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Impact of Mobile Diabetes Self-Care System on patients' knowledge, behavior and efficacy

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ABSTRACT

Evaluating the impact of emerging mobile technology on chronic disease management such as diabetes mellitus has been a persistent concern among healthcare professionals. However, most of the previous studies have focused on assessing metabolic outcomes, rather than changes in patients' self-care ability and practices, which have been found critical in properly managing the disease. The research team developed a system, called Mobile Diabetes Self-Care System, for people with diabetes, which facilitates the patients to enhance their self-care ability and practices with the flexibility of timing, location and choices. The study evaluates the system's effectiveness in patients' self-care knowledge, behavior and efficacy. Twenty-eight patients with type 2 diabetes participated in the six-week intervention. Questionnaires were used to measure their changes before and after the intervention. The results indicate that the mobile system enhanced the patient's self-care knowledge and behavior by 17% and 22%, respectively, with statistical significance, yet only marginally increased their self-efficacy. The majority of the participants have enjoyed using the system. Remarks on the biggest advantages of using the system include portability, convenience in maintaining and accessing personal records, and flexibility in learning necessary information. Integrating mobile technology with patient education and support services bears great potential in combating the global burden of chronic diseases.

1. Introduction

The prevalence of diabetes is increasing in most countries of the world. The number of global diabetes population changes dramatically from 171 million in 2000 to 366 million in 2011, according to the report of International Diabetes Federation [1]. The diabetes epidemic has largely exceeded previous prediction. WHO had estimated the population to reach 366 million in 2030 [2], yet a renewed estimation by International Diabetes Federation pronounced that the population will reach 552 million by 2030 [1]. In Asia, approximately one in ten adults suffers from such a disease [3]. Additionally, conditions accompanying to diabetes (e.g. kidney damage caused by diabetes) are frequent causes of poor quality of life and higher healthcare uses [4,5]. With the expanded number of patients, improving diabetes care to relieve burdens caused by the disease is widely viewed as a significant global concern [6–9]. In addition to medical interventions, government policies and healthcare programs have recommended educating patients to engage in self-care actively.

Explicit principles and appropriate strategies which enable the patients to better manage their diabetes would be required. The guideline on diabetes self-care education, AADE7™, announced by American Association of Diabetes Education (AADE) and endorsed by the American Diabetic Association, contains essential information for both diabetes educators and patients [10–12]. This guideline includes a set of daily activities such as healthy eating, active exercising, monitoring health conditions, medication taking, problem-solving and risks reduction [11,13]. Living up to the guideline to modify lifestyle requires many efforts, such as learning diabetes food exchange knowledge. Studies reported that patients did not adhere to recommendations rigidly [14,15]. Limited involvement in diabetes self-care is often caused by lack of knowledge, low confidence and feelings of helplessness [16]. Delays or failed access to needed care is another reason [17,18]. Clinical settings play a central role in offering diabetic services, but many of them over-emphasize on stabilizing metabolic status through medical interventions rather than patients' self-care ability enhancement [7,19]. An effective tool

Abbreviations: WHO, World Health Organization; AADE, American Association of Diabetes Education.

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or method to enhance patient's self-care ability is required. Use of information technologies would be helpful in reaching the objective [20,21].

Mobile technologies have matured to the point where healthcare services for chronic disease could be provided beyond hospital borders [22,23]. The usage of mobile-health (m-health) technologies has the potential to enhance a patient's self-care ability, thereby modify their lifestyles and improve metabolic conditions [23–28]. Despite of the fact that the benefits of m-health interventions for diabetic patients are well established, the impacts on diabetes self-care practices have not been extensively validated. Most m-health studies have emphasized on assessing clinical metabolic outcome, such as decreased level of HbA1C [29], rather than validating self-care processes from the patient's perspectives. Little is known about the effect of m-health on self-care processes [20,29–31]. Outcomes of self-care ability enhancement can be categorized as immediate (knowledge and skills acquisition), intermediate (behavioral change) and long term manifestation (improved health status) [7,11,12]. Studies have suggested adding focuses on identifying immediate and intermediate outcomes [7,29].

The purpose of this study is to assess the effects of the mobile-based interactive system, called Mobile Diabetes Self-Care System, developed by the research team. The effects are evaluated through three dimensions: (1) knowledge acquisition; (2) self-care behavior change, and (3) self-care efficacy.

2. The mobile support system

2.1. Mobile Diabetes Self-Care System design and development

The research team developed the Mobile Diabetes Self-Care System in supporting diabetes patients for their daily care. The system consists of a service center and a support application embedded in a mobile device. The processes of developing the Mobile Diabetes Self-Care System included (1) analyzing requirements, (2) designing a service framework, and (3) developing the Mobile Self-Care Support application.

The multidisciplinary research team consists of endocrinologists, a senior nurse, a diabetes educator, and informational technology developers. The research team firstly gathered information through extensive interviews with patients in a local community and a tertiary hospital with the questions of "how do you manage your diabetic conditions currently?", "what are the barriers to managing the conditions as you would expect?", "what may help you better manage the disease?" Though not necessarily a complete user story is collected for each user, the transcripts of the interviews were carefully analyzed and discussed among team members in developing the required functionality of the support care system. Analysis of the interview transcripts revealed that the patients encountered the following issues in self-care: (1) knowledge deficits or inaccurate information on diabetes care; (2) lack of easily accessible venues for disease management information; (3) perceived difficulty in controlling diabetes. For example, one female interviewee said, "*I do not know how to control diabetes. I cannot eat any food with sugar in it. Nurses have given me diabetes information sheets, but I lose these information sheets.*" Based on the interview results, the research team developed a system that characterizes three major features described below.

- A diabetes self-care knowledge base

  This knowledge base contains information as well as instructions on developing self-care skills. For example, indication of blood glucose levels and modification factors, dietary information and intake advises, foot care importance and complication risk management, etc. The system also provides quizzes that patients can self-test.
- An interactive system which facilitates the patients to manage their behavior

  The system is designed to facilitate the patients in managing their diabetic relevant conditions in a less intrusive approach, where the patients can acquire relevant knowledge or actionable advises without time and geographical constraints. The users could choose the path and set the speed of managing their own health with multiple options facilitated by the software system. The system acts as coach in facilitating the patients to reach their own goals. It actively monitors individual health status, and sends out reminders or appropriate advises timely. For example, as a patient logs his/her blood glucose level using the mobile device routinely, the system helps monitoring the trend and changes in blood glucose level. When a patient's blood glucose exceeds an alarming threshold, the system automatically creates a reminder message and recommends plans for the patient to act on.

  The system interacts with the users in a dynamic way. Options of exercise regimes are suggested pursuant to the dietary intakes recorded by the patient, and an interface is provided for logging exercise time for each chosen activity.
- An active and responsive consultation system

  Consultation services are provided by care managers at the service center upon patients' request. The database contains longitudinal and comprehensive records that provide abundant information for care managers to suggest behavioral adjustments for patients. The patients may call or send messages to the service center for any questions, concerns, or distresses encountered in self-care. The care managers provide not only instructions on knowledge and skills solicited by the patients, but also psychosocial supports for patients' reconciling diabetes conditions with daily lives. The care manager may be instructive in leading the patients navigating through the possibly rocky journey of self-care management, but not in a directive manner.

2.2. Framework of the Mobile Diabetes Self-Care System

The three major features are accomplished through integrating patient activities and care manager activities facilitated by the mobile Diabetes Self-Care System. Fig. 1 shows the overall framework of the system for individuals with diabetes.

The tasks that the patients and care-managers perform are described as follows.

Patient-side tasks are facilitated through a Mobile Self-Care Support application.

- Acquiring self-care knowledge and skills related to diabetes care.
- Recording personal activities relevant to diabetes care, such as, dietary intake (types and amount of food or beverages), exercises taken (type, strength, and duration of exercises), medicine intake (type, dosage and frequency of medications), foot care, and any relevant complications, on chosen devices (Internet connected smart-phone, tablet or desk-top computer).
- Relaying the above records through Internet to the service center.

Care manager-side tasks are facilitated by a service center.

- Monitoring metabolic variations as well as health conditions of the patient and alarming the patient if necessary.
- Sending alarm messages as well as advises to patients whose conditions have crossed the individually set threshold.
- Providing self-care consultation as well as psychosocial supports.