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Importance of Mobile Technology in Successful Adoption and Sustainability of a Chronic Disease Support System

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***Abstract*—**Self-management is becoming a new emphasis for healthcare systems around the world. But there are many different problems with adoption of new health-related intervention systems. The situation is even more complicated for chronically ill patients with disabilities, illiteracy, and impairment in judgment in addition to their conditions, or having multiple co-morbidities. Providing online decision support to manage patient health and to provide better support for chronically ill patients is a new way of dealing with chronic disease management. In this study, the importance of mobile technology through an m-Health system that supports self-management interventions including the care provider, family and social support, education and training, decision support, recreation, and ongoing patient motivation to promote adherence and sustainability of the intervention are discussed. A proposed theoretical model for adoption and sustainability of system use is developed, based on UTAUT2 and IS Continuance of Use models, both of which have been pre-validated through longitudinal studies. The objective of this paper is to show the importance of using mobile technology in adoption and sustainability of use of an m-Health system which will result in commercially sustainable self-management support for chronically ill patients.

***Keywords*—**M-health, e-health, self-management, disease.

I. Introduction

With the recent boom of information and communication technologies (ICT), m-Health has become an attractive application area. The abundance of smart phones, tablets and similar communication technologies have provided potential in a variety of areas in healthcare for many different functions, such as: real-time monitoring of patient vital signs; delivery of healthcare information to clinicians, collecting health data, direct provision of care, performing more accurate and effective research on patient care improvements, etc. [1].

Among these applications, patient self-management seems to have considerable promise. For example, chronic disease care accounts for over 40% of Canadian healthcare expenditure in direct medical care costs [2]. Therefore, shifting more care responsibility to the patients themselves has become a major consideration in controlling healthcare costs. Self-management is a collaborative care approach that empowers patients to manage their own chronic illnesses, through support by mobile technology, or m-health. If this approach is to be successful, its integration with support from the patient's circle of care (family, physicians, nurses, specialists) and the healthcare provider organization is vital [3].

Self-management's major goal is to improve patient quality of life as well as health status and health behavior, in a normal setting such as the patient's home [4]. Successful implementation of a self-management project can result in less utilization of healthcare system resources [4], achieving a major goal of reducing cost of care. However, there are some important technological as well as human factors that may complicate this process [5]. Further, sustainability in usage is another important factor in any m-Health project. Based on several reports [6]-[9], an m-Health project should have specific standards for accessibility (the degree to which the system is available and easy to access by patients, often through assistive technology), trust levels, and sponsorship (adoption by major healthcare organizations) to provide support and to ensure sustainability.

Although cost reduction is very important in successful commercialization of any type of m-Health project, its ultimate success depends upon successful adoption and sustained use of the system by patients. Therefore, the major research question to be answered is: "what are the influential factors in the successful adoption and sustainability of an m-Health project?" In this paper, we define health self-management and its related tasks and interventions in more depth. Then we explore the potential obstacles and other factors that are important in the successful adoption and continuance of use of an m-Health system. Further, we also discuss the importance of the use of mobile technology in overcoming these obstacles and eventually supporting system sustainability.

II. Patient Health Self-Management

Patient health self-management is a complex task that has four internal components [3]: 1) Self-monitoring, 2) Self-care, 3) Adherence and 4) Decision Support. Each of these components has a vital role in achieving the goals of self-management. Further, there are three external components that help patients in a supportive and sustainable manner, including: 1) Family and community support, 2) Education and training and 3) Sustainability elements (Entertainment, social network, etc.).

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III. Internal Components

A. Self-Management

Self-management, which is important for both disease prevention and disease management, is a cognitive process, as it includes recognition and evaluation of the importance/significance of changes in conditions/symptoms, and the implementation of any required adjustments to treatment [10]. Nevertheless, the process depends on patient decision-making and judgment, which needs to be supported by education, access to healthcare professionals, and adjustments to actions, according to an acquired skill set and feedback from the system [11].

B. Self-Care

Riegel et al. [12] defined self-care as "a naturalistic decision-making process that patients use in the choice of behaviors that maintain physiological stability (symptom monitoring and treatment adherence) and the response to symptoms when they occur." Self-care includes the following inter-related behaviors: Complying with prescribed medication and non-prescribed (e.g. herbal) remedies, symptom monitoring, dietary adherence, alcohol restriction and smoking cessation, exercise and weight loss and preventive behavior (e.g. oral and body hygiene) [12].

C. Self-Monitoring

In general, self-monitoring can be defined in the context of decision support, as the continuous and ongoing assessment and monitoring of the symptoms of a certain condition (problem or disease), as well as other important factors (such as weight, sleep, etc.) at any place other than a clinic (e.g., home, workplace, etc.) by patients or their care partners (possibly a family member) [13].

D. Adherence

Adherence refers to a specific behavior of patients who accept and follow special treatment regimens ordered and prescribed by their physicians. For many chronic illnesses, the level of adherence usually declines from the time when an initial regimen is prescribed. Moreover, it has been found that close to half of all patients will not continue with their prescribed regimens beyond a year [14]. According to [15], the probable causes of non-adherence are: complexity of treatment, lack of patient self-efficacy, lack of social support, lack of disease knowledge, availability of treatment alternatives, costs, side-effects, disruption of patient lifestyle.

E. Decision Support

Health self-management could be assisted by patient support through a decision support system. A decision support system (DSS) assists patients in decision-making activities by compiling useful information based on raw data, treatment guidelines, acceptable ranges for patient vital signs (heart rate, blood pressure, blood sugar, etc.) and other status indicators (body weight, etc.). It also provides knowledge regarding the specific problem or set of related problems, which eventually helps patients to make better decisions [16].

IV. External Components

A. Family & Community Support

The patient's family can influence the course of a disease in several ways. For example, through direct help with patient self-care and disease management, which can improve the patient's psychological and emotional well-being [17]. Active involvement of at least one family member in the disease management and treatment process can be the key to achieving successful psychosocial intervention [17].

Furthermore, community support (relatives, friends, etc.) can also be an important factor in providing help and support for chronically ill patients. From a study of 22 quantitative and 7 qualitative journal articles examining the relationship between social community support and the well-being of chronically ill patients, community support seemed to have a modest positive relationship with chronic illness self-management [18]. Patient dietary behaviors were especially subject to change under the influence of the patient's social network [18].

B. Education & Training

A direct relationship has been found between a person's current health status and awareness, health literacy, and his/her ongoing and related decision-making. In particular, increased awareness of the complications of a health problem is related to improved decision-making [19], especially in cases of chronic disease [20].

C. Sustainability Elements

Sustainability, as defined by Loman et al. [21] is: "the continued implementation of a practice at a level of fidelity that continues to produce intended benefits," therefore becoming a desired goal for successful interventions. Unfortunately, the growing burden of chronic illnesses threatens the sustainability of healthcare systems everywhere. Therefore, a new approach to improve the continuous delivery of primary care services for chronic diseases and ensure the sustainability of care is needed [22].

According to different studies [22], [23], the role of nurse practitioners as well as the use of Chronic Care Model (CCM) could have beneficial effects on processes of care and clinical outcomes. Furthermore, a recent study [24] provides eight themes in the two categories of barriers and facilitators, as well as some recommendations: Barriers: 1) patient concerns about use of medication, 2) provider concerns about use of psychotherapy, 3) increased workload for clinic staff, 4) delay in receiving outcomes data, and 5) lack of resources to sustain the program. Facilitators: 1) patient benefits: improved clinical outcomes, quality of care received, access and satisfaction; 2) provider benefits: increased awareness and reduced anxiety, and 3) clinical benefits in the form of reduced costs of care. Recommendations: 1) changes in communication patterns among providers, 2) specific changes in procedures, 3) changes in resources, and 4) changes in clinic organizational cultures.

In the current study, special attention is paid to the use of CCM, nurse practitioners, community support, family care

partner support, educational & training tools and programs to ensure adherence and sustainability. The barriers and facilitators of sustainability (discussed above) are also taken into account. Attention is given to the motivation of patients to continue adherence to their treatment plans. Three new components: social media, recreational games and simulations, and reward systems, are especially designed to increase the motivation of patients to adopt and to continue using health self-management.

1. Online Social Networks

Research shows that at the end of 2010, almost three quarter of Americans used the Internet on a daily basis and, among the applications used, after e-mail and search engines, the most popular online activity for adults was using social media and searching for health related information on the Internet [25]. Therefore, using social media as a channel for health promotion seems to be promising.

2. Entertainment Components

Games and simulations can have positive learning and motivational outcomes in various situations. The knowledge and skills developed by learners in these circumstances include the development of the learner's capacity to refer to concepts, definitions, and theories acquired beforehand and to apply them to concrete situations during simulations. Simulation tends to support the consolidation of knowledge through repetition and variability of actions [26]. There are several success stories in the design and implementation of serious games [27]. Further, in the case of patient motivation, if game play is self-motivating and successful, it promotes the achievement of specific learning and recreational outcomes [28].

3. Patient Reward System

According to several different studies [29]-[31] rewards and incentives provide a strong motivation for behavior change. Financial reward on the other hand is even more effective in that sense. Therefore, a type of reward system is incorporated into our proposed system in order to provide real financial incentives for the patients. Patients will collect points by regularly using the system and these points will be converted to gift cards, movie theater tickets, etc. when they reach a certain limit.

V. Adoption & Continuance of Use

The technology acceptance model has been continuously studied and expanded during the past decades and newer versions of TAM (including TAM 2 [32], the Unified Theory of Acceptance and Use of Technology or UTAUT [33] and TAM 3 [34]), each of which proves the effectiveness of the two major determinants "Perceived Ease of Use" and "Perceived Usefulness" in predicting the acceptance and use of a new technology. In UTAUT, social influence and facilitating conditions are other factors that could influence the adoption and use of a new technology where age, gender and experience of the users may be moderators of these influential factors [33]. After a longitudinal study on the various factors and variables that influence user adoption and use of a new technology, Venkatesh et al. [35] recently introduced an extended version of Unified Theory of Acceptance and Use of Technology (UTAUT2) by adding three important constructs (hedonic motivation, price value and habit) to the original UTAUT constructs (performance expectancy, effort expectancy, social influence and facilitating conditions). UTAUT2 has also inherited all three moderator variables (age, gender and experience) from the original UTAUT. Research has found that such hedonic motivation directly influences technology acceptance and use and is an important determinant in this context. Therefore, it is important that hedonic motivation be considered as a predictor of user intention to use a new technology [35].

Since sustainability elements in our proposed research have a strong role in stimulating hedonic motivation to keep using the system, it seems reasonable to adapt the UTAUT2 model as a basis for our research. Further, The UTAUT2 model has been tested in a longitudinal empirical study of an information system and proven to be a robust predictor of initial adoption as well as usage continuance behavior [35]. Thus, using the UTAUT2 model as a predictor of adoption and continuance of use for our proposed system seems to be justified.

On the other hand, while perceived ease of use (effort expectancy) and perceived usefulness (performance expectancy) appear to be strong predictors in initial acceptance of an information system [36], user satisfaction is stronger than these factors in the Continuance Of Use model, although all three are still important factors in predicting satisfaction itself [37]. Further, initial acceptance attitude is based mostly on cognitive beliefs (e.g. ease of use, usefulness) which are potentially formed through second-hand information from media, friends or other sources that could be biased and therefore, uncertain, unrealistic or inaccurate. However, post-acceptance satisfaction and continuous usage intention is grounded in first-hand experience with the information system [37]. As a result, both cognitive beliefs and satisfaction should be taken into account when studying pre- and post-acceptance of an information system.

UTAUT2 is missing the important constructs of confirmation and satisfaction. However, IS Continuance Use model includes both of these constructs. Since the intention of this study is to test whether users continue to use the system over a long period of time after initial acceptance, it is common sense to consider both the "IS Continuance Intention" construct in the IS Continuance Use Model [37] and "Behavioral Intention" in the UTAUT2 Model [35] as equivalents. Further, as Venkatesh et al. (2003) explained, both "perceived usefulness" and "performance expectancy" constructs are equivalent in nature [33]. Therefore, we have two tested models in hand and it seems reasonable to combine these two models for the purpose of our research.

The UTAUT2 and IS Continuance Use Intention models both include the performance expectancy (perceived usefulness) construct, but what is missing in both models are factors which direct influence the performance expectancy

construct itself. UTAUT and its related predecessors (TAM, etc.) have been applied to a large number of technologies in various settings with successful results [38]. UTAUT2 is related to UTAUT but was through a longitudinal study. It helps to explain that what leads to the adoption of a new technology are the beliefs about performance of the new technology as well as the effort users need to adopt and use the system. [35], [38].

Brown et al. (2010) have shown that UTAUT model as a whole could be a moderator between user beliefs and actual use behavior. They developed a validated framework that relates some constructs that are believed to influence user beliefs as the antecedents of the key constructs (Performance Expectancy, Effort Expectancy, etc.) of the UTAUT model [38]. Since UTAUT2 is not dramatically different from its predecessor (UTAUT), we can infer that the Brown et al. (2010) approach is also valid with the UTAUT2. In our proposal, what would be expected to influence these beliefs is a set of facilitators provided by our proposed system.

Those facilitators are divided into two categories: Support Elements and Sustainability Elements. The first category, "Support Elements", includes care provider support, decision support, family and community support and education and training [28]. All of these major factors influence the perceived usefulness of the system in some way. They also affect user satisfaction with the system indirectly. The second category, "Sustainability Elements", includes online social network and entertainment components (e.g. entertaining videos, games, etc.). These factors affect the hedonic motivation of the users to continue using the system. Fig. 1 demonstrates the full framework of our proposed system. Using this approach, we have an opportunity to test and validate the full model, including those facilitators that are believed to influence the users in the sense of performance expectancy as well as hedonic motivation. Patient-specific data such as Age, Gender and Experience will be collected and used to test whether these measures moderate any of the linkages between other model constructs.

The main sustainability hypothesis in this research is that continuing education and recreational simulations, combined with decision support to provide feedback to patients that monitor their status regularly, can be a significant factor in successful chronic disease self-management and its long term sustainability. It is expected that positive results of this nature would be useful to healthcare system policy makers by demonstrating a significant impact on healthcare through improved self-care and management of patient chronic diseases, better communication among healthcare team members, reduced need for family physician appointments, reduced hospitalization and emergency room visits for patients, as well as improved cost-effectiveness of the healthcare system.

VI. Discussion

In this study, the essential elements of a comprehensive and effective self-management support system such as family and social support, education and training, decision support, recreation and ongoing patient motivation have been reviewed. A theoretical framework was presented for the initial adoption and then continuance of use (sustainability) for the chronic disease care system that fully supports self-management. The self-management system is an example of an m-Health project that could support chronically ill patients in their regular self-management tasks and daily healthcare decision making. It can also be used by patients for preventive care to maintain their health and mitigate the risks of developing an illness, through education, recreation, monitoring, feedback, decision support, communication, and mutual support within the patient's circle of care (patient, care partner and physician) and others with similar interests and problems (social network).

However, in order to be able to implement those mentioned elements (interventions), the need for mobile technology reveals itself, since it would be very difficult to implement these self-management interventions without the use of mobile technology. According to a study in 2001 [39]: "behavioral and social interventions offer great promise to reduce disease morbidity and mortality, but as yet their potential to improve the public's health has been relatively poorly tapped". The reason was that, at the time, Information and Communication technology wasn't as conveniently available to individuals as it is today [39]. Also, the claim is further confirmed by another study on mobile intervention for obesity which studied the trends of relevant communications and computing technologies (mobile technology such as smart phones, tablets, PDAs, etc.) and argued that proper use of these technologies, and the easy reach and mass customization and interactivity that these technologies provide, builds an effective tool for population-level tailored interventions and care for obesity in particular, and chronic disease in general [40].

Finally, at least one other study has shown that mobile technology can be effectively implemented to intervene in a variety of health, physiological and psychological conditions and symptoms [41]. Therefore, Information and Communication Technology in general and Mobile Technology (e.g. smart phones, tablets, PDAs, etc.) in particular seem to be promising as effective interventions for various types of chronic disease. Eventually, the success in adoption and sustainability of use of any m-Health project will result in both higher patient quality of life as well as commercial sustainability of the system in the long run. Of course, the theoretical model presented here must first be validated through a full Randomized Control Trial involving a comparison of results from patients with usual care and patient users of the intervention being studied.

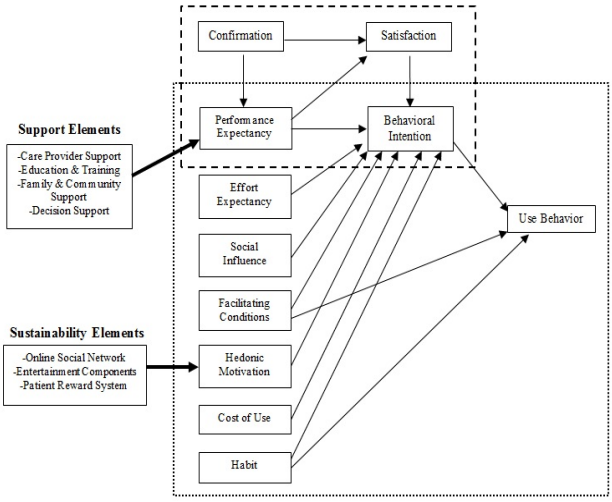

Fig. 1 Proposed framework for a chronic care self-management system

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