Usability Dimensions for Chronic Disease Mobile Applications: A Systematics Literature Review

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ABSTRACT

Many mobile health (m-health) applications have been developed in recent years. However, only few statistical evidences on the acceptability and usability issues have been discussed by previous studies. In addition, the requirements for the chronic disease applications are often overlooked. Failure to include the requirements has led to the rejection of the m-health applications. The existing usability evaluation models consist only the general dimensions for evaluating mobile applications, which are unable to capture the complexities of different categories of mobile applications. Such categories require different functional and non-functional requirements; thus, customized usability evaluation models are required. The main objective of this paper is to provide usability dimensions and measurement to evaluate the chronic disease m-health applications users' requirements. The related data were gathered by interviewing selected users and analyzed using Nvivo. The Systematics Literature Review (SLR) approach was also used to select 60 articles from established journals in the Computer Science and Medical. From these articles, 15 relevant dimensions for chronic disease were determined which were later simplified into six dimensions. These six dimensions provide the basis for developing the development of the usability evaluation model for chronic disease mobile applications. This evaluation model can facilitate application developers in creating better applications that will increase the adoption of the chronic disease mobile applications in the clinical practice. Ultimately, the overall impact of these applications may increase.

Keywords: Usability evaluation model, usability dimensions, mhealth, chronic disease, mobile applications

I INTRODUCTION

Mobile applications are widely developed and comprehensively used by users in various domains. Various mobile applications have different users' requirements. Many developers tend to build mobile application meant for common usage without considering type of users and domains. User requirements and usability have been ignored while developing mobile applications that are specifically meant for the chronic disease patients. Moreover, the number of applications is increasing with less effectiveness and incomplete design (Schnall, Bakken, Rojas, Travers, & Carballo-Dieguez, 2015; Schnall et al., 2016). Nowadays, patients suffering from chronic disease are looking for applications with simpler and easier interfaces that can ease their usage particularly for elderly users. Currently, most of the applications tend to ignore the needs of older adults who are the common victim of chronic diseases. To date, the literature on the usability of m-health applications is still lacking. In addition, about 95% of the mobile applications have not undergone usability testing. Therefore, a systematic evaluation and rating of the m-health applications by independent and credible organizations and researchers are needed to assess the usability of such technologies (Al-Mardini, Aloul, Sagahyroon, & Al-Husseini, 2014; Baig, GholamHosseini, & Connolly, 2015; Brown & Hocutt, 2015; Househ, Shubair, Yunus, Jamal, & Aldossari, 2015; Zapata, Niñirola, Idri, Fernández-Alemán, & Toval, 2014).

Usability is the biggest fear of m-health applications, as it is one of the most significant factors to their accomplishment (Househ et al., 2015). If usability is not given attention, m-health could import unwanted, negative results, for example, a high number of medical errors and communication difficulties between healthcare providers and patient. Moreover, the needs of elderly are different than normal people and each disease possesses different requirements. For example, the blind needs Braille application, the mute requires application that enables more auditory while the deaf needs more visual enabled application. These indicate that usability of the application varies according to the type of disabilities.

M-health applications facilitate the communication amongst healthcare practitioners during a meaningful exchange of information and help patients with good clinical decisions by integrating data from different resources, lowering the medication cost and reducing useless medical test and errors (Taiwo, Awodele, & Kuyoro, 2016). Therefore, it is essential to ensure the usability of m-

health applications in order to reduce medical errors. However, issues such as limited internet connectivity, high power consumption rate, limited input modalities, and small screens need to be considered while designing application for small and portable devices (Ventola, 2014). Moreover, majority of the current health applications do not adhere to the international consensus guidelines and lack medical professional's involvement. In the future, applications and studies should include evidence-based guidelines, medical professional's involvement, and self-management functions explicitly personalized to patient (Con & De Cruz, 2016).

Analysis of m-health applications by Aitken and Gauntlett (2013) concludes that a significant number of the current available m-health applications do not have sufficient variety of usability dimensions because the functionalities were developed with little guidance and support from physicians or consultants. As a result, patients are facing a maze of m-health applications with low uptake and awareness. The end users or patients expect to see more user-friendly applications with higher usability and multi-functionalities. According to Zhang et al. (2014), there is a clear gap for a comprehensive usability evaluation approach containing usability dimensions, criteria, and metric. Moreover, based on the literature review, the existing usability models do not consider the information security as one of the essential dimensions, whereby the major threat faced by these applications are security and privacy, especially in terms of patient identification and confidentiality of medical data. There is also a clear need for enhancement in the design and structure of these applications based on the medical and ethical standards (Baig et al., 2015). Thus, customized usability models are needed to evaluate the various m-health applications.

II METHODOLOGY

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 review focused on identifying relevant and appropriate journal or conference proceeding articles which are related to the usability dimensions and metrics of m-health applications. The dimensions and metrics are required as the basis for developing a usability evaluation model for chronic disease mobile applications. As a first step, related keywords were identified to ensure that every relevant paper was detected. The following key words were chosen namely usability dimension, usability evaluation applications, usability measurements, chronic disease applications, mobile applications and m-health. Every hit was reviewed in terms of its relevance and explicit link to chronic disease mobile applications and usability.

To achieve this objective, five main HCI journals and three conference proceedings were selected from 2010 onward and this method of selection has a basis from (Coursaris & Kim, 2011; Seffah, Donyaee, Kline, & Padda, 2006) as shown in table 1. These journals and conference proceedings that have been selected are among the top most in the human computer interaction (HCI) and medical fields. The method used for the selection of the relevant papers was mainly focused on the area of usability study, evaluation method/design, as well as usability principles and dimensions/design guidelines. All the relevant papers selected were carefully reviewed and quality information was gathered to identify the requirements of chronic disease, creating the base for dimensions and metrics.

Table 1. 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 carefully read to determine its relevancy before the actual review. Similarly, based on the quality and relevancy of the paper, 477 papers were selected for review. Table 2 indicates the journal/conference proceeding names, year of publication and number of papers downloaded:

Table 2. 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 the relevant and suitable papers that mainly focus on usability evaluation and chronic disease mobile applications. After cautious study and analysis, the relevant and suitable papers were reduced to sixty (60) as mentioned in Table 3:

Table 3. 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

The findings of the SLR reported the dimensions that are constantly being used in usability measurement of mobile applications. Besides, the requirements of chronic disease mobile applications were also identified.

A total of 25 dimensions were collected from 60 papers selected through SLR. However, only 15 dimensions were chosen based on the frequency being mentioned and used in literature for usability evaluation, mobile platform and m-health. In this study, the dimensions were chosen based on the number of count of its appearance in the literature. Dimensions with more than three (3) counts are included into the list following the identification process of Baharuddin et al (2013). This process is discussed in detail in the third section.

Besides the SLR, the dimensions of the m-health application for chronic disease evaluation model have also been identified by gathering related requirements through interview with selected chronic disease mobile application users. The interviews were conducted with ten (10) users and recorded as video outputs, which were then analyzed using Nvivo. A total of ten (10) diabetic and high blood pressure patients were chosen since a minimum of 10 people are considered enough for interview and must not exceed 25 people (Nielsen, 1994). In addition, the minimum number of users were interviewed because most patients do not willing to participate. The age of the chosen participants ranged from 30 to 40 years old. All of them were mobile phone users and had been using mobile application to monitor their health conditions. The purpose of the interview was to understand the users' needs and experiences.

Participants were interviewed with ten (10) open-ended questions to gather information regarding their needs for m-health applications and the challenges faced during usage of an application. As a guide, prepared questions were used during the interview. During the interview, interviewees shared their experiences and obstacles they face in terms of using m-health application to self-tracking. Through the interview, user requirements were identified which contribute towards the identification of the specific requirements for chronic disease mobile applications. The outcome of the interview session was analyzed thoroughly using the Nvivo software, which is commonly used for qualitative analysis. One by one specific keywords identified such as "less graphic", "less text", "more image", "privacy" and "alerts" led towards identification of similar requirements that were shared by the participants. For example, participant A and participant C had similar requirement that the application should have reminders or alerts for reminding them to take medicine or follow the instruction as prescribed by doctor. Through the interview, information about perceivable items such as "attractive interface" was identified. This is significant since in the literature it was found that the "attractiveness" is generally missing in the m-health applications. M-health

application users were more focused towards having applications that provide them security as they share their everyday routine and personal information through the application. Moreover, they also preferred graphical interface and video demo in an application rather than fully text or audio outputs because most of them were novice technology users. Most of the participants agreed on the difficulties faced by using the application such as irritating textual representation and lesser alerts. By using the Nvivo software, specific keywords or also known as nodes were identified and categorized together. This helps identifying the frequency of the keyword been used by the interviewee in expressing their needs for an application.

The requirements that have been gathered from the literature such as self-tracking, push notification and alerts, and multimedia elements were matched with the findings from the interview conducted earlier. There are few requirements that were frequently mentioned in the SLR and highlighted in interviews to include in the m-health applications. These requirements are considered the most needed aspects that should be given extra consideration while developing the m-health application especially for chronic disease so that applications meant for these elderly patients can be utilized easily. According to the analyzed literature, the lack of these aspects could lead towards unusable applications that are mostly being discarded after development. This has also been proven during the interview with the real users. Thus, the requirements of the chronic disease mobile applications were taken into consideration while choosing the appropriate dimensions for the proposed usability evaluation model. User participation in the model development gives a strong intuition that the model would be more focused on this community rather than ending up being general (Baharuddin, Singh, & Razali, 2013; Harrison, Flood, & Duce, 2013; Hussain, 2012).

III USABILITY DIMENSIONS CHOSEN FOR THE PROPOSED MODEL

Literature review and interviews with real users showed that chronic disease applications need to be focused in terms of user requirements because it becomes increasingly difficult to find an application in this plethora of options that is suitable for one's needs. This problem is caused by lack of effectiveness and limited functionality because most of the applications are developed without following any usability model or guidelines. This study assists in providing basic usability dimensions following the real user's requirements that will then help in developing a usability model for chronic disease mobile applications. According to the frequency of important dimensions mentioned in the previous studies, 15 dimensions related to the usability evaluation of chronic disease mobile applications were chosen from 60 selected papers. All these 15 dimensions were later simplified into 6 measurable dimensions as shown in Figure 1 after reducing the redundancy and similarity in terms of measurement and also by taking into consideration the simplicity to the utmost concept by ISO 9241-11 (ISO, 1998). Besides that, a few of identified dimensions were omitted since the application is only targeted for specific medical patients. A model that consists of many dimensions are not necessarily good unless the chosen dimensions are determined based on the importance, user need and functionality of the application (Harrison et al., 2013). Thus, wisely chosen dimensions are needed to ensure that the proposed model caters users' needs while considering the well-functionality of the application.

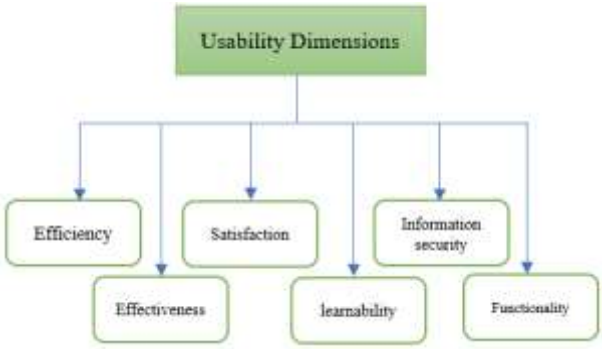

Figure 1. Chosen Dimensions For Chronic Disease Usability Model

Efficiency is considered as one of the important dimensions. According to Albrecht and von Jan (2017) there is an ample evidence of widespread inefficiency in health care applications and it needs to be considered seriously. Measuring effectiveness focuses on the accurateness and completeness of the task of an application that is developed for patients of chronic diseases while ensuring an error-free and easy application. It ensures that the application is focused on the medical issues and acts accurately for user's needs. Satisfaction also identifies the attitude of user towards using an application, whereby, if the application is satisfying, users will have more interest in using it frequently and continuously (Dubey, Gulati, & Rana, 2012). However, the main concern is the issue of poor rating given by users relating to the clinical usability of the m-health applications. This issue is also directly related to satisfaction (Singh et al., 2016).

At the same time, the dimensions are also carefully selected in terms of user, technology, task and environmental contexts which support the contextual factors as agreed by previous studies (Coursaris & Kim, 2011; Baharuddin et al., 2013; Harrison et al., 2013). Pertaining to the user context,

many user characteristics influence the use of the application such as experience with the device or application (Coursaris & Kim, 2007), age, gender, physical ability (Bragg et al., 2015), occupation and education level (Ling et al. 2006). Thus, the dimensions are derived upon consciousness of the relevancy towards chronic disease and health care user context (Shaffiei & Aziz, 2012; Bragg et al., 2015) such as information security, health literacy and functional suitability, which have been highlighted as the independent dimensions that are needed to be measured. Furthermore, many studies do not take these dimensions into consideration (Broderick et al., 2014; Cho, Park, & Lee, 2014; Choi, Lovett, Kang, Lee, & Choi, 2015; Iribarren, Schnall, Stone, & Carballo-Diéguez, 2016; Sunyaev, Dehling, Taylor, & Mandl, 2015). The tendency of not taking into account the security as an independent dimension is because most of the previous studies only focused on the usability evaluation models that are general in nature. Thus, the security dimension is included into the proposed model to help in detailing the usability measurement for specific chronic disease mobile application.

Mobile platform was considered as an important element to focus on while choosing the dimensions since the general usability evaluation models reviewed in the earlier literature do not cater the limitation of mobile devices (Zahra, Hussain, & Mohd, 2017). Therefore, some modifications to the available models need to be done to ensure appropriateness and practicality in the chosen dimensions. As for this study, the usability dimensions were determined based on the various components and functions of the mobile application platform towards the chronically ill users' requirements. The following part of the study will focus on deriving appropriate usability criteria and metric according to the dimensions for chronic disease mobile applications gathered earlier.

IV CONCLUSION

This paper discusses the appropriate dimensions gathered for the chronic disease mobile application. As agreed by the real user (patients), it is proven that most of the mobile application failed to incorporate the security and users' requirement dimensions and provide more suitable functions. At the same time, the available models are more focused on desktop application and ignored the end user's requirements in handling specific application especially for the chronic patients. Therefore, to fulfil the need for a usability model, a number of dimensions were derived from literature review and by interviewing the end users. However, the model is incomplete without criteria and metrics for the evaluation process. As for the next step of the study, criteria and metrics will be derived and proposed as a complete model. Expert based evaluation, focus group session and usability testing will also be carried out to validate and verify the developed model. Eventually, this will equally help to determine the effectiveness of the proposed model.

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REFERENCES

Aitken, M., & Gauntlett, C. (2013). Patient apps for improved healthcare: from novelty to mainstream. Parsippany, NJ: IMS Institute for Healthcare Informatics.

Al-Mardini, M., Aloul, F., Sagahyroon, A., & Al-Husseini, L. (2014). Classifying obstructive sleep apnea using smartphones. Journal of biomedical informatics, 52, 251-259.

Albrecht, U.-V., & von Jan, U. (2017). Safe, sound and desirable: development of mHealth apps under the stress of rapid life cycles. mHealth, 3.

Baharuddin, R., Singh, D., & Razali, R. (2013). Usability dimensions for mobile applications—A review. Res. J. Appl. Sci. Eng. Technol, 5, 2225-2231.

Baig, M. M., GholamHosseini, H., & Connolly, M. J. (2015). Mobile healthcare applications: system design review, critical issues and challenges. Australasian Physical & Engineering Sciences in Medicine, 38(1), 23-38.

Broderick, J., Devine, T., Langhans, E., Lemerise, A. J., Lier, S., & Harris, L. (2014). Designing health literate mobile apps: Institute of Medicine of the National Academies.

Brown, M. E., & Hocutt, D. L. (2015). Learning to use, useful for learning: a usability study of Google apps for education. Journal of Usability Studies, 10(4), 160-181.

Cho, J., Park, D., & Lee, H. E. (2014). Cognitive factors of using health apps: systematic analysis of relationships among health consciousness, health information orientation, eHealth literacy, and health app use efficacy. Journal of medical Internet research, 16(5), e125.

Choi, A., Lovett, A. W., Kang, J., Lee, K., & Choi, L. (2015). Mobile Applications to Improve Medication Adherence: Existing Apps, Quality of Life and Future Directions. Advances in Pharmacology and Pharmacy, 3(3), 64-74.

Con, D., & De Cruz, P. (2016). Mobile phone apps for inflammatory bowel disease self-management: A systematic assessment of content and tools. JMIR mHealth and uHealth, 4(1).

Coursaris, C. K., & Kim, D. (2007). A research agenda for mobile usability. Paper presented at the CHI'07 Extended Abstracts on Human Factors in Computing Systems.

Coursaris, C. K., & Kim, D. J. (2011). A meta-analytical review of empirical mobile usability studies. Journal of Usability Studies, 6(3), 117-171.

Dubey, S. K., Gulati, A., & Rana, A. (2012). Integrated model for software usability. International Journal on Computer Science and Engineering, 4(3), 429-437.

Harrison, R., Flood, D., & Duce, D. (2013). Usability of mobile applications: literature review and rationale for a new usability model. Journal of Interaction Science, 1(1), 1-16.

Househ, M. S., Shubair, M. M., Yunus, F., Jamal, A., & Aldossari, B. (2015). The Use of an Adapted Health IT Usability Evaluation Model (Health-ITUEM) for Evaluating Consumer Reported Ratings of Diabetes mHealth Applications: Implications for Diabetes Care and Management. Acta Informatica Medica, 23(5), 290.

Hussain, A. (2012). Metric based evaluation of mobile devices: mobile goal question metric (mGQM). University of Salford.

Iribarren, S. J., Schnall, R., Stone, P. W., & Carballo-Diéguez, A. (2016). Smartphone Applications to Support Tuberculosis Prevention and Treatment: Review and Evaluation. JMIR mHealth and uHealth, 4(2), e25.

ISO. (1998). International Standard: ISO 9241-11(Guidance on Usability). Geneva.
Kitchenham, B. (2004). Procedures for performing systematic reviews. Keele, UK, Keele University, 33(2004), 1-26.
Nielsen, J. (1994). Usability inspection methods. Paper presented at the Conference companion on Human factors in computing systems.
Schnall, R., Bakken, S., Rojas, M., Travers, J., & Carballo-Dieguez, A. (2015). mHealth technology as a persuasive tool for treatment, care and management of persons living with HIV. AIDS and Behavior, 1-9.
Schnall, R., Rojas, M., Bakken, S., Brown, W., Carballo-Dieguez, A., Carry, M., . . . Travers, J. (2016). A user-centered model for designing consumer mobile health (mHealth) applications (apps). Journal of biomedical informatics, 60, 243-251.
Seffah, A., Donyaee, M., Kline, R. B., & Padda, H. K. (2006). Usability measurement and metrics: A consolidated model. Software Quality Journal, 14(2), 159-178.
Singh, K., Drouin, K., Newmark, L. P., Lee, J., Faxvaag, A., Rozenblum, R., . . . Bates, D. W. (2016). Many mobile health apps target high-need, high-cost populations, but gaps remain. Health Affairs, 35(12), 2310-2318.
Sunyaev, A., Dehling, T., Taylor, P. L., & Mandl, K. D. (2015). Availability and quality of mobile health app privacy policies. Journal of the American Medical Informatics Association, 22(e1), e28-e33.
Taiwo, O. O., Awodele, O., & Kuyoro, S. O. (2016). A Usability Framework for Electronic Health Records in Nigerian Healthcare Sector. International Journal Of Computer Science Engineering, 5(1), 16-20.
Ventola, C. L. (2014). Mobile devices and apps for health care professionals: uses and benefits. Pharmacy and Therapeutics, 39(5), 356.
Zahra, F., Hussain, A., & Mohd, H. (2017). Usability evaluation of mobile applications; where do we stand? Paper presented at the AIP Conference Proceedings.
Zapata, B. C., Niñirola, A. H., Idri, A., Fernández-Alemán, J. L., & Toval, A. (2014). Mobile PHRs compliance with Android and iOS usability guidelines. Journal of medical systems, 38(8), 1-16.