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The Role of mHealth in Facilitating Prediabetic and Diabetic Patients' Involvement in Health Interventions

Research-in-Progress

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Abstract

Health interventions are useful tools for preventing and alleviating diabetes which show low adherence in medical practice for prediabetic and diabetic patients. mHealth technologies have the potential to facilitate health management and improve prediabetic and diabetic patients' self-management outcomes. Building on Social Cognitive Theory, this research-in-progress paper proposes a research model to account for the role of physician's recognition in promoting self-management behaviors for prediabetic and diabetic patients through mHealth technologies. To test the research model, authors developed a mobile diabetes management application and cooperated with a large tertiary hospital in China. In this research-in-progress, we propose to recruit 280 subjects who are in the prediabetic or diabetic conditions. This study is expected to contribute to the research on and practice of the health interventions through mHealth technologies.

Keywords: Health intervention, mHealth, adherence, recognition, diabetes

Introduction

Diabetes is a chronic disease that results in significant morbidity, mortality and economic costs (American Diabetes Association 2016a). Prediabetes is a non-diabetic stage with an excess risk for diabetes (American Diabetes Association 2015). Efforts in self-management activities, such as dietary management, daily exercise and self-monitoring of blood glucose, are required from both prediabetic and diabetic patients. Good self-management can reduce glycated haemoglobin (HbA_{1C}) levels, achieving a 40–70% relative risk reduction of developing diabetes and a decrease of 37% in likelihood of developing diabetes-related complications, respectively (Tabák et al. 2012). Health interventions have proved useful tools for promoting self-management behaviour, and consequently, preventing and alleviating diabetes (Ley et al. 2014).

Health interventions refer to the promotion of activities for improving human health by preventing diseases, curing or reducing the severity or duration of existing diseases, or restoring function lost through disease or injury (Smith et al. 2015). So far, medical practice suggests a low adherence to health interventions, motivating us to examine the role of mobile technologies. We focus on prediabetic and

diabetic patients, because these patients often encounter significant barriers to diabetes management because of a lack of disease-related knowledge and understanding of self-management behaviour, and poor patient–physician communication.

In general, mHealth technologies are found to assist in health management, leading to patient behavioural change and self-management improvement outcomes (Wang et al. 2014). Health interventions operationalised and transformed via the mobile platform are behaviourally-based tools to improve mental or physical health (Eysenbach & Consort-eHealth Group 2011). Research has shown that health interventions through mHealth technologies have statistically significant effects in reducing HbA_{1C}, improving self-efficacy, increasing disease knowledge, enhancing physician–patient communication and lowering diabetes incidence through information delivery, education, self-management, therapeutic advice and drug guidance (Saffari et al. 2014). So far, little is known about how to facilitate adherence to health interventions on the mobile platform. The objective of this paper is to explore how mHealth technologies assist prediabetic and diabetic patients to increase their level of adherence to health interventions and promote self-management activities.

Stimulating prediabetic and diabetic patients' consistent adherence to health interventions is particularly critical in China. According to the International Diabetes Federation, in China, more than 110 million adults had diabetes at the end of 2015 (Ogurtsova et al. 2017). Medical resources are limited in China. Large tertiary hospitals in the large urban areas, with advanced medical facilities and a good platform for cooperation, absorb much of the economic and human resources. Regardless of geographical distance, patients tend to go to the large tertiary hospitals in their province or those in developed areas, whether it is necessary or not. This ultimately leads to an unbalanced ratio between physicians and patients, and over-crowded conditions in large tertiary hospitals. Physicians who are busy providing clinical services may fail to track every individual prediabetic or diabetic patient. Therefore, most prediabetic and diabetic patients must rely on themselves to manage their health conditions and health-related behaviours following discharge from the hospitals. However, physician involvement is important for motivating patients and providing professional support (Nam et al. 2011). This paper focuses on the role of physician feedback in promoting physical health behaviours for prediabetic and diabetic patients.

Unlike most types of feedback, social recognition provides only a small amount of behaviour-related information. Social recognition means that an individual provides personal acknowledgement, approval and appreciation to another individual after the exhibition of desired behaviour through verbal or written forms containing an evaluation component. Thus, this proposal develops a mHealth application to explore:

What is the impact of physician's recognition on adherence of health interventions through mHealth technologies?

This paper is organised as follows. Section 2 presents the theoretical background, Section 3 develops hypotheses and Section 4 describes the research methodology. The last section details expected contributions.

Theoretical Development

Social Cognitive Theory

Social cognitive theory (SCT) is a behavioural change model frequently applied for intervention development (McSweeney et al. 2017). It concerns the capability of cognitive, affective and behavioural learning through observation of others' behaviours in the context of social interactions, experiences and mass media (Bandura 2001). SCT evaluates behavioural change through the dynamic interaction of person, environment and behaviour (Bandura 1997). Environment refers to factors that can affect a person's behaviour. Reinforcements are common types of environmental factors. The interaction of the three factors leads to responses to a person's behaviour that affects the likelihood of strengthening the behaviour (Skinner 1963).

There are two kinds of reinforcements: positive and negative. Positive reinforcement occurs when a pleasant stimulus presents after a behaviour, resulting in an increased frequency of that behaviour in the future (Doggett & Koegel 2013a). Negative reinforcement occurs when a behaviour is followed by the removal, reduction or avoidance of an unpleasant stimulus, resulting in an increased frequency of that behaviour in the future (Doggett & Koegel 2013b). Positive and negative reinforcements are similar in that both lead to increased responsive behaviours in the future, but are dissimilar in that negative reinforcement involves the removal of a stimulus, while positive reinforcement involves the presentation of a stimulus.

Feedback and Social Recognition

Feedback refers to actions taken by organisations or other individuals to provide information regarding the performance of an individual's task behaviours (Kluger & DeNisi 1996). It can inspire people by increasing knowledge and awareness of their behaviours. When a person receives feedback, he/she compares their behaviours to the standard, and decides whether to adjust their behaviours to be more consistent. A prior study has showed that physicians' feedback can increase the effectiveness of chronic disease interventions (Kripalani et al. 2007) because feedback promotes health-related sustainable behavioural change. Based on the feedback content, three types of feedback are usually employed to positively affect behaviour (Hawkins 2008) (see Figure 1). The first type is descriptive feedback, summing up an individual's behaviour information and reporting back to him/her (McCambridge et al. 2013). The second type is comparative feedback, providing social comparison information through contrast of an individual's performance with those of others (Ávila et al. 2012). The last one is evaluative feedback, which contains judgement information based on an individual's performance (Littman 2015).

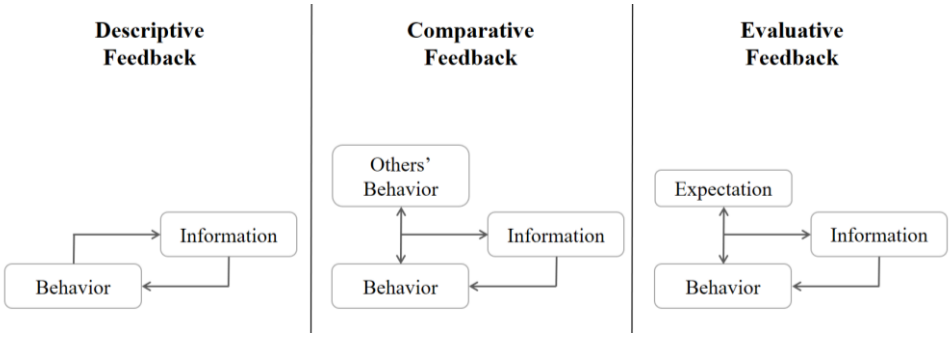

Figure 1. Types of Feedback: Descriptive, Comparative and Evaluative

This paper focuses on a specific form of evaluative feedback—social recognition. From the social cognitive perspective, social recognition is critical to behaviour engagement for the enhancement of satisfaction, motivation and morale (Mone & London 2014). Most research on the effect of social recognition on change in behaviours has been carried out in the school and workplace context (Burke 2013). Social recognition leads to planned behaviours for the near future and results in maintaining or improving performance.

Health Interventions for Prediabetic and Diabetic Patients

Various strategies are followed in health interventions, in both public health and clinical care settings, including drug administration, vaccines, health education, behavioural change strategies and health management methods (Niccolai & Hansen 2015). There are two types of health interventions. The first is preventive interventions for prediabetic patients, which prevent the disease from occurring and thus reduce the incidence of the disease. Prior research shows that preventive interventions towards prediabetic patients can reduce incidence of diabetes in China by more than 40% (Pan et al. 1997). The second is therapeutic interventions for diabetic patients, which refer to treatment, mitigation or postponement of the disease. Diabetes may not be curable, but can be controlled by health interventions, such as a combination of education and behavioural change interventions, and long-term monitoring of

blood glucose (Smith et al. 2015). Long-term monitoring is a barrier to traditional health interventions, but is important for both preventive and therapeutic interventions for prediabetic and diabetic patients.

Health interventions based on mHealth technologies improve personal healthcare outcomes through positive behavioural change theories, especially when the interventions are modelled by SCT (McIntosh et al. 2017). Based on SCT, personalised feedback through mHealth technologies (generated by automatic learning algorithms) has proven beneficial for diabetic self-management and behavioural change (Yom-Tov et al. 2017). Another kind of feedback, social recognition, plays a key role of promoting desired behaviours and achieving performance improvement (Peterson & Luthans 2006).

In the self-management context, physicians cannot provide social recognition to patients in China, and since patients do not have the chance to constantly talk to physicians outside the hospital, they cannot report their involvement in health interventions to physicians. A health intervention system provides an opportunity for strengthening physician–patient communication. After prediabetic and diabetic patients are discharged from the hospital, physicians can observe the patients' health condition, communicate with patients, send them reminders and provide health interventions through mobile apps. This paper develops a health intervention mobile system for prediabetic and diabetic patients and their physicians. By using mobile apps, health interventions, such as health education, dietary guidance, physical activity advice, medication and glucose monitor reminders, can be advocated. This provides physicians the opportunity to manage their discharged patients and promote adherence to health interventions.

Hypotheses Development

Direct Effect of Social Recognition

Hypothesis H1 examines the impact of positive and negative recognition by physicians on adherence to health interventions through mHealth technologies. SCT suggests two types of recognition: positive and negative (Skinner 1937). We first focus on positive recognition offered by physicians to prediabetic and diabetic patients when the targeted behaviour is achieved and identified through the mobile platform. We anticipate that positive recognition will have a positive impact on heath intervention adherence through mHealth technologies, for three reasons.

First, positive recognition is based on empowerment (Mone et al. 2011) and the reduction of uncertainty regarding behaviour through the provision of a criterion of good performance. With positive recognition, people repeat the targeted behaviours. Health interventions through mHealth technologies require professional support from physicians. Prediabetic and diabetic patients usually do not have sufficient medical knowledge to regulate health intervention behaviours. When they receive positive recognition from a physician, their personal subjective uncertainty regarding mHealth interventions is anticipated to decrease, leading to the repetition of previous desired behaviours. Therefore, patients would achieve an improved adherence to mHealth interventions.

Second, positive recognition provides a predictive reward of personal attention from the individuals who provide the recognition (Brun & Dugas 2008). In mHealth, positive recognition confirms patients' current self-management behaviour, providing them with an expectation of desired health conditions in the near future. At the same time, physician attention to prediabetic and diabetic patients is valuable in the medical context in China. The physician's positive recognition may act as a social action in which his or her attention is transmitted to the patient, resulting in an improvement of self-satisfaction, and finally, continuous engagement in subsequent intervention behaviours.

Third, based on the evaluative component, positive recognition can satisfy patients' autonomy needs, motivating patients to achieve better performance (Mumm & Mutlu 2011). Taken together, we anticipate that positive recognition by physicians will exert a positive effect on patients' health intervention adherence.

H1a: A physician's positive recognition will enhance patients' heath intervention adherence through mHealth technologies.

When the targeted behaviour is not recognised, request messages are sent by physicians to prediabetic and diabetic patients until they make an effort to engage in health interventions and use the mobile

platform for an intervention report. Then, physicians apply negative recognition to encourage the intervention effort. We examine the impact of negative physician recognition on adherence to health interventions through mHealth technologies. We anticipate that negative recognition will have a positive impact on heath intervention adherence through mHealth technologies, for two reasons.

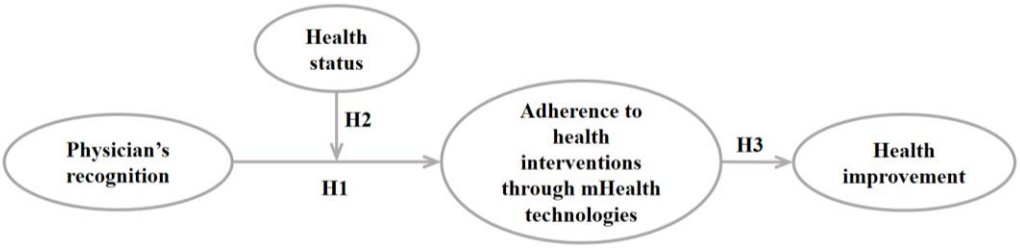

Figure 2. Research Model

First, the physician's negative recognition informs the patients of an unsatisfactory performance and emphasises the discrepancy between the desired and current behaviour (Burgers et al. 2015). Thus, negative recognition can convince patients to improve adherence to health interventions.

In addition, negative reinforcement can eliminate the unpleasant and stressful stimulus, resulting in enhanced behaviour (Fisher et al. 2005). Since patients do not like to receive pressing requests from the physician, they are anticipated to improve adherence. Hence, we hypothesise the following:

H1b: A physician's negative recognition will enhance patients' health intervention adherence through mHealth technologies.

Moderating Effect of Health Status

Health status describes the individual's relative level of wellbeing and illness. Patients' current health status can influence their feelings and beliefs about their future health condition, and affect the effectiveness of long-term health interventions (Martin et al. 2010).

Diabetes patients may doubt the efficacy of their treatment (Horne & Weinman 1999). Over time, many diabetic patients reduce their expectations for treatment from physicians, because they find that changing their health-related behaviour, such as dietary management and regular exercise, may not substantially enhance their health (American Diabetes Association 2016b). In contrast, prediabetic patients are motivated to take steps to prevent the development of diabetes, and thus, strictly follow physician recommendations. Thus, prediabetic people are more likely to adhere to health interventions through mHealth technologies when social recognition is applied than diabetic patients. We predict that diabetic patients are less influenced by physician positive/negative recognition than prediabetic patients.

H2a: An individual's health status moderates the effects of physician positive recognition on health interventions through mHealth technologies, such that the effect of physician positive recognition on health interventions is weaker for patients with a poorer health status.

H2b: An individual's health status moderates the effects of physician negative recognition on health interventions through mHealth technologies, such that the effect of physician negative recognition on health interventions is weaker for patients with a poorer health status.

Health Outcomes

Health interventions through mHealth technologies are effective in health condition monitoring, smoking cessation, dietary management and regular physical activity and maintaining or reducing blood glucose (McIntosh et al. 2017). When prediabetic and diabetic patients achieve good adherence to health interventions on the mHealth platform, they are likely to perform desired self-management behaviours and maintain their blood glucose at a relatively low level. Hence, we hypothesise as follows:

H3: Health intervention adherence levels of prediabetic and diabetic patients through mHealth technologies will have a negative impact on their blood glucose level.

Research Methodology

Experiment Setup

To test the above hypotheses, we cooperated with The Fourth Affiliated Hospital of Harbin Medical University (HMU) to conduct two field experiments. HMU is one of the top two medical universities in northeast China. The Fourth Affiliated Hospital of HMU is one of the top 100 hospitals in China, with 2,700 inpatient beds and more than 3,000 staff. In the experiment, physicians in this hospital will help to recruit prediabetic and diabetic patients, and conduct health interventions using mHealth applications. To collect data, we developed a mobile diabetes management application (APP). The APP will help the prediabetic and diabetic patients to manage their daily health conditions through self-report and follow the physician's request. Based on the real-time data, physicians can follow up with the prediabetic and diabetic patients after hospital discharge and send reminders to them. In the experiment, both prediabetic and diabetic patients will use this APP to watch health interventions videos, receive reminders from physicians, report daily physical activities and record their blood glucose levels.

In this research-in-progress, we outline the plan to conduct our experiment. The experiment will take place between June 2018 and November 2018. Prediabetic and diabetic patients who visit the hospital in the first three months will participate in the experiment. Physicians will ask them to use the APP functions as requested, then the APP will track each patient for the following 90 days. We plan to recruit 130 prediabetic patients and 150 diabetic patients, respectively.

Experiment Design and Procedures

We will implement a two (recognition type: positive vs negative) by two (health status: prediabetic vs diabetic) plus two (control groups using the mobile apps) experiment design.

Subjects are randomly assigned to positive vs negative recognition groups. Subjects in the positive recognition group will receive a reminder that their health-related behaviours have been recognised in the past week from the physician. Subjects in the negative recognition group will receive a reminder that their health-related behaviours have not been recognised in the past week from the physician. Both groups will receive the apps message one week after the health interventions. The message content of the positive and negative recognition groups is shown in Table 1. To increase the external validity of our findings, we do not manipulate health status (prediabetes vs diabetes). Instead, we will invite physicians to check each subject's blood glucose condition two days before the experiment. Subjects are assigned into prediabetic or diabetic groups based on the inspection results.

Table 1. Implementation Messages of Physician Positive and Negative Recognition Conditions

Condition	Implementation message content
Positive recognition	You did much better in physical activities last week than most patients on my list. Keep it up!
Negative recognition	You did much worse in physical activities last week than most patients on my list. Please exercise as requested!

The experiment procedures are as follows. The experiment will span 90 days. Before the experiment, subjects will be asked to take a blood glucose test to obtain initial blood glucose levels, and be informed to use the APP for self-management. On Day 1, subjects will be reminded to watch health intervention videos of health education and clinical case demonstrations through the APP. Several simple tests are designed under each video to check whether the health interventions have been performed. After that, physicians will send reminders of the common physical activity requirement of 20 minutes moderate intensity physical activity daily, and ask subjects to report blood glucose levels before breakfast and daily physical activities every day for the coming month. On Day 8, subjects will receive physician recognition based on their weekly physical activity performance. On Day 30 and Day 60, new health interventions are recommended, with repeated reminders and recognition. We will trace the activity and health condition data over the 90 days.

Expected Contributions

In this paper, we applied SCT to develop a theoretical model to explain the role of physician recognition of prediabetic or diabetic patients' health status that influence health intervention adherence through mobile technologies. We will empirically verify our model using a field experiment methodology.

This research will make a contribution to theory and practice on health interventions and mHealth applications. From a theoretical perspective, it will enrich the mHealth application literature, by selecting a special form of feedback from the working and school context. In addition, it introduces a disease-related factor to moderate the primary relationship. This research model is expected to provide a solid foundation for future studies on health interventions and mHealth applications. From a practical perspective, this research will highlight the role of physicians in health interventions through mHealth technologies, and guide the future design of mobile prediabetes and diabetes self-management.

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