Usability Evaluation of a COPD Remote Monitoring Application

Berglind SMARADOTTIR[1], Martin GERDES, Rune FENSLI and Santiago MARTINEZ

Centre for eHealth and Healthcare Technology, University of Agder, Norway

Abstract. Telemedicine applications have the potential to enhance patient's safety at home by remote monitoring of chronic diseases. Telemedicine involves the interaction between multiple user groups through a system, making the usability aspect of such system crucial for the continuous, efficient and satisfactory use of the application. The main objective of this study was to carry out a usability evaluation in the field of a telemedicine application for remote monitoring of chronic obstructive pulmonary disease (COPD) patients to improve the application's user interface before system deployment. A field trial was performed with six COPD patients at their homes, continuously using the system's application on a tablet for seven days. The usability evaluation identified 23 usability problems related to users' interactions and system's functionality. These problems were solved with the refinement of the system through an iterative application development process. The outcome of the study was the improved telemedicine application that was adopted by the partners of the FP7 EU project United4Health.

Keywords. eHealth, remote monitoring, telehealth, usability evaluation, user-centred design

Introduction

The prevalence of chronic diseases is increasing and chronic obstructive pulmonary disease (COPD) is predicted to be the fourth most fatal disease globally in 2030 [1]. COPD patients suffer from exacerbations with frequent admissions to hospital, leading to a reduced quality of life [2] and an increase of medical expenses for the society [3]. In Norway, a health reform [4] urged health care providers to implement new clinical pathways. Hence, telemedicine technology was introduced to facilitate new services that support communication, optimize resources and increase cost effectiveness. In the FP7 EU project United4Health (U4H) [5], technology for remote monitoring of chronic diseases is being developed and the potential benefits of its use evaluated. In particular, the Norwegian contribution to the U4H project was to develop a telemedicine system that supported remote monitoring of COPD patients after hospital discharge.

The aim of this study was to specify usability requirements of the telemedicine application through a field trial, as a part of a User-Centred Design (UCD) process [6]. The telemedicine application was validated from an operational and qualitative usability aspect.

---

[1] Corresponding Author: Berglind Smaradottir, University of Agder, Department for ICT. Postbox 422, N-4604 Kristiansand, Norway. E-mail: berglind.smaradottir@uia.no

1. Methods

In order to identify usability issues of the telemedicine application, a field trial was run in a home environment in March and April 2014. The field trial had 6 participants, 2 male and 4 female aged between 59 and 81 years (mean of 72), all diagnosed with COPD and living at home. They described their computer skills as "medium" or "low", and used the Internet for purposes such as sending e-mails, banking and reading newspapers. Two of them were experienced tablet PC users, one had minor experience and three had never used a tablet PC.

The field trial consisted of three phases: 1) participant's user training; 2) participant continuous use of the application for one week at home; 3) usability evaluation and interview at participant's home. In phase 1, individual user training was delivered by nurses at a telemedicine centre where participants were debriefed about the research project and demonstrated the daily tasks in the telemedicine application running on a tablet device. The daily tasks included: taking measurements of pulse and blood oxygen (SpO_2) that were transmitted wirelessly from a measurement device to the tablet application, and filling in a questionnaire for self-evaluation of symptoms. Readings and results were wirelessly transmitted to the telemedicine centre. In addition, the participants had to answer a videoconference call on the tablet device from a nurse in the telemedicine centre. At the end of the user training, the participants were asked to perform the tasks in the tablet application themselves. They were observed by the nurse and the research team. In phase 2, each participant performed the daily tasks in the tablet application at their home for a week. In phase 3, the research team visited participants at home and performed a usability evaluation of the user's interactions with the tablet application on daily tasks, based on a think aloud protocol [7]. Semi-structured interviews were carried out to complete participants' feedback.

Each participant was equipped with a suitcase including a pulse oximetry device (Nonin Onyx II, 2012), and a tablet device (Lenovo ThinkPad tablet 2, 2013, Windows 8.1) with the telemedicine application installed. In addition, an adjustable USB camera and a headset were included for the videoconference.

Observations and interviews were audio-visually recorded, with a total of 8.5 hours, where the mean duration was 45 minutes in user training (phase 1), 12 minutes for usability evaluation and 27 minutes for the interviews (phase 3). Recordings were transcribed verbatim and categorised based on a qualitative content analysis [8]. Patient's suggestions and feedback collected through the field trial were used to improve the system's user interface (UI) before its final implementation.

2. Results

2.1. User Training

The user training comprised 4 tasks, with a total of 26 associated actions. An in-depth analysis of the observations revealed 10 usability problems that were categorized into 3 groups.

System's functionality: 3 major problems were identified. 2 were related to transmission of data measurements. First, the results of previous measurements were sent instead of the current ones. Second, incorrect date and time configuration in one of the tablets made measurements be shown on the wrong date after data transmission to

the telemedicine centre. The third problem was concerned with the videoconference's poor quality of video and sound due to insufficient mobile network coverage.

Users' interactions: 5 problems were identified. The most important one was related to problems with the double touch action. Participants struggled to employ the appropriate speed when touching the starting icon of the application, e.g., participants had to try up to five times to succeed. Additionally, touching the UI was problematic in some cases due to finger low humidity skin. A stylus was used as a successful replacement in those cases. Regarding the videoconference, the USB camera and picture's size on the screen required a fine adjustment for optimal viewing. The use of headset increased perception of sound in the videoconference, especially for participants with hearing impairments. However, this introduced a new risk of user not hearing the call, because, when the headset was plugged in, the sound was off on the tablet's speakers and limited to the headset.

Graphical UI: 2 problems were identified. One was related to the small size of UI's touch area for answering videoconference calls (especially for users with large fingertips), and the other with some spelling errors in the UI wording.

2.2 Usability evaluation

The usability evaluation comprised 4 tasks and 26 associated actions. It was conducted after one week of using the application. An in-depth analysis of the observations revealed 13 usability problems that were categorized into 3 different groups.

System's functionality: 3 problems were identified. 2 were classified as major ones and were related to the lack of notification to the user when there was a data transmission error. For instance, a progress bar showed on the screen an ongoing transmission, but without notifying whether the transmission was successful or not. This led to situations where participants thought that the data transmission was successful because they could see the progress bar working, but on the other end the telemedicine centre did not receive the measurements. In addition, there was a time limit of 90 seconds for the action *start measurement*, where the measurement device had to make and send the measurement to the tablet application. If the action was unsuccessful (i.e. data was not received by the tablet application), then the measurement device had to be taken off user's finger to automatically switch off and repeat the action from the beginning. This led to some misunderstanding among users, who waited for too long without knowing that the time allowed for measuring (90 seconds) ran out. In addition, the videoconference had problems with sound and video quality. Initially, the quality was satisfactory, but it was gradually reduced with some minor sound and video problems. Only one participant had satisfactory quality during the whole test.

Users' interactions: 6 problems were identified. Double touch action was problematic for 3 of the users, who needed to try multiple times to succeed. The interaction with the UI screen required a stylus for 3 users, and for another, both stylus and finger. The difficulties associated with touch speed, correct pressure, low humidity finger skin or large fingertips were the reasons for using a stylus. One user had forgotten the correct action for starting the application, and found a way around by touching another UI area. When adjusting the camera for videoconference, one user accidently switched off the application twice before succeeding. Regarding the measurement device, one of the participants had problems with taking a measurement and was asked after 12 minutes to take the hand up from the table and hold the finger in

the air. Then, the measurement succeeded, making the user aware that pressure influenced the measurement. Due to problems with the sound quality of the videoconference, around half of the users preferred to use a headset.

Graphical UI: 4 problems were identified. 2 problems were related to the action of taking a new measurement. The text "new measurement" was used twice in the same screen, as heading and also as an action bar, creating confusion of which was the one to select to start the action. Another problem was that when choosing the same action bar, a pop-up window opened in the middle of the instruction text, impeding its reading. All participants commented on the small size of the touch area to answer videoconference call. In the questionnaire, the answer options of two questions regarding medication were misunderstood and some doubts were expressed about the answers.

2.3 Interviews

All participants had successfully connected the equipment by themselves at home, but one had a problem opening the camera's USB-cap and another forgot how to enter the PIN the first time, because in the keyboard the numbers were not visible and an action for switching from letters to numbers had to be taken. The user manual was evaluated as clear and instructive, but one participant highlighted that the written text had to be exactly as on the screen as some mismatch was found. Due to transmission errors, four participants received an unscheduled home visit by a nurse or technician during the field trial, in order to identify reasons for errors in the transmission and also to change the videoconference configuration to optimize its quality. The main frustration expressed was the videoconference problem, which was related to mobile network coverage.

Regarding the interface design, text size was evaluated as sufficient and the choice of colours was appropriate. The interface of the main screen, measurement and the symptom self-evaluation questionnaire were easy to understand and had sufficient contrast between the elements. In the questionnaire, the size of boxes was sufficient and the overview of filled-in answers before sending was evaluated as a positive feature. Two participants suggested including one more answer option, "feel better today", related to the symptom self-evaluation questionnaire. For the interaction with the UI, most users stated that during the week they got more familiar with the correct speed and pressure for touch actions, but a few still remained using the stylus.

The participants' overall evaluation of the application was satisfactory. Users stated: *Imagine that someone made such an easy program so that even I could understand it* […] *I would call this user friendly and easy to use; if I can use this others can also since I am not a very technical person.*

3. Discussion

In this paper, a usability evaluation of a telemedicine application for COPD patient remote monitoring has been presented. The field trial was a part of a UCD process, and it studied the continuous usage of the telemedicine application implemented in a tablet device. The application was used at participants' home for a week and provided useful information about the interactions between users and technology, but also between the different technologies involved. A total of 23 usability problems were identified related to the use of the tablet application, where 6 were classified as major ones and

prioritised to be addressed. Most of the problems were corrected in several iterations in order to optimize system's functionality and to ensure a better support for user interactions. The study showed that despite the fact that several participants had little or no experience using tablet devices, all reported that their use of the telemedicine application was satisfactory. Due to that, user training was described as a key factor for providing patients with the relevant information and necessary confidence to operate the application by themselves at home. The usability evaluation performed at participant's home after a continuous use of the application for seven days allowed having a more complete understanding of how the system operated from user perspective. The period was found generally sufficient for users to explore the possibilities of the system and feel confident with it. It also gave enough time to report suggestions, possible application's errors and limitations when they were interviewed. In addition, the field trial showed the benefits of an evaluation carried out in a familiar environment for users. This research study has some limitations, such as a reduced number of end-users and non-laboratory test settings, where the user's home environment provided less control to the research team of the possible variables studied when compared with laboratory settings. However, the field trial was preceded by a laboratory user evaluation [6] and the home environment gave the opportunity to test the system in real-world settings, providing a familiar context of use for participants and, above all, the real scenario where the deployed system will run. This aspect might have a positive influence on the satisfaction levels reported by the participants in the interviews. Regarding the reduced number of users, there is research evidence that 5 participants are enough for qualitative usability studies [9].

Finally, the telemedicine tablet application has culminated with the adoption of the system by the FP7 EU project United4Health's partners [5] and, by this, hundreds of Norwegian citizens and residents across the country will be using the system. Future work will cover integration of further devices with the telemedicine application to support other patient groups and clinical pathways.

References

[1] C.D. Mathers, D. Loncar, Projections of global mortality and burden of disease from 2002 to2030. *PLoS Med* 3 (11) (2006), 2011-30: e442. DOI:10.1371/journal.pmed.0030442.

[2] T.A. Seemungal, G.C. Donaldson, E.A. Paul, J.C. Bestall, D.J. Jeffries, J.A. Wedzicha, Effect of Exacerbation on Quality of Life in Patients with Chronic Obstructive Pulmonary Disease, *Am J Respir Crit Care Med*, Vol. 157, No. 5 (1998), pp. 1418-22. DOI: 10.1164/ajrccm.157.5.9709032.

[3] S.D. Ramsey, S.D. Sullivan, The burden of illness and economic evaluation for COPD, *Eur Respir J*; 21: Suppl. 41 (2003), 29s–35s. DOI: 10.1183/09031936.03.00078203.

[4] Norwegian Ministry of Health and Care Services. *The Coordination Reform – Proper treatment - at the right place and right time*. Report No. 47 to the Storting (2008-2009), 2009

[5] United4Health [Internet].Transforming the patient experience with telehealth in Europe. European Commission- ICT Policy Support Programme and Competitiveness and Innovation Framework Programme; [cited 2015 Feb 9]. Available from: http://www.united4health.eu/.

[6] B. Smaradottir, M. Gerdes, R. Fensli, S. Martinez, User interface development of a COPD remote monitoring application- a user-centred design process. Accepted for publication at the 8th International Conference on Advances in Computer-Human Interactions; 2015 Feb 22-27; Lisbon: Portugal.

[7] M.W. Jaspers, A comparison of usability methods for testing interactive health technologies: methodological aspects and empirical evidence, *Int J Med Inform*, 78(5) (2009), 340-53.

[8] J. Lazar, J.H. Feng, H. Hochheiser, *Research methods in human-computer interaction*, John Wiley & Sons, 2010.

[9] J. Nielsen, T.K. Landauer, A mathematical model of the finding of usability problems. Proceedings of ACM INTERCHI'93 Conference; 1993 Apr 24-29; Amsterdam: Netherlands:206-13.