User-centred Design of the User Interface of a Collaborative Information System for Inter-municipal Dementia Team

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Abstract: In the Norwegian Health sector there are currently undergoing changes at local, regional and national level triggered by recent health reforms. Municipalities are facing for first time the duty of implementing new primary health services. Inter-municipal coordination (IMC) health care teams have been created to operate across borders to share costs, extend geographical range of operation and optimise resources. This study focuses on the development and evaluation of the user interface (UI) functional prototype of a collaborative information system for IMC dementia team in Norway. Employing a user-centred design approach, the interface prototype was built based on the information gathered on two workshops where the end-users described their current clinical workflow of dementia assessment and how the UI would best fit into their daily work. The outcome of the workshops creatively informed the design of a working prototype that was qualitatively usability tested. Results showed that the UI effectively and efficiently supported the work of the IMC dementia team, with a sufficient level of satisfaction among the end-users. The resulting prototype established the foundation for the system implemented in the FP7 EU project *United4Health*.

1 INTRODUCTION

In Norway, the Coordination reform urged municipalities to implement new specialised health care services (Norwegian Ministry of Health and Care Services, 2008-2009). One key consequence is the need for an effective coordination and collaboration between professionals, organisations and end-users of the Norwegian Health National system. This could be achieved by a balanced combination of medical expertise, technology innovation and interdisciplinary research where new technological solutions can satisfactorily attend the demands of the health sector. In this context, the research project *eHealth-extended Care Coordination* evaluated the existing clinical workflow in an inter-municipal coordination (IMC) for dementia assessment. The ultimate goal of the project was to develop a *Collaborative Information System* (CIS) for assessment of dementia for patients from different municipalities. To accomplish acceptable levels of effectiveness, efficiency, and satisfaction, the creation of the final CIS was preceded by the essential phase of designing, evaluating and refining the implementation of a functional prototype. This paper presents the user-centred design (UCD) (De Vito Dabbs et al., 2009; Rogers et al., 2011; Nielsen, 1994) and evaluation of the user interface (UI) of a CIS for IMC dementia team. The prototype was designed with the active involvement of the end-users and led by a research team with the essential participation of an interaction designer. The prototype was conclusively validated from operational and a qualitative usability perspective.

The research questions (RQ) of this study were:

RQ1*: How can a functional prototype be developed for the collaborative evaluation and assessment of dementia taking into account the needs and the requirements of an IMC dementia team?*

RQ2: *What lessons from this study are transferable to real-world scenario and what methodological procedures are applicable to the development of technological solutions for other clinical workflows?*

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2 RESEARCH BACKGROUND

Research evidence shows that early assessment of dementia increases case findings (Borson et al., 2006; Harvan et al., 2006; Boustani et al., 2005; Callahan et al., 1995). However, negative attitudes towards assessment and diagnose represent barriers to efficiently diagnose cognitive deteriorations (Connolly et al., 2011; Boise et al., 1999; Borson et al., 2007). Due to the Coordination Reform (Norwegian Ministry of Health and Care Services, 2008-2009), municipalities are encouraged to establish IMC in order to carry out new specialised health tasks. For instance, IMC dementia teams have been established (Directorate of Health, 2011) for the assessment of dementia in neighbour municipalities. IMCs generally face the challenge of information flow across the different Information Systems. A CIS for IMCs can be a contributing factor to improve the information flow in the medical detection of dementia. The development of such system requires involvement of end-users to adapt system to the clinical workflow, taking into account that a qualitative usability evaluation can increase user satisfaction and improve operational procedures (Jaspers, 2009; Bastien, 2010; Kushniruk and Patel 2004).

This research study focuses on one IMC for collaborative dementia assessment formed by six especially trained health care professionals.

3 MATERIALS AND METHODS

The UCD process for the CIS was divided into four phases: user workshops, development of prototype, usability evaluation and graphic user interface evaluation.

3.1 User Workshops

Two workshops with end-users were set up in April and May 2013. The participants were two members of an IMC dementia team (mean age of 40.5 years) with an experience of two years from IMC dementia team and 11 years of clinical systems' use. An interaction designer responsible for the prototype development participated in the workshops moderated by two research team members.

The workshops had the aim to analyse the current workflow of the IMC dementia team, provide understanding of the context of use and establish user requirements. The workshops were arranged as interactive sessions and had an average duration of 2.5 hours. In first part of workshop 1, a patient scenario was created to map the workflow in the IMC dementia team. The participants described how they would like to interact with the CIS, making suggestions about the User Interface Design (UID). Colourful post-it notes (see Figure 1) and hand-made sketches were used to describe ideas for the functionalities and design of the CIS.

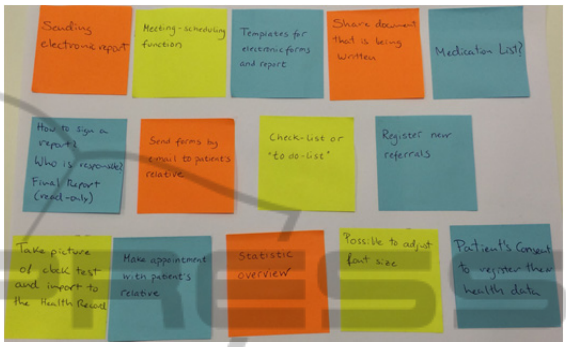

Figure 1: Post-it notes sample from user workshop.

In second part of workshop 1, the interaction designer presented wireframe sketches (see Figure 2) for the CIS, based on previous research in the project *eHealth-extended Care Coordination*. The participants gave feedback on sketches and made suggestions about the graphic user interface (GUI).

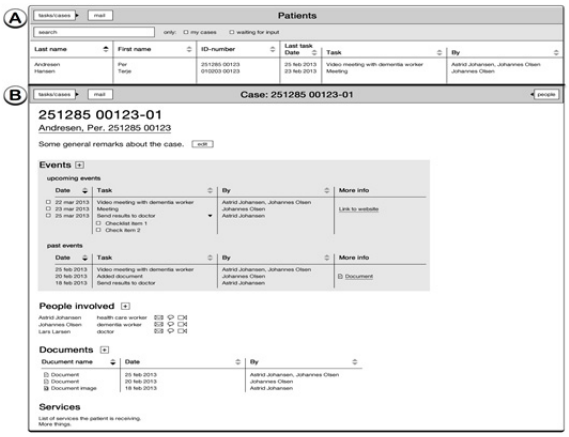

Figure 2: Wire frame sketches from user workshops. (A) Overview of patients' list. (B) Patient's information data.

In workshop 2, the interaction designer presented a graphical UI for the CIS, based on the patient scenario and the user suggestion from workshop 1 to demonstrate the proposed functionalities and interface design. The participants' evaluated and gave feedback on the proposed GUI.

3.2 Development of Prototype

Based on the user workshops, the interaction designer developed a prototype for the CIS. The prototype was developed as an interactive web application, implementing several of the proposed functionalities.

3.3 Usability Evaluation

As a part of the UCD process, usability evaluation was made with end-users performing representative tasks related to work in IMC dementia team.

The usability evaluation was carried out in the Usability Laboratory (Gerdes et al., 2014) at the Centre for eHealth and Healthcare Technology of the University of Agder in June 2013. The Usability Laboratory had a test room and observation room connected through an one-way mirror. The test room had a laptop and two video cameras and the observation room had monitors where the research team could follow in real time the evaluation being performed. The test participants were 5 IMC dementia team members, two male and three female, aged from 25 to 56 years (average of 45) and with an average of 13.6 years of experience using clinical systems. They evaluated their computer skills as 'medium'. The evaluation team had four members with health background and ICT background.

The test plan was based on the workflow description from the user workshops and followed a concurrent think aloud protocol (TA) (Jaspers, 2009; Kushniruk and Patel 2004; Nielsen et al., 2002; Fonteyn et al., 1993; Ericson and Simon, 1980). The evaluation was run in five individual test sessions that started with informed consent and a pre-test interview. The test session were guided by a moderator and had the duration of 22 to 38 minutes (average of 27 minutes).

A post-test questionnaire, Scale of Usability Satisfaction (SUS), (Brooke, 1996) was filled in individually and two post-evaluation group interviews (n=3, n=2) were conducted to qualitatively analyse the output of the test, with an average duration of 25 minutes.

3.4 Graphic User Interface Evaluation

A graphic user interface evaluation was made in December 2013 by teachers with graphic design expertise. There were 3 male participants, with average age of 45 years and average experience of 14 years in teaching web and interface design. They did not have previous experience with clinical systems. The evaluation was run in the Usability Laboratory as individual test sessions using a TA protocol with tasks related to graphic design and understanding of the user interface. The sessions had a length of 24 to 29 minutes (average of 26 minutes).

3.5 Data Collection

The user workshops, usability evaluation and graphic user interface evaluation were audio-visually recorded and transcribed verbatim and categorised based on qualitative content analysis (Lazar et al., 2010). In addition, the usability and graphic user interface evaluations used a screen capture tool.

This study was approved by Norwegian Social Science Data Services (project number 28027)

4 RESULTS

The results of each phase in the UCD process are separately presented.

4.1 User Workshops

The results of the user workshops are categorized into three groups.

4.1.1 Workflow of Dementia Assessment

The participants described the workflow (see Figure 3) for dementia assessment in an IMC dementia team as consisting of three main parts: preparation of dementia assessment, visit to patient's home and creation and sending of assessment final report.

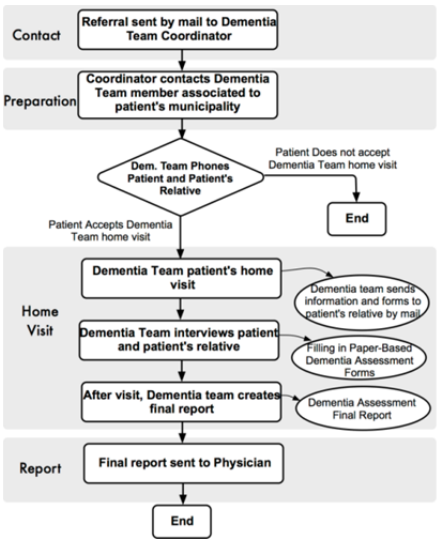

Figure 3: Inter-municipal dementia assessment workflow.

The information flow was mainly supported by phone and paper mail communication. The process started with a paper-based referral to dementia team coordinator, who established a dementia team for the individual patient by contacting dementia team member in patient's municipality and made an arrangement for visit to patient's home. In the home visit, paper-based dementia assessment forms were employed and afterwards the dementia assessment report was created by the dementia team and sent by paper mail to physician.

4.1.2 User Suggestions for Interaction with the System

The participants were asked in the workshops how the CIS could facilitate and improve work processes within the IMC dementia team. The main idea suggested was to provide a collaborative access to the system and improve the electronic information flow between the municipalities and ideally reduce phone and post mail communication.

4.1.3 User Suggestions for Interface Design

In terms of UID, users' suggestions referred to the visual organisation of the information on the screen. For instance, a typical "Log in" page with user name and password was mentioned as a mechanism to access the system. After entering the system, a "Home page" would allow to create a new patient record or find an existing one. When selecting an existing patient, a new page would show the health and administrative information related to the selected patient. In the same page, the patient's name should be clearly visible at the top: *There should be no doubt what patient record you are dealing with*. About the graphical layout, it was more important to have a good contrast than a wide range of colours: *Good contrast instead of too strong colours*. The users suggested having a design adaptable for both PC and tablet devices, since both would be used in the described scenario.

Users suggested electronic referral into system, with automatic transfer of name, birthday and address into CIS and also who referred the patient. In addition, a meeting scheduling function, check-list for tasks to do and video-conference and chat functionalities. They proposed SMS reminder or email before home visit to the dementia team members. Regarding dementia assessment forms, they proposed a digital version with pre-filled name from the system and the possibility of taking picture of relevant documents and information, e.g., clock test, paper referral and import them to CIS. They asked for remote access e.g., in patient's home, and also screen sharing for simultaneous report writing in two municipalities. A document had to be un-editable after finalised and signed by liable person. Finally, statistics with a selection function was proposed.

4.2 Development

Based on the user workshops, the interface design of the prototype for CIS for IMC dementia team was developed. Figure 4 shows the home page divided in two sections. The section on the left side (blue colour), shows the "Overview of patients' list" presented after users logged in. The patients under dementia assessment were placed at the top of the list. The patients earlier assessed were placed below the line. The right side (green colour) includes the statistical data. It contained information visualisation of data, such as age and gender.

Figure 4: Overview of patients' list.

By selecting one patient's name on the patients' list, the individual patient's data was presented as seen in Figure 5. Four sections were differentiated by colours: Tasks (purple), People involved (turquoise), Documents (red) and Patient's personal information (yellow). The goal was to satisfy user requirements by maximising the amount and usefulness of information showed at one glance that could be easily distinguishable and understandable without overloading the interface.

Figure 5: Patient's information data.

4.3 Usability Evaluation

The overall evaluation was positive, although not all the aspects of the system were optimally developed. Some of the issues were caused by the fact that the assessment was made of a prototype instead of a fully implemented system. The usability evaluation entailed 3 tasks, with a total of 15 subtasks and the analysis revealed 9 usability problems that were categorised into 3 groups. In addition, the scores of the Satisfaction Usability Score (SUS) questionnaire and post-test group interviews are presented.

4.3.1 Graphic Design

7 problems were identified. There were problems related to understanding of the meaning of icons, especially the external message icon and its size. The UI should have to entirely fill the screen in order to minimize user scrolling. For the task-list, it was not obvious whether tasks were done or had to be done, and that the meeting scheduling function and some numbers beside patient name in overview of patient list could be misunderstood. In addition, there was poor visibility of written text in overview of patients' list which needed for better colour or contrast. One stated: *The colours are very good because each theme has its own colour. So you can know, just by the colour, what you are choosing.*

4.3.2 Interaction with the System

In general the interaction during task solving was successful, but 2 problems were identified. For the interaction it was not clear how to switch view on the screen (threes stripes in the left up corner) and not all participants understood how to add information to system ("+" symbol on each heading).

4.3.3 Functionality of System Related to Work Processes

The possibility to communicate between municipalities through the CIS, instead of via phone or post mail as it is currently done, was greatly appreciated by participants. They were unanimously satisfied about the statistics function and stated that the video-chat function would provide the opportunity to collaboratively write a final dementia report at distance. Some added features were suggested, such as displaying patient distribution by municipality and the capacity of reporting different diagnoses to the government. The visualisation of the patient's information data was rated as useful and important, providing a good overview of key information visually separated by colours and where the patient's name was clearly visible and indicating which patient's record was opened. One participant of the usability evaluation stated: *I got a lot of important information at one glance: patient's general and contact information and about his relatives*.

Table 1: Satisfaction Usability Scale (SUS).

Question	P1	P2	P3	P4	P5	M	SD
Q1	4	5	4	5	5	4.6	0.5
Q2	2	4	1	2	1	2.0	1.2
Q3	3	3	4	3	5	3.6	0.9
Q4	1	1	2	4	1	1.8	1.3
Q5	4	4	3	4	5	4.0	0.7
Q6	1	1	2	1	1	1.2	0.4
Q7	4	4	5	4	4	4.2	0.4
Q8	1	1	2	3	1	1.6	0.9
Q9	3	4	3	2	4	3.2	0.8
Q10	2	4	5	3	1	3.0	1.6

P*i* = participant *i;* M = mean; SD = Standard Deviation

Positive Response: Agree or Strongly Agree for positive questions; Disagree or Strongly Disagree for negative questions

Neutral: neither Agree nor Disagree

Negative Response: Agree or Strongly Agree for negative questions; Disagree or Strongly Disagree for positive questions

4.3.4 Scores of Satisfaction Usability Scale

The scores of the SUS questionnaire are presented in Table 1 (modified version of MacLellan et. al., 2012 and Bangor et. al., 2009). Overall, the mean of the satisfaction ratings were on the range of "Agree" or "Strongly Agree" for the majority of answers to the positive questions (except one mean rating with neutral value), and in the range of "Disagree" or "Strongly Disagree" for the majority of answers for the negative questions (except two mean ratings with neutral values).

4.3.5 Post-test Group Interviews

Participants' comments gathered during the interviews expressed a need for user-training and self-exploration of the interface in order to learn more about how to use the system. One participant stated: *The system realistically fits in our current workflow; however I would need some user training.*

For evaluation of the final version of the system they suggested a test plan that followed the task scenario associated with a real patient case. In addition, performing an individual evaluation followed by a group one to analyse the system from a multi-personal perspective was proposed. For the UID, it was suggested that when placing the mouse cursor over an icon, its name should be displayed on the screen, which was also pointed out by the graphical specialists' evaluation. Readability and notification of new messages were relevant for the participants.

For the functionality of the system, interoperability with other existing systems was highlighted, which could ideally eliminate the need for transferring information between them. Participants also assumed that the chat function was a time efficient way to effectively communicate between colleagues (e.g., asking questions and getting the answers in a quick way).

4.4 Graphic User Interface Evaluation

The overall evaluation of graphic user interface of the prototype was positive, but there were some recommendations for design changes. The evaluation entailed 2 tasks, with a total of 13 subtasks and revealed 7 usability problems.

4.4.1 Graphic Design

4 problems were identified. The text in overview patients' list had poor visibility, were the contrast between the background colour and text white font could be improved by including a visible cell border between the rows. The icon for external messages and the 'x' for closing up patient information were confusing and could be replaced with more intuitive ones. Using lines instead of bars in the statistical charts improved the visual clarity and distinguished finished tasks from undone ones in the task list.

4.4.2 Interaction with the System

The interaction with the CIS during the task solving was generally successful, but 3 problems were identified: when mouse hovers over icon text should be shown related to the associated action; a mechanism to navigate backwards should be inserted for avoidance of using browser back-oriented arrow; a confirmation notification window was lacking when adding a new team member

4.4.3 Overall Evaluation

The test participants positively agreed that the system was designed using validated methods for designing interfaces. One of them stated that: *The system is clear, easy to read and understand.*

The abundance of colours was justified because they visually informed users about the section's functionality in which they were currently working on. It helped to distinguish different sections at one glance. Monochromatic or black and white set of colours would have probably blurred the different section functionality. This was expressed during the evaluation: *From the design point of view, the colours are used to separate elements, which works well to get the overview of the screen. This would diminish user training.* However, it was reported an insufficient system structure overview because the different sections of the system could be only accessed by scrolling down. Instead, providing redundant access through a menu with the same colours at the top would probably be more effective giving a direct access to the sections eliminating scrolling action. On the "Home page", the information load was rated as "too high" but the overall rating was balanced by the correctly structured sections, placing the most relevant at the top.

5 DISCUSSION

The elaboration of a CIS to be used by IMC dementia teams was developed following a UCD process. The aim was to support and ease the

existing workflow with a technological solution that allowed electronic access, storage of patient data and served as a communication tool. For the RQ1 that enquired about the prototype development for IMC dementia team, it was found that a UCD approach effectively took on board users' needs regarding the current workflow of operation. In addition, a test of such workflow incorporating the prototype in simulated clinical settings together with a qualitative usability evaluation was decisive in the development and refinement of the prototype. For the RQ2 about the lessons applicable in real-world scenarios, the study has shown that a fully-implemented system based on the prototype presented, potentially avoids the risks associated to paper-based procedures. Lessons learned throughout this study are three. Firstly, the workshops with representative users became essential to gathering the system requirements. Secondly, through the same workshops it was possible to acquire the understanding of the current workflow of operation of an IMC dementia team. Thirdly, the evaluation of the prototype tested was performed from a usability and graphical expert perspectives.

The end-users' and graphic professional's evaluations of the system were generally positive. The workshops provided a key insight in the dementia assessment workflow and how the interaction with the CIS functionality would best fit the existing work processes. The suggestions about the UID were made in line with the need to visualise useful information at one glance at the same time that the functionalities of the system were clearly differentiated, for instance, by colours.

In the qualitative usability evaluation the graphic design and colour scheme used was generally approved and some features were pointed out as potentially confusing, such as icons and heading wording. This is consistent with the development of prototypes in early stages of UID (Snyder, 2003; Nielsen, 1993). The iteration process expected in future work precisely refines these types of potentially problematic findings. One of the most acclaimed features was the possibility of communication through the system by messages and chat. The statistical summary offered by the system was unanimously satisfactory because of its contribution to the workflow.

Finally, the graphic interface evaluation was made by professionals in the field (Acevedo et al., 2008; Tory et al., 2005) and valuable recommendations were incorporated into the design of the next iteration of the prototype.

There were some limitations associated to this research study. Firstly, although the laboratory facilities realistically represented the work environment, the study was performed in a simulated environment. Therefore, caution is required in the direct transferability of the results to a real-world scenario. Instead, this study might be seen as a necessary step for the validation of the controlled conditions that should be carried out before the use of the system in real clinical settings. Secondly, the reduced number of participants in the UCD process might be seen as an impediment of the applicability of the findings in a larger scale. However, in qualitative usability studies a small number of participants can be sufficient for having valid results (Nielsen and Landauer, 1993). Thirdly, the prototype was not completely operative compared to a fully implemented system. Nevertheless, the prototype provided a satisfactory simulation of how users could hypothetically interact with the system in a real scenario.

6 CONCLUSIONS

This work was framed inside the project *eHealth-extended Care Coordination*, which revealed a need for improving communication processes with efficient technology within IMCs. In this study, a UCD process was employed in the development of a working prototype. The CIS would ideally be the core for a fully-implemented system potentially adaptable for any health IMC's team. The end-users' participation in workshops allowed gathering key information to build the prototype based on user needs and requirements. The usability evaluation together with graphical assessment of the prototype led to the positive refinement of the functionality, effectiveness and *look and feel* of the solution. In addition, the resulting UI established the foundation for the technological solution implemented in the FP7 EU project United4Health (United4Health, 2014), currently being successfully used in IMC in Norway.

Future research will include a full implementation of the system, with its corresponding evaluation in the field from a usability and operational perspective.

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