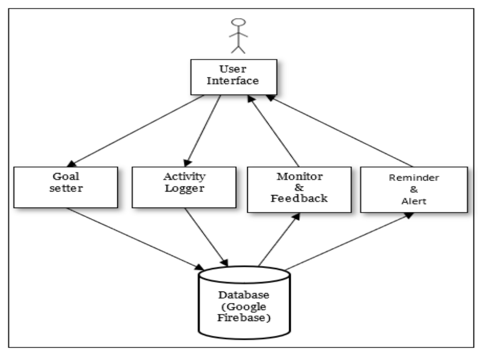

Figure 2: System Architecture

Language principle:

Judgmental language that demeans or shames the patient often leads to diabetes distress and negatively impacts health outcomes (Dickinson et al. 2017). Borrowing from Dickinson et al. (2017), we designed our messages using language that is a) non-judgmental and based on facts, b) does not shame the patient, and is c) respectful, inclusive and gives hope. Thus, the tone of feedback messages were either congratulatory when goals were met ("Great Job! You have met your exercise goal for today!") or neutral/encouraging if goals were not fully met ("Great start towards your goals for the day. Keep it up!")

Presentation principle:

MUPs have low literacy rates and limited language skill. Simple messages and short messages are more effective in enhancing comprehension and improving communication for patients with low literacy skills (Doak et al. 1996). Keeping this in mind, the app interface design does not use graphs, charts, and complex language, which are commonly found in many mHealth applications. All messages and instructions are developed at a middle school level of reading. Messages are written in a conversational style using active voice, simple words and short sentences (Doak et al. 1996). Speech bubbles attached to a stylized stick figure (the diabetes buddy) are used to simulate a person providing feedback.

Accessibility principle:

The accessibility principle emphasizes comfortable user experience by avoiding clutter. Keeping in mind the language and literacy skill of MUP users, the interface features large and easy to read text, low information density, visual cues, and easy to navigate interface. Following Rao and Ramey (2011), both verbal and written communication are provided to enhance accessibility. A vocalization feature enables users with limited reading skill to use the app without challenge.

Prototype Development

Figure 2 depicts the system architecture. The user interacts with the system through the user interface, which is designed using accessibility principle described earlier. The goal setter enables the user to set goals, which are based on AADE7 self-care behavior framework (AADE 2010). The user can set daily and weekly goals regarding food consumption, exercise, and medication. Activity logger allows the user to log activities/ accomplishments related to various goals. The monitor tracks accomplishments against goals and provides appropriate feedback. This module implements feedback principle and language principle described earlier. Two sets of feedback messages, one in the morning and another at the end of the day, are provided daily to encourage users to achieve self-set goals and log progress on those goals. The user can also set custom goals and schedule their own reminders to enable him/her keep track of events helpful in managing diabetes. This empowers the user to actively engage in managing his/her health condition. The system uses the health data (e.g. blood glucose level) provided by the user to create alerts as needed. The app has been developed using Android Studio 3.5 (updated during development) and supports most smart phone devices available. It is compatible with Android 4.1 through Android 9 and can be updated to Android 10, if necessary. Google Firebase 16.0.9 (core firebase functionality) with Firestore 17.1.2 (cloud storage) is used to store data. The database is HIPAA compliant and uses encryption to protect patient data. Figure 3 shows sample screenshots to illustrate the user interface design and feedback presentation.

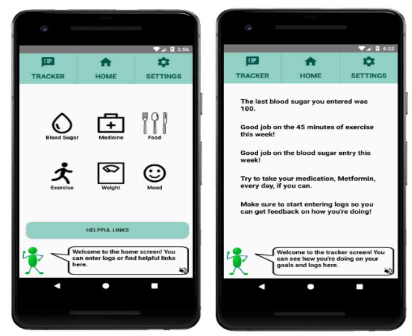

Figure 3: Sample screenshots

Evaluation

We are in the process of evaluating the prototype using a randomized control experiment. 30 type 2 diabetes patients 18 years or older who can read, write and speak English will be recruited from among medically underserved populations residing in a large urban center in the USA to participate in a six-week study. Each will be randomly assigned to either the treatment group or the control group. Subjects in the treatment group will use the diabetes app during the study period, whereas those in the control group will not use any app. All participants will fill out surveys three times – at the beginning, at midpoint and at the end of the study period to assess the efficacy of the intervention. Evaluations will be conducted at three levels – (1) user experience, (2) impact on behavior change, and (3) impact on health outcome. User experience assessment will measure how comfortable users are in using the system. This is a critical factor considering the unique characteristics of the target user population. Behavior change will assess the impact of the system in helping users adopt self-care behavior in managing their diabetes condition. Finally, the health data captured by the system will be used to assess if there was any impact on improving health conditions of the users.

Conclusion

Diabetes is a chronic illness that is widely prevalent around the world. MUPs, who are poor, less literate, and lack access to medical care suffer immensely from this chronic illness. Promoting self-care behavior among diabetes patients has been found to enhance their quality of life. We used a design science research method to articulate key design principles for an mHealth app that is designed to promote adoption of self-care behavior among medically underserved diabetes patients. The app has been developed keeping in mind the unique characteristics of this patient population. This research contributes to the discourse on design for behavior change and illustrates the potential for mHealth apps to promote healthy behavior. The results of the evaluation of the app will be shared during the conference.

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