Enhanced Patient Self-efficacy and Behavioral Changes: Cloud-based mHealth Platform and Mobile App Service

Dyna Y.P. Chao1,2; Tom M.Y. Lin1, PhD; Wen-Ya Ma3, MD
1 School of Graduate Institute of Management, Taiwan University of Science and Technology, Taiwan (R.O.C.)
2 Department of Health Promotion Center, New Taipei City, Taiwan (R.O.C.)
3 Department of Medicine, Cardinal Tien Hospital, New Taipei City, Taiwan (R.O.C.)

Corresponding Author:
Dyna Y.P. Chao, Doctoral
National Taiwan University of Science and Technology
health inventor company
No.43, Sec. 4, Keelung Rd., Da’an Dist.
Taipei City 106
Taiwan (R.O.C.)
Phone: +886 917 508975
e-mail 1: d10316001@mail.ntust.edu.tw
e-mail 2: dynachao@m-healthi.com

Abstract

Background: The prevalence of chronic disease is rapidly increasing. Health promotion models have shifted toward to patient-centered care and self-efficacy. Devices and mobile applications in the Internet of things have become critical self-management tools for collecting and analyzing personal data to improve individual health outcomes. However, the precise effects of web-based interventions on self-efficacy and the related motivation factors behind individuals’ behavioral changes have not been determined.

Objective: The objective of this study was to use a mobile application to determine individualized health promotion interventions and to apply these interventions to improve patients’ self-management and self-efficacy outcomes.

Methods: The study used data from the eHealth database (n = 3,128). An experimental design (n = 121) and randomized controlled trials were employed to determine patient preferences in health promotion and self-management interventions. Mobile questionnaires were administered for pre- and post- intervention assessment through mobile application. A dynamic questionnaire allocation method was used to follow-up and monitor patient behavioral changes in the subsequent 6–12 months.

Result: Participants were excited about the individualized proactive health education initiative. The results indicate that overall compliance rate increased after the mobile-application-based health intervention.

Conclusion: Various intervention strategies based on patient characteristics, health-care-related word-of-mouth communication, and social media may be used to improve clinical outcomes. Future related studies should consider the effects of patients’ mental statuses on their interactions with the diabetes-education volunteers as well as the effects of volunteers’ training, public health education challenges, and institution scale.

KEYWORDS: diabetes; word-of-mouth; intervention; self-management; patient-physician engagement

Introduction

Financial Burden

Noncommunicable chronic diseases are not only a critical health problem but have also become a major economic burden in Asian populations. Globally, diabetes mellitus (DM) has been diagnosed in 415 million people, and DM and its complications are a global health emergency, accounting for 12% of global health expenditure [1]. The most survey revealed that 11.6% of adults in China (approximately 114 million people) have received DM diagnoses. DM prevalence has resulted in a substantial financial burden on medical systems, families, and societies. DM is more prevalent in older age groups and among people living in economically developed regions. Overall DM-related expenditure in 2013 was approximately 548 billion United States dollars (USD), accounting for 10.8% of total health expenditure worldwide. DM-related expenditure is expected to exceed 627 billion USD by 2035 [2,3].
Information Technology Transformation

Relieving patient burden has become a critical approach for improving patient self-management, and market demand has emerged for related innovations. The basis for many of the recommendations given to chronic disease patients is anecdotal. Evidence-based approaches must be developed. Researchers must assess the efficacy of medical strategies rather than focusing on patients’ failures to adhere to recommendations of questionable therapeutic value [4]. Effective healthcare management may not only prevent chronic disease complications but also reduce overall disease cost and family burden and improve patients’ quality of life [1,5-7].

Patient-centered Approaches

Despite advances in applications of information technology, most hospital services still mainly rely on clinical data and status from hospital records when administering services. This approach may be effective for managing the conditions of patients with acute diseases, but it is not effective for patients who must change their lifestyles to manage chronic diseases. Patient-centered approaches should be developed as new engagement models and as enhancements to existing models. These approaches should focus on improving clinical outcomes as well as patients’ self-management skills, wellness knowledge, and satisfaction with treatment [8–10].

A high-quality and effective health promotion plan should include information from numerous stand-alone hospital systems, such as electronic health records, electronic medical records, clinical management outcomes, patients’ body of information measurement records, and patients’ knowledge and psychosocial assessments [11,12]. Physicians and health educators lack an integrated information system that can be used to provide aggregated information tailored to patients’ clinical situations and lifestyles [13]. Thus, mobile apps, the Internet of things (IoT) [14-16], and other social tools for patient self-management and self-study may serve essential functions in health promotion strategies to improve clinical outcomes [10,17-19]. The aim of patient self-care initiatives is to increase patient knowledge about diseases, enhance positive attitudes, and encourage patients to engage in electronic word-of-mouth communication to motivate therapy partners [20]. Patients should be educated in nutrition, physical activity, self-monitoring of blood pressure and glucose, and medication use. Patients should also be able to monitor their overall health and determine suitable health practices for daily life through engagement with social activities and communities [21-24].

Methods

Research Design

In this study, we developed a cloud-based interactive healthcare management mobile application, interactive personalized management framework (IPMF), and adopted a platform as a service tier. The platform integrates and displays patient information on a 360-degree dashboard. The dashboard may be used to monitor patient health status and facilitate engagement with physicians. Interactive wellness education is also offered through the mobile-based application and cloud-based interactive service platform [18,25-27].

Figure 1: 360-degree health management dashboard displaying three-dimensional triaxial data analysis of IPMF (x: disease, y: level, z: IF)
In addition to genetic and environmental factors, patient behavior is a critical factor associated with chronic disease. The effectiveness of disease management depends not only on patients’ clinical status but also on their lifestyle, disease knowledge, health literacy, beliefs, cognitive state, behavior changes, and emotional state [28-32].

Studies have demonstrated that health educators and care managers must understand a patient’s disease literacy level, personal characteristics, and readiness for action to determine effective treatment [1,33]. Care providers should create a service environment that enables patients to adopt appropriate behavioral changes [34,35]. This study used a transtheoretical model to monitor patients’ behavioral changes during preintervention assessment, follow-up, and postintervention assessment periods [1,5].

Information technology and IoT measurement devices have become common means for supporting disease management and have been used to provide evidence-based health education tailored to individual patients [18,36]. In the developed system, the application programming interface (API) engine uses a three-dimensional analysis tool to aggregate individual patient data and health status. The X axis denotes disease type and indicates undiagnosed but high-risk and at-risk status, early diagnosed disease, self-perceived symptoms, and diagnosed disease. The Y axis denotes the severity of each symptom. Finally, the Z axis mainly displays the factors that may influence patients’ health in daily life, including family history, education, economic situation, lifestyle, and stress (see Figure 1).

The main focus of this study of the developed mobile app was to analyze patient lifestyles and compliance tendencies and to use a knowledge simulation platform to determine factors for improvement (see Figure 2). The factors assessed were patient self-management, self-education, self-monitoring, and efficacy of self-motivation. Analysis of these factors was used to improve clinical outcomes and to enhance patient–physician engagement [37–39].

**Self-management preference**

Patients exhibit individual preferences for self-care management, and these preferences influence overall compliance and clinical outcomes. Considering the heterogeneity of patients’ lifestyles, knowledge and feelings about diseases, states of action readiness, and risk conditions, this study hypothesized that care strategies based on individual preferences are critical to compliance with care recommendations.

**Intervention**

A personalized intervention and health education system may positively affect patients’ compliance in chronic disease self-management. The relation between compliance and health outcomes is complex. Thus, we designed an IPMF interactive system to observe the patient-insight factor. The second hypothesis in this study was that interventions using the IPMF interactive system would positively influence patient compliance.
**Influence factor**

Patient characteristics and wellness status may influence compliance. Studies of online services have indicated that demographic characteristics such as age, sex, education, and income affect patient acceptance of information technology applications. This study hypothesized that patient adherence depends on characteristics and wellness status according to individual disease progression.

**Recruitment**

The purpose of this research was to determine how patient insight might influence adherence to self-management recommendations. A pilot study focused on Asian people and was conducted to test the effectiveness of the IPMF and the mobile-based interactive results. In total, 121 patients signed consensuses to join the study. All participants were stratified according to age and sex and were then randomly assigned to a case or control group. Case group patients experienced the IPMF system when they revisited outpatient departments, and control group patients were provided with traditional care without information-technology- or mobile-app-system support.

Patients who had received DM diagnoses within the prior 3 months were invited to participate in the pilot group based on criteria of disease knowledge and self-management in DM patients. All patients provided informed consent and were interviewed by a professional team comprising a physician, health educator, and service consultant. All recruited patients were provided with regular clinical advice and medication.

The pilot study was performed over a 6–12-month period. To integrate the intervention into the wellness service flow, the interactive mobile applications were provided to the participants through a mobile tablet while they were waiting to see a doctor or health educator. Mobile tablets, such as iPads and smart phones, also served as supporting tools for physicians and health educators to access patients’ integrated information. Patient compliance data were collected through the interface of the IPMF as the patient entered the pilot start phase for preintervention assessment and the closure phase 6-9 months later for postintervention assessment. The patient self-assessment score was a taxonomy reference. The behaviors outlined in the American Association of Diabetes Educators (AADE) 7 Self-Care Behaviors™ program [10,34,40] were used as indicators. These behaviors comprise healthy eating, being active, blood-glucose and blood-pressure monitoring, medication
use, problem-solving, use of healthy coping strategies, and risk reduction.

Patient demographic data that were relevant to health promotion factors were provided by the hospitals providing care and inputted into the IPMF. Participants then received interventional DM education about the AADE7. Physicians and health educators conducted educational interventions according to patient’s interests and specific requirements to enhance their self-management abilities. The interactive mobile physician dashboard system improved patients’ willingness to engage in continual health education.

Application Design Framework

The proposed framework was used to construct a service platform for DM education to integrate the collected information and serve as a pilot environment for testing patient learning behavior. The developed framework may be used to help physicians and health educators understand patients’ specific needs and areas for improvement. The IPMF model not only aggregates information from clinical databases but also involves a questionnaire generation mechanism and knowledge bank feature for collecting information regarding patients’ DM literature, DM-related beliefs and emotions, diet, glucose self-monitoring, and the influence of disease on patient productivity (see Figure 3).

Figure 3: Prescreening and self-assessment correlation map

Data Collection

Interactive patient assessment system (mobile app, iPad)

In the pilot study, patients’ health status, lifestyle and treatment preferences were collected. Pre- and post- intervention assessments were conducted. Patient feedback was stored in a cloud-based IPMF platform and was used to determine factors that contributed to sustainable behavior changes.

Patient readiness evaluation system (mobile app, iPad)

As described, the AADE7 Self-Care Behaviors™ are critical to DM management.

Thus, in the study, the system collected the information of patients with type 2 DM regarding healthy eating, physical activity, blood-glucose and blood-pressure monitoring, medication use, problem-solving, risk reduction, and use of healthy coping strategies. The collected information was used to evaluate patient mental readiness regarding DM management. After the readiness evaluation, patient score and disease level were transmitted to a physician dashboard for the next intervention stage.
**Interactive physician dashboard system (mobile app, iPad)**

Patient clinical status, results from patient assessment, and readiness evaluation systems were presented on a physician dashboard. Patients interacted with the dashboard, and the system suggested an individualized education program based on evaluation results and patient lifestyle and preferences. Physicians and health educators used the comprehensive dashboard, wellness articles, and self-assessment tools to engage with patients. The dashboard tool illustrated the correlation between disease progression patient’s self-efficacy (see Figure 4).

Figure 4: Self-evaluation app screenshot (mobile device and iPad)

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**Statistical Methods**

The patient intervention activity and integrated data were recorded in the physician dashboard system. Data were analyzed using IBM SPSS Statistics version 19.0. A paired t test was used for pre- and post-intervention assessment analysis, and the t test and chi square test were used for group comparisons.

**Results**

**Descriptive Statistics**

In total, 121 patients (n = 121) were enrolled in the study. The case group included 62 participants (case group, n = 62; control group, n = 59), and these patients completed 305 intervention interactions (n = 62, interactive times = 305) by using the IPMF. After 6–9 months of intervention, 58 patients completed postintervention assessments. An additional 59 participants were then assigned to the case group. Patients were free to choose categories of DM self-management according to their interests. As described, the seven categories featured in the IPMF were healthy eating, physical activity, blood-glucose and blood-pressure monitoring, medication use, problem-solving, risk reduction, and use of healthy coping strategies. Of the 305 of interventions, healthy eating was selected 98 times, and thus was the most-selected category (see Figure 5).

The demographic characteristics of case group patients who finished the behavioral education course and completed postintervention assessments (n = 28) are listed in Table 1.
The average age was 63.71 years, and the age range was 37–88 years. Among participants who completed postintervention assessments, 60% were over 60 years old. This finding demonstrates that age was not a barrier in mobile device usage. In addition, education level was not a barrier to using a mobile device (such as an iPad) for wellness education. Among the participants, 79.5% reported a high school education level. Compliance frequency from pre- and postintervention-assessments were compared to analyze the effects of the IPMF intervention. The results indicate that patients’ average compliance frequencies for diet, exercise, blood-sugar monitoring, blood-pressure monitoring, and use of healthy coping strategies increased after intervention (see Table 2), and the changes in dietary compliance reached statistical significance.

In total, 42.8% of participants exhibited dietary compliance improvement. Based on the compliance changes, 28 participants were then divided into an improved group (patients who exhibited improved compliance after the pilot) and an unchanged group (patients whose compliance was unchanged or decreased) for comparison. The improved group contained a higher number of patients who experienced diet-related intervention through the IPMF than the unchanged group (47.4% vs 33.3%; see Figure 6). This finding indicates that the intervention stimulated behavior changes in participants with greater interest in healthy-diet-related behaviors.

Patient characteristics that affected diet-related behavioral changes were also investigated. The results indicate that patients with higher systolic blood pressure, higher diastolic blood pressure, higher body mass index (BMI), and who were younger exhibited positive changes in dietary compliance (see Table 3). This finding demonstrates that patients with worse health indicators (blood pressure and BMI) were likely to change their behaviors. Hence, the IPMF system may be particularly helpful for type 2 DM patients with hypertension or who are overweight. The dietary-compliance-improved-group also exhibited significantly lower preintervention assessment dietary compliance and younger age than the unchanged group. Patients with low levels of wellness recognized in the preintervention assessment stage may have been more motivated to improve by the postintervention assessment stage. In particular, the younger-aged patients may have been more readily motivated to change their lifestyles to prevent disease progression.

The majority of the patients in the improved group were women (58.3%), and the unchanged group comprised only 25% women (see Table 4). This result implies that an interactive tool, like the IPMF education system, may be especially effective for women. The study results indicate that other surveyed health behaviors, including smoking status and drinking status, did not affect dietary compliance.

Mobile phones are increasingly prevalent, but only 28.6% of participants owned a smartphone. This low smartphone ownership may have been correlated with average participant age, which was 63.71 years. However, the participants were willing to join and complete the study regardless of whether they owned smartphones, indicating that older patients can benefit from IoT resources.

Discussion

Conclusion

The study results indicate that overall patient compliance rate increased after the IPMF-based educational intervention. The IPMF system was developed based on critical factors that affect patients’ levels of self-awareness and involved personalized education and care plans. In this study, the system enhanced patient compliance related to self-management of DM; 42.8% of participants improved in dietary compliance. Thus, the IPMF may be useful for a wide population when deployed on the market.
The use of IPMF to improve patient compliance may help control health insurance costs and enable hospitals to establish stable customer relationships and retain patients. In addition, this study demonstrated that women and patients with worse health indicators are more likely to exhibit behavioral changes after IPMF intervention. The findings also suggested older patients and patients who report low technology use to not experience barriers when receiving healthcare services through mobile technology. The personalized interactive education approach used in this study improved overall compliance with recommended health behaviors.

In conclusion, health recommendation compliance can be improved when a care team uses individual data to understand patients’ specific needs and requirements and
offers encouragement and recommendations for health behavior changes accordingly.

This study also found that clinical outcomes in follow-up were improved after the IPMF intervention, indicating that organized information collection and delivery helped patients execute their care plans. Based on the results of this study, the IPMF system will be revised and redeployed in the near future, targeting the Asian market, and further evidence will be gathered to validate the effects of its use in health care management.
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Reference

Abbreviations
AADE7: American Association of Diabetes Educators
Self-Care Behaviors™
IPMF: interactive personalized management framework