Requirements and Design Strategies of Chronic Disease Mobile Applications

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ABSTRACT

Despite the huge amount of currently available chronic disease applications, the functionalities offered are limited and do not capture the real users' requirements. Patients and physicians should be directly involved in the application development to tackle the lack of usability and users' requirements especially for the chronic illness target group. Even though, the use of mobile applications to monitor health and chronic health conditions is gaining popularity but their effectiveness in managing disease is still lacking. Consequently, such applications are usually being misused or underutilized, which lead to the failure of meeting the development objective. Nevertheless, it is believed that the future of the mobile health applications development is presumably optimistic. Therefore, the objective of this study is to identify the related requirements and design strategies which are often neglected while designing the chronic disease mobile applications. A systematic literature review (SLR) has been conducted based on 60 journal and conference proceeding articles from various established journal and conferences proceeding such as IEEE, ACM, Science Direct, JMIR and other established medical journals. To strengthen the findings form the SLR, real users were also interviewed to ensure the usability and requirements of the chronic disease applications follow accordingly to the users' needs. The merging of these two strategies helps to determine the usability dimensions which provide the basis for developing a usability evaluation model as the next part of this study.

Keywords: Usability, requirements, chronic disease, mobile health, mobile applications.

I INTRODUCTION

Mobile health (m-health) is rapidly expanding, as of 2015, more than 165,000 m-health applications were available on the Apple iTunes and Android Application store, and 34% of mobile phone owners had at least one health application on their mobile device (Jake-Schoffman et al., 2017). Although not all users know about the usability and efficacy of most of the commercially available applications, it is estimated that 60% of the world population is due to die because of chronic disease (Park et al., 2016). Chronic diseases can be defined as long-term medical conditions that are usually progressive. Some examples of chronic diseases include heart disease, diabetes, cancer, stroke, hypertension and chronic respiratory problems (e.g. COPD). Chronic diseases are also the main reason for impulsive adult deaths in various parts of the world. The prevalence of chronic diseases due to poor health behaviors is a significant challenge for the world and is associated with increased cost of treatment and management. In the United States, 75% of healthcare expenses are spent on the individuals suffering from chronic conditions. Moreover, 60% of global healthcare expenditure is spent on patients with chronic diseases and has the possibility to reach up to 80% by the end of 2020. The increase in chronic diseases necessitates the prioritization of strategies development in enhancing the care for patients suffering from chronic conditions (Parmanto et al., 2013). Patients with low income and older age show more interest in using m-health to manage chronic disease (Ramirez et al., 2016). According to research guidance, the biggest market in the next five years for mobile health applications would be diabetics, followed by hypertension, obesity, chronic obstructive pulmonary disease (COPD) and coronary illness (Jahns, 2015).

However, many applications still do not gain much popularity among patients may be due to the failure in meeting their expectations. Previous studies agreed that although the specific applications can provide many benefits, users' satisfaction for the interface usability might be an effect for the less popularity (Harrison et al., 2013). Technical and social obstacles need to be overcome before m-health applications can exert a positive impact on a larger scale (de Bruin et al., 2015). These need to be addressed to bridge the gaps in justifying the advantages of mobile applications for patients suffering from chronic disease. Moreover, m-health devices are not only for the improvement of diagnosis and treatment but also provide the social communication between patients and healthcare providers (Lee et al., 2018). However, current literatures highlight that m-health approach shows inconsistent results for health improvement, whereby some studies indicate that the application is

potentially effective in chronic disease management, whereas others do not obtain supportive results.

Areas that need to be studied include the optimum length of time and frequency of the m-health delivery system as well as type of technology and training. For example, effective frequencies of automated reminders or coaching messages, when additional reminders should be sent, and when people become tired or irritated by automated messages need to be studied. Users of m-health might experience fatigue from automated reminders and eventually the applications could become ineffective. Yet little work has been done to create a rigorous and standardized process to design the m-health applications. It is important to engage patients in the use of the technology that can best be achieved through the design strategies that are perceived as easy to use and useful. Moreover, if the users' requirements are not met, the m-health applications will be misused or underutilized and ultimately fail to meet the initial objectives (Schnall et al., 2016). Therefore, the relationship between the m-health applications requirements in enhancing the engagement of users to the m-health tools and design strategies for outcome improvement need to be discussed. Despite all that, mobile applications are becoming increasingly popular and approaching mainstream status around the world (Coursaris & Kim, 2011).

II MOBILE APPLICATIONS FOR CHRONIC DISEASE

Chronic disease applications are increasing as many health workers and clinicians already embraced smartphones in their extensive and diverse practices. On the other hand, the developing world is still burdened with 80% of deaths due to cardiovascular disease and diabetes mellitus, 90% are attributable to chronic obstructive pulmonary disease and cancer, while many are suffering from hypertension and arthritism (Cole-Lewis & Kershaw, 2010).

Chronic disease mobile health applications can be used for the long-term prevention and management of the disease (Lacerda et al., 2014) and provide solutions such as uninterrupted access to health facilities independent of place and time (Silva et al., 2015). As the first step in conducting the SLR, the most downloaded applications from the Apple Application and Google Play Stores were identified. Apart from ratings, the Google Play Store provides information about the number of downloads as another indicator of the applications' popularity. Since this information is not provided by the Apple Application Store, the comparison of the two operating systems was not possible. However, the difference of the two systems has been shown through the number of downloads that correlate with the number of ratings and awarded stars. All the available information given by both stores were considered in identifying the requirements of the novel applications. However, there is no admission requirement currently exists for the newly-developed applications for Google Play store, whereas the IOS application is internally reviewed by a review board before publishing on the Applications Store.

Table 1. Most Downloaded Chronic Disease Applications On Google Play Store

Application	Usage	Category	Total Downloads
Diabetes: M	Diabetes management	Medical	100,000 - 500,000
Blood Pressure (BP) Watch	Manages and tracks blood pressure	Medical	1,000,000 - 5,000,000
Early Detection Plan	Help to detect and manage chronic diseases	Medical	415
Care Zone	Self–tracking and manages medication	Medical	13862
Blood Pressure	Manages blood level	Medical	25,555

Table 2. Most Downloaded Chronic Disease Applications On Google Play Store

Application	Usage	Category
Diabetes Applications Lite	Controls and tracks blood sugar	Medical
Blood Pressure Companion Free	Manages blood level and tracks progress	Medical
Medscape By WebMD	Looks up for medications and dosages, information for patient care	Medical
Heart Decide	Patient engagement platform and enhance patient's understanding.	Medical

Table 1 and 2 list the most downloaded applications for most prevalent chronic disease such as diabetics

and high blood pressure provided on the Google Play and Apple Stores.

In the literature, it is mentioned that chronic disease mobile health applications help to improve patient–provider communication and assist in disease management. Individual chronic patients can improve their life quality, self-efficacy and medication adherence by using the personal health applications (Johnson et al., 2015). The use of the m-health platform on a routine basis is acceptable and feasible to people with chronic disease for medicine intake, daily symptoms reporting, oxygen saturation measurement and pulse rate detection. Majority of the patients have access to the self-management plans, video clips and messages for respiratory nursing through the m-health applications (Hardinge et al., 2015). The leading principle of health intervention is to change patient behavior by focusing on goal setting, self-monitoring and feedback (van der Weegen et al., 2013).

According to the study of the Institute for Healthcare Informatics (IMS) by Aitken and Gauntlett (2013), the figure of m-health applications crosses more than 100,000 if added the Google Play Store and other platforms (Molina-Recio et al., 2015; Xu & Liu, 2015). There are thousands of applications related to cardiology which include tracking of blood pressure, interpreting ECG and monitoring heart rate using external devices. However, only a few of these cardiac applications guides heart transplant patients on how to manage cardiac conditions. Research shows that work on medical applications has uneven distribution. Despite the fact of the significant contribution, these applications focus heavily on few areas while ignoring the others (Martínez-Pérez, De La Torre-Díez, López-Coronado, et al., 2013). There are some enhanced m-health applications to manage various chronic diseases, like hypertension, strokes, and diabetes; educate about health care data; collect clear information and make centralized storage available to professional physician caregivers. However, a study done in 2014 found that out of the 656 diabetic applications analyzed, only 355 offered just one function and the number of functions that were significantly negative correlated with usability. Therefore, it is necessary to consider the requirements of the chronic disease patients in developing a novel application.

III METHODOLOGY

This paper provides a guideline to identify relevant and appropriate journal/conference proceeding articles to identify strategies and requirements for chronic disease m-health applications using the systematic literature review (SLR) by Kitchenham (2009). The SLR is an approach mainly used to repeat the existing evidence regarding treatment of data that can be utilized to summarize the empirical evidence of the benefits and limitation of a peculiar method (Kitchenham, 2004). This method functions as a template to discover current strategies and requirements for chronic disease m-health applications from the literature related to both the human computer interaction (HCI) and mobile health areas. Likewise, this provides an idea of generating relevant and appropriate strategies and requirements to construct the dimensions and measures for the usability evaluation model of mobile health applications. Articles and academic materials that have been gathered from the digital libraries and publishers were categorized in term of metadata, knowledge area, research type as well as exploratory domain. These categories are described as follows: Metadata: Authors, Year of Publication, title, source, keyword, and institution; Knowledge area: usability evaluation, chronic disease/medical, m-health, older patients, methods, metric, criteria's, guidelines, dimension, principles; Research type: evaluation, experience, development; and Exploratory Domain: mobile application usability model, software engineering.

As the first step, keywords were identified to ensure that every relevant paper was detected. The following key words were chosen; usability dimension, usability evaluation applications, usability measurements, chronic disease applications, mobile applications and mobile health. Every hit was reviewed in terms of its relevance and explicit link to chronic disease mobile applications and usability. Papers that had been selected and downloaded were sorted according to the journal and conference proceedings publication year. Following that, a total of 477 papers were selected which later scrutinized into 60 for depth review. To achieve the objective of this paper, five main HCI journals and three conference proceedings have been selected from 2010 to 2016 as shown in Table 3. This selection method is based on the suggestion from Coursaris and Kim (2011) and Seffah et al. (2006). These selected journals and conference proceedings are among the top most in the field of HCI and health. All the selected relevant papers were carefully reviewed to gather quality information for strategies and requirements. This is important to assist usability researchers to construct the usability dimensions and measure for the chronic disease mobile health applications.

Table 3. Designated Journals And Conference Proceedings

Journal/Conference Proceeding	Publisher
International Journal of Human Computer Interaction (IJHCI)	Taylor and Francis Group

Software Quality Journal	Springer Science
Journal of Usability Studies	Usability Professional Association
International Journal of Computer Science and Engineering	Elsevier
International Journal of Mobile Human Computer Interaction	IGI Global
Journal of Medical Systems	Springer Science
International Conference on Human Computer Interaction with Mobile Devices and Services	ACM Annual conference
Journal of Medical Internet Research(JMIR) uHealth mHealth	JMIR Publications

The abstracts of the downloaded papers were read to determine its relevancy before the actual review. Based on the quality and relevancy, 477 papers were selected for review. Table 4 indicates the journal/conference proceeding names, year of publication and number of papers downloaded:

Table 4. Paper Downloaded For Review From Journals And Conference Proceedings

Journals/ Conference Proceedings	**Year**	**Total**
	07 08 09 10 11 12 13 14 15 16	
IJHCI	09 11 09 06 08 06 04 05 03 02	63
SQJ	08 09 11 07 09 06 07 - 01 02	60
JUS	06 05 09 12 11 09 11 07 01 -	71
IJCSE	- - 10 08 09 08 03 02 - 03	43
JMS	- 05 08 05 09 05 07 05 06 09	59
JMIR	- - - - - - 06 13 23 15	57
IJMHCI	- - 06 05 08 09 04 07 02 01	42
ICHCIMDS	13 06 08 15 10 07 09 11 03 -	82
Total		477

The main goal of the SLR was to select relevant and suitable papers that mainly focus on the design, strategies and requirements of the chronic disease mobile applications. After cautious study and analysis, the relevant and suitable papers were reduced to sixty (60) as mentioned in Table 5:

Table 5. Final Papers For Review

Journals/Conference Proceedings	Year 10 11 12 13 14 15 16	Total
IJHCI	- - - - - - 1	1
Software Quality Journal	- - - - 1 - -	1
Journal of Usability Studies	- 1 - - - 1 -	2
IJCSE	- - - 1 - - 2	3
IJMHCI	- - - - 2 1 1	4
Mobile HCI	- - - - 4 - -	4
JMS	1 2 4 4 5 4 3	23
JMIR	- - - 5 6 7 4	22
Total		60

Based on the selected papers, the issues related to the design strategies and requirements of the chronic disease mobile applications are discussed in the following section.

IV REQUIREMENTS OF CHRONIC DISEASE APPLICATIONS

With the development of m-health applications and increased number of users, the design of the contemporary m-health applications needs a better understanding of users' requirements including their basic needs, design strategies and challenges regarding usability (Diamond et al., 2014). However, issues such as limited internet connectivity, high power consumption rate, limited input modalities, and small screens need to be given careful consideration when designing application for small and portable devices (Ventola, 2014). Similarly, the context of use is also one of the strongest concerns in chronic disease application development. The requirements of chronic disease applications and active engagement of target users in the design process are vital in improving the m-health applications. Currently, many of the available m-health applications are designed with minimal input from users and without considering the basic needs of the target users.

The m-health applications have been facilitating elderly patients with chronic illness such as arthritis, asthma, COPD, diabetes and heart failure. The usage helps authorities to save cost and provides increased independence and quality of life of elderly patients. Applications for the chronic disease are helpful in getting information for prescription refills or x-ray results. It is more significant for users to get

and manage all medical history in one place. These features provide better medication safety and healthcare outcomes for patients (Choi et al., 2015). Daily assessment helps patient feel more secure and provides greater satisfaction. Even though, most of the health applications are provided with the main core function of tracking, if not executed properly, would weaken users' experience (Mendiola et al., 2015).

Currently, about one out of five health applications appears to be providing useful interaction between patient and healthcare provider. Since the ratio is very low, providers and patients may get confused with the selection possibilities of health applications (Zhang et al., 2014). Research had also been done on tuberculosis applications. Out of 1332 relevant applications for tuberculosis, 24 were fulfilling inclusion criteria (Iribarren et al., 2016). Although many healthcare applications are in operation with different functionalities, several issues such as inconsistent data entries, incorrect grammar and spelling, and links without featured data are found. The most frightening concern was that some of these applications provide inaccurate information which is harmful to patients, such as natural healers and remedies for tuberculosis. Many of these applications were not compatible with new devices and operating systems because developer did not update them for almost a year (Iribarren et al., 2016). In their wide-ranging analysis of 43,689 mobile healthcare applications offered by iTunes Store, Aitken and Gauntlett (2013) pointed out that patients' needs remain to be fulfilled and covered as well-functionalities by all applications. These applications were directly related to a patient's treatment. However, since the number of applications is huge, a complete functionality assessment has not been done. Majority of the current applications do not adhere to the international consensus guidelines and lack medical professionals' involvement. In the future, application development and studies should include evidence-based guidelines, medical professionals' involvement, and self-management functions that explicitly personalized to patient (Con & De Cruz, 2016). Therefore, these requirements helps in developing a usability model for the evaluation of chronic disease mobile applications and thus, will give impact to nearly every department in a hospital as well as the financial stakeholders such as usability practitioners and developers; medical doctor and most importantly patients and care takers.

The above discussion shows that there is a significant amount of variations regarding the functionality of the current m-health applications. The categories of the functionality include to inform, instruct, record, display, guide, remind/alert, and communicate. Table 6 presents the requirements of the chornic disease health applications based on previous literature.

Table 6. Requirements Of Chronic Disease Health Applications

Author and year	Requirement	Comments
(Con & De Cruz, 2016), (Hardinge et al., 2015). (Con & De Cruz, 2016)	Self -tracking and self-management	Self-tracking still need rigorous research. Many features are not discussed
(Househ et al., 2015),	Clinical effectiveness	Clinical effectiveness is the most important requirement
(Iribarren et al., 2016) (Choi et al., 2015), (Plachkinova et al., 2015) Sunyaev et al., 2015)	Privacy and security	Privacy and security policies are often absent
(Johnson et al., 2015)	Medication adherence and self-efficacy	Medication adherence is not found in many applications
(Lacerda et al., 2014),	Remote monitoring	Important features
(Martínez-Pérez, de la Torre-Díez, & López-Coronado, 2013), Ratnam et al., 2014),	Accessing information	Application accessibility should be easy and available every time
(Aitken, M., & Gauntlett, C., 2013)	Recording health data	Data should be recorded precisely
(Lacerda et al., 2014) (Aitken, M., & Gauntlett, C., 2013)	Warning and sending alarms	Application should send alarms at the right time
(Cole-Lewis & Kershaw, 2010).	Counseling	Patients' needs counseling with medicine
(Scandurra, Hägglund, Persson, & Ahlfeldt, 2014), (Baysari & Westbrook, 2015)	Usability	Usability evaluation needs to perform on all applications
(Beratarrechea et al., 2014). (Van Deen et	Interaction between patient and physician	Application should provide direct interaction

al., 2015) (Skorin-Kapov et al., 2014), (Mirkovic et al., 2014)		without any interruption
(Broderick et al., 2014). (Cho et al., 2014)	Health literacy	Heath applications should be designed for novice users
(Kagan et al., 2014) (Baysari & Westbrook, 2015)	Feedback	User feedback is necessary to include in health applications
(Caburnay, 2015) (Zapata et al., 2015). (Aitken, M., & Gauntlett, C., 2013)	Display and attractiveness	Application display should be attractive and interesting for patients
(Umali et al., 2016) (Caburnay, 2015)	Guidance to novice users	Application should provide demo to guide users
(Beratarrechea et al., 2014).	Communication	Better communication is needed
(Lacerda et al., 2014) (Martínez-Pérez, de la Torre-Díez, & López-Coronado, 2013)	Data collection	Data collection should be done with downtime backup
(Lacerda et al., 2014), (Ramirez et al., 2016) (Kirk et al., 2013)	Disease management	Application should be able to help patients to manage his disease with physician support
(Jones et al., 2013).	Online networking	Often found absent
(Majeed-Ariss et al., 2015). Oreskovic et al., 2015)	Customized design	Application design should be customized according to patients age group and choice to develop interest in using the applications frequently

V CHRONIC DISEASES M-HEALTH DESIGN STRATEGIES

A discussion paper was published by the Institute of Medicine (IOM) based on roundtable discussion of the health literacy's collaborative on modern technologies in 2013. This study comprises of various related literature and strategies suggested by different authors in improving the health literacy among novice users and usability of health applications. This information facilitates in designing more appropriate health literate applications for older adults and people with little education. These strategies are developed based on the US Department of Health and Human Services and adapted for the development of m-Health applications. The strategies are listed as follows:

- The identification of user needs and what they are expected to do and how to involve them during the application design.
- During the applications design phase, writing of useful content and putting the most relevant data are required by using positive and realistic approach. The complete process should be explained in action steps and simple language is recommended.
- In mobile applications, the small screen and low graphics are mostly discussed pertaining to the usability issues. So, it is preferred to display the main content clearly with visible fonts, white space and clear headings or labels and use short paragraphs.
- The application design should be easy to use and provide rapid access to the main menu and home page with direct information. Application design is also recommended to use labels and provide simple buttons to perform search and browse functions.
- It is significant to engage users in the application by adding tools that are printer-friendly with attractive and interactive content with modest controls and buttons.

To develop better user-friendly interface, it is necessary to evaluate and revise the applications by experienced moderators, which are then tested by the novice users with low literacy and low health literacy and then verify and improve the design according to their feedbacks. On the other hand, testing usability of an application needs to consider many attributes to ensure that the application is suitable and usable (Coursaris & Kim, 2011; Baharudin et al., 2013). Moreover, no research is found which highlights the issues regarding the development and design of multi-featured m-health applications for chronic disease patients which support symptom management tools and online communication between healthcare providers and patients (Mirkovic et al., 2014). The existing m-health applications have simple design and help little more than providing information. On the full assessment of the applications functionality, only

two third of the mobile health applications are able to provide information. Nevertheless, 50 percent of these applications can deliver instructions and only 20 percent could track data.

According to the above finding, mobile applications being developed for the chronic patients are not able to provide the care according to their needs. Thus, the mobile application for the chronic disease is required to be studied explicitly to guarantee the final product that reaches the community is usable. The chronic disease mobile applications requirements such as self-tracking, push notifications and multimedia content need to be instilled so that it is easier for the users to adapt into the current technology without being left behind. To explore the learnability and further attractiveness of the m-health applications for chronic disease, it is significant to adopt usability models in designing the evaluation processes. Automated evaluation tools also can be developed because most of the papers only evaluate application by questionnaires and interviews (Zapata et al., 2015). This indicates that specific model for chronic disease mobile applications usability evaluation is unavailable and the existing usability models do not adequately capture the complexities of interacting with applications on a mobile platform (Zahra et al., 2017). This could also be the reason of neglecting the needs of the chronic patients as part of the usability of an application.

VI CONCLUSION

Currently, thousands of health applications are available on the stores that make it difficult to shift and separate the failed from the all-star applications. Therefore, the primary challenge faced by patients is to find suitable m-health applications that provide significant healthcare support. There is also a need to improve the usability and develop a model to validate these applications to provide professional healthcare. However, these efforts are still underway and have limited scope and impact. This study could encompass the body of knowledge in the aspect of usability evaluation from the functionality and user's perspective, considering that the approach to usability evaluation of chronic disease application tends to be overlooked despite its likely impact on both doctors and patients. This is also related to the lack of or limited previous studies that concentrate on this particular issue specifically for chronic disease mobile applications. It may equally serve as a guide to the researchers who are conducting a similar study. Moreover, it will assist usability practitioners and mobile software developers in designing more effective and usable interface that follows a set of requirements and meets patient's satisfaction. The specific requirements which are meant for the chronic disease patients would enable detailed usability instead of general evaluation. As future work, the researchers should be focusing on the development of usability metrics for usability evaluation model for chronic disease mobile health application according to the requirements obtained.

ACKNOWLEDGMENT

The co-author wishes to thank the Universiti Utara Malaysia in funding this study under the PBIT grant, S/O code 12319, and Research and Innovation Management Centre, Universiti Utara Malaysia, Kedah for the administration of this study.

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