

Usability Evaluation of a Collaborative Health Information System

Lessons from a User-centred Design Process

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Abstract: In Norway, a recent health reform urged municipalities to implement new primary health care services for their citizens. In order to optimise resources, municipalities have established inter-municipal coordination (IMC) to collaborate across organisational borders. Information systems become a necessary tool to support collaboration and shared access to information in an IMC. In this context, the research project *eHealth-extended Care Coordination* identified a specific need for a collaborative information system for the process of evaluation and assessment of dementia in IMC teams. This paper presents the usability evaluation of a collaborative information system for dementia assessment built using a user-centred design approach. Mixed methods such as observations, semi-structured interviews and a questionnaire were used for data collection. The results showed that the new information system supported the collaborative work of the inter-municipal dementia team with a sufficient level of satisfaction among the end-users. The prototyped solution established the foundations for the system implemented in the Norwegian trials of the FP7 EU project *United4Health*, dedicated to Point-of-Care Services.

1 INTRODUCTION

In Norway, the Coordination reform (Norwegian Ministry of Health and Care Services, 2008-2009) addressed the continuity of care in national health and care services. Services that traditionally were carried out by specialised health care were transferred to primary health care provided by municipalities. Small and medium size Norwegian municipalities faced the challenge of providing specialised services to their citizens, accomplishing the need for structural, organisational and technological changes. This brought to light the need for an effective coordination and collaboration across organisational borders.

In this context, the research project *eHealth-extended Care Coordination* (Samhandling uten grenser) 2011-2015, focused on information flow in inter-municipal cooperation (IMC) health care teams. In the first phase of the project, a field study identified the need for a collaborative information system (CIS) to improve the information flow in

IMC health care teams. In the second phase, an IMC dementia team participated in a user-centred design (UCD) process entailing user workshops, laboratory evaluations and interviews for developing a functional prototype for a CIS for dementia assessment (Smaradottir et al., 2015b). In the third phase, a usability evaluation of electronic dementia assessment forms for home visits and a videoconference solution for collaborative report writing were performed with the participation of an IMC dementia team (Smaradottir et al., 2014).

This paper reports from the fourth phase of the project. The final version of the CIS was developed and a usability evaluation was carried out together with end-users in order to validate whether the system accomplished acceptable levels of effectiveness, efficiency and satisfaction. In addition, reflections from the UCD process that involved the IMC dementia team are presented.

The research questions (RQs) of this study were:
RQ1: *How can an information system be evaluated taking into account the needs and requirements of*

the end-users for collaborative access and information sharing by an inter-municipal team of dementia assessment?

RQ2: *What lessons and methodological procedures from this study are transferable and applicable to development of technological solutions for other clinical assessment workflows?*

2 RESEARCH BACKGROUND

Dementia is a clinical syndrome with deterioration of mental abilities and cognitive skills (Gustafson, 1996). For assessment of the cognitive aspects of dementia, a widely used method is the cognitive mental status examination, the *Mini-Mental State* (MMS), (Folstein et al., 1975). The MMS is a set of questions whose scored answers result in a category of cognitive mental status.

A dementia plan was implemented in Norway in 2007 (Norwegian Ministry of Health and Care Services, 2007), aiming at improving capacity, competence and quality in dementia care and enhancing the need for qualified competence in primary care. However, due to the small or medium size of many Norwegian municipalities, specialised IMC dementia teams have been established (Directorate of Health, 2011) to collaboratively carry out the assessment of people with dementia in neighbour municipalities.

Recently, a Delphi study with experts in coordination and IMC in health services reached consensus about the challenges concerning electronic communication. Specifically, the lack of tools impeded the collaboration of IMCs (Holen-Rabbersvik et al., 2013). Therefore, IMC dementia teams face challenges generated by their nature of operation, such as limited information flow across the municipalities and interoperability problems between different information systems (IS). The aim of developing a CIS for IMC dementia teams was to provide a platform that supported the information flow and collaborative work across municipal borders.

An effective IS requires a detailed analysis of end-users' needs to inform system design. In addition, the usability of such application is crucial for the continuous, efficient and satisfactory use of the system. In system development, the approach of UCD involves end-users throughout the each stage of the development cycle (Lazar, 2006; Gulliksen et al., 2003; Nielsen 1993). UCD considers the needs of the end-users through field studies, evaluations and task analysis, helping to understand context of

use and workflow, which are key elements for the construction of an IS for a clinical workflow (Chan et al., 2011; Goldberg et al., 2011). In addition, usability evaluation is necessary to analyse user's interaction and user satisfaction with the system (Jaspers, 2009; Kushniruk and Patel, 2004; Lazar et al., 2010).

3 MATERIALS AND METHODS

The prototype from the earlier phases of the *eHealth-extended Care Coordination* project was further developed by an industry partner as a full functioning version of the CIS which was implemented within the secure Norwegian Health Network (NHN, 2015). The evaluation of the CIS was executed during two days in June 2015 and entailed three steps: (1) test in usability laboratory with end-users, (2) individual questionnaire and (3) group interview. A mixed methods research approach was used including observations, interviews and a questionnaire.

3.1 Usability Evaluation

The usability evaluation was made with end-users in a laboratory. The facilities had two rooms (test and observation) connected through one-way mirror (described in Gerdes et al., 2014). In the test room, the system was accessed and used on a laptop connected to an external screen and keyboard. In the observation room, the evaluation was followed by the research team in real-time through four monitors connected to two stationary computers.

5 participants (4 female, 1 male; aged 41-57, average 55.6 years) with the professions nurse, nurse coordinator and social educator, took part in the tests. They were all members of an IMC dementia team from 4 municipalities. They reported an average of 16.8 years of experience using clinical systems and evaluated their computer skills as *medium*.

Each test session started with a pre-test interview with questions about background and experience with clinical systems. A member of the research team moderated each session. Participants were asked about their first impression of the graphical user interface (GUI). A concurrent Think Aloud protocol (Jaspers, 2009; Kushniruk and Patel 2004; Ericson and Simon, 1980) was employed. The task list included 9 differentiated tasks to perform within the system. After each task, the participants were asked to score the task solving into five categories:

very easy, easy, medium, difficult and very difficult. The tasks were based on the IMC dementia team workflow description from the UCD workshops (Smaradottir et al., 2015b). The test sessions had duration of 39 to 62 minutes (average 47 minutes).

3.2 System Usability Scale

In order to evaluate the user satisfaction, the participants individually answered the post-test questionnaire System Usability Scale (SUS) consisting of with 10 questions (Brooke, 1996).

3.3 Group Interviews

In order to complete the feedback, two post-test semi-structured group interviews (n=2, n=3) were conducted to qualitatively analyse the output of the test (average duration 37 minutes). The CIS was shown on a screen during the interviews, allowing the participants to follow in detail the GUI and comment on its functionality. The main findings from the usability evaluations were also discussed.

3.4 Data Collection

Audio-visual recordings were made with two cameras (1 fixed and 1 portable) and a screen capture tool (in usability evaluation) merged into one single video file using the software Wirecast v.4.3.1. The recordings (.mov format) were imported into QSR NVIVO 10 for transcription and a qualitative content analysis (Lazar et al., 2010). This study was approved by Norwegian Social Science Data Services (NSD, 2015) with project number: 37920. All participants signed a consent form.

4 RESULTS

The results are presented following the three steps of the evaluation.

4.1 Usability Evaluation

The test started with the screen patients' overview (see Figure 1) and questions about participants' first impression of the GUI. They generally stated that the screen was useful to get a fair overview of patients. Three participants positively commented on the search function used to find a specific patient. About the GUI, comments highlighted the appropriate choice of colours, with the exception of poor readability and contrast of black text over blue

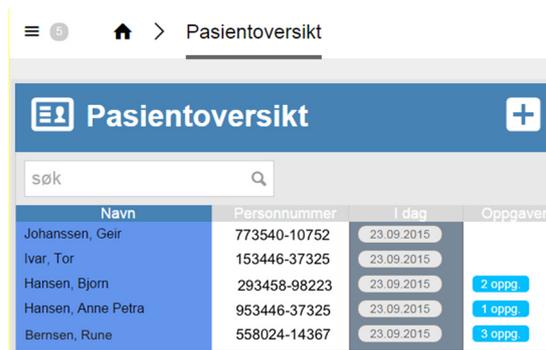


Figure 1: GUI of patients' overview.

background in patients' overview screen. It was pointed out that it could be difficult to read white text sections, especially in rooms with bright light. In addition, the insufficient font size both in text and headings was stated recommending to adapt the GUI to the full screen size. Suggestions included being able to run a search writing only 3 letters and increasing the speed of the search results.

On each individual patient's view, comments of the GUI (see Figure 2) confirmed the abundance of colours, intended to visually inform about the sections' functionality. In this line, participants commented: *I liked the choice of colour and graphic design. Very clear and easy to read. When you are working on a patient, the colours can tell you where you are.* Patient's key information was coloured as a yellow section and placed at the top right.

4.1.1 Task Performance

All 5 participants successfully solved all the tasks, with different degrees of help from the moderator.

Task 1: Add a new patient to CIS

Participants had to click the '+' sign to access administrative functionalities and be able to register a new patient into the system (see Figure 3). The task was unanimously scored as *easy*. 2 participants had errors with the

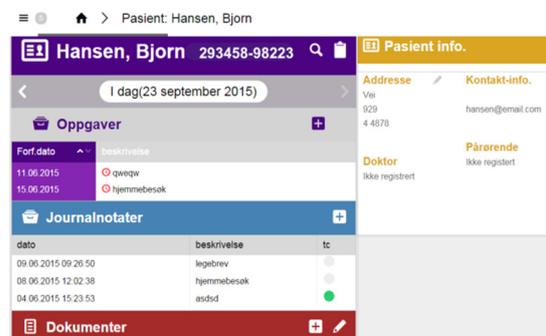


Figure 2: Individual patient's view.

Pasientens navn:	Opprettet av:	Opprettet:	Aksjoner
Berssen, Rune	IS APPPOOL.DefaultAppPool	25.04.2015	Red. pasient Legg til personell Slett sak
Hansen, Anne Petra	NHN\ntno-runefo	12.09.2015	Red. pasient Se personell Slett sak
Hansen, Bjorn	NHN\ntno-runefo	04.09.2015	Red. pasient Legg til personell Slett sak
Ivar, Tor	NHN\ntno-runefo	24.08.2015	Red. pasient Legg til personell Slett sak
Johanssen, Geir	NHN\ntno-runefo	24.08.2015	Red. pasient Legg til personell Slett sak

Figure 3: GUI of administrative functionalities.

input format while registering patient's birthdate, having to try few extra times. Suggestions were made about having text boxes with the exact format of the field to avoid errors. Error messages would have to be written in colour to improve readability. When typing a post code, the city would have to automatically appear. The labelling of the button to register a new patient was suggested as save instead of create as a more intuitive description. The list of patients was suggested to be sorted either alphabetically or chronologically; for the chronological order, the newest patients would be placed at the top.

- **Task 2: Add General Practitioner to CIS**
To solve the task, the administrative functionality of the GUI had to be accessed and *health care professional* be chosen as action for data input. All participants needed help to solve the task, one participant needing up to nine attempts. Task was scored as *difficult* and finding administrative functionality was tagged as *problematic*. 2 system errors were identified relating to repetition of information: 1) when clicking twice on *create*. In this case, patient was stored twice with the same name without notifying the user. 2) when typing a long email address the phone number field became invisible due to lack of space.
Comments on navigation issues in the GUI: *Information input was ok, but the navigation was difficult. The task was difficult to solve, because the problem was navigation.*
- **Task 3: Add relative into CIS**
To solve the task, the administrative functionalities of the GUI had to be accessed. Then, *health care professional* had to be chosen and change the role to *relative* for data input. 4 participants successfully solved the task without help; one of them tried few times before succeeding and another asked for help.

3 participants scored the task as *easy*, 1 as *medium* and 1 as *difficult*. Participants suggested being able to add different types of relatives such as *closest relative*, *friend*, *guardian* or *other*. They also suggested that it would have been preferable to be able to make a priority list of whom to contact in case of multiple relatives registered. Comments related to understanding how the roles were interpreted in CIS: *I found health care professional but did not understand that it was the right one, and the role had to be changed to relative. It is difficult when I have not seen the system before... Difficult to navigate, the input was easy.*

- **Task 4: Navigate to patient's view in CIS**
To find the new patient's view, firstly the icon *home* had to be selected and then selecting patient's name in order to enter patient's view. 4 participants successfully solved the task and one needed help after two incorrect actions.
- **Task 5: Add a task into the Patient's View**
It was necessary to click on '+' symbol in the section *Tasks* to solve the task. 3 participants successfully solved the task, although 2 needed help: *I did not see the heading Tasks... I did not see tasks, did not understand to watch on top.* 2 participants scored the task as *easy*, 1 as *medium* and 1 as *difficult*. One word regarding who to perform an action was misunderstood and that led to confusion.
- **Task 6: Upload a referral into CIS**
Participant had to click the '+' symbol in *Documents* section and upload a document to solve the task. 2 participants successfully solved the task and 3 needed help. 2 participants evaluated the task as *easy*, 1 as *medium* and 1 as *difficult*.
- **Task 7: Upload a dementia assessment report into CIS**
The task was similarly solved as task 6, adding a document and uploading it. All participants successfully solved the task and graded it as *easy*: *Now I have tried this once before.*
- **Task 8: Upload the clock-test into CIS**
The task was solved similarly as task 6 and 7, adding a document and uploading it. All participants successfully solved the task and graded it as *easy*: *Now I start to understand how the program is organised.*

- **Task 9: Write a journal note into the just-registered patient's view**

Participants had to click on the '+' symbol in the *Journal note* section to solve the task. All 5 participants successfully solved the task and graded it as *easy*.

4.2 System Usability Scale

The scores of the SUS questionnaire are presented in Table 1. The colour visualisation scheme presented is a 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*, *Strongly Agree* or *Neutral* for the majority of answers to the positively enunciated questions and in the range of *Disagree*, *Strongly Disagree* or *Neutral* for the majority of answers for the negatively enunciated questions.

Table 1: Responses of System Usability Scale (SUS).

Question	P1	P2	P3	P4	P5	M	SD
Q1	3	3	4	4	3	3.4	0.5
Q2	4	2	1	3	3	2.6	1.1
Q3	3	4	4	3	3	3.4	0.5
Q4	1	2	1	3	1	1.6	0.9
Q5	4	4	5	4	3	4.0	0.7
Q6	2	2	1	3	2	2.0	0.7
Q7	5	4	4	4	4	4.2	0.4
Q8	2	5	1	2	2	2.4	1.5
Q9	3	4	3	3	3	3.2	0.4
Q10	2	4	1	3	2	2.4	1.1
Pi = 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 Post-test Group Interviews

The group interview results are presented in four categories.

4.3.1 Test Scenario and Procedure

Participants defined the test experience as exciting and similar to the earlier tests. They found that the questions made after each task to grade the difficulty of the task accomplishment were slightly more difficult to answer. A participant commented on it: *I did not find everything, but still I don't think this was a complicated program. When you receive help*

once, then you learn how to do it and it is easier next time. If I had used longer time during each task I would have probably found it by myself.

4.3.2 User Training

Participants suggested that having user training in advance would have been useful and, in addition, would help them to provide more feedback. They commented that in their daily basis, they have user training when new functions and updates are implemented in the systems. One participant commented: *If I had been allowed to sit 10 minutes by myself to explore the system, the test would have been much easier. [...] If we had been instructed in advance about the three main elements I would have understood the structure earlier.*

4.3.3 Navigation

Participants found the data input for all tasks *easy* with good visibility of the displayed information. Participants found difficult how to access patient's journal from the administrative section (task 4). In this line, one participant commented: *It was not obvious; I would not have found it without help.* In general, they suggested as few clicks as possible, displaying some information only in request (e.g., email address, contact information to GP) using icons.

4.3.4 Municipal EHR versus CIS

The IMC dementia team used a municipal electronic health record (EHR) system in their daily work. Even though participants were positive earlier in the research project towards the new collaborative information system, in this evaluation they expressed some scepticism about the co-existence of the new system with the ones previously used by the team: *I would find it a bit cumbersome to have two different systems, one system for the inter-municipal dementia team, and one for everything else. [...] I would not like to change the system we have now, since we would have two systems to use. I don't think that is smart and would be more difficult to work.*

One of the reasons argued was that the initial circumstances when the project started have changed throughout the project period. One participant commented: *We get new tasks all the time and that demands more from us. We need to ease the working processes as much as possible. We should not have too many programs to use. I am afraid that this system will cause double work, instead of having one*

single system. Four years ago, I was much more positive, because then, we did not have e-messages or access to EHR systems in other municipalities. Some of the problems we had at that time are now solved. The implementation of e-message (1.5 years ago) did revolutionise our daily work. The dementia report is now sent as e-message. In addition, we are now used to the tablet and to take a picture of the clock test to upload into the municipality EHR, instead of scanning as we did earlier. So there are fewer papers involved now.

Another participant stated: *Instead of implementing a new system, I would suggest a collaborative space in the [municipal EHR]. That would be helpful, with collaborative access for the inter-municipal dementia team to the patients undergoing dementia assessment.*

Another reason was that, when the project started, the IMC dementia team was recently established and they were inexperienced as a collaborative team. Since then, they have had over a 100 dementia assessments. Routines have been improved and less time is now used on each home visit and in the report writing. In addition, the laws regarding shared access to medical information across health organisations have been changed during the project period, and the nurse coordinator now had acquired legal access to the EHR systems in the involved municipalities (even though with separate username and passwords for each system to log in). Although the participants expressed a sceptical attitude towards implementation of the CIS, it was stated: *I like this new system and would find it helpful. In [municipal EHR] there are too many clicks and the information input is much more complicated.* Another participant commented: *Anyhow, I think this system would be useful. In [municipal EHR], I need to search a lot for information. I liked the visibility of the key information.*

Overall, participants positively commented the participation in the research project: *The participation in this project has been interesting. They received the news that the outcome of the earlier phases of this project informed the creation of another IS for remote monitoring of COPD patients: Nice to hear that what we have participated in has been used in another system, living its own life. [...]* *So our contribution already has come to use.*

5 DISCUSSION

In this paper, the usability evaluation of a collaborative information system for an IMC dementia team has been presented. The aim of the IS was to provide a platform that supported the information flow and collaborative work across municipalities' borders. An effective IS requires a detailed analysis of end-users' needs, preferences and suggestions to inform system design. For this reason, a UCD process was employed involving end-users in design and evaluation throughout the entire development cycle.

The two research questions presented at the beginning of the paper were answered based on the results of this study. About the RQ1, which asked about how to take into account user needs and requirements in the evaluation of a new IS, the study showed that the mixed methods approach efficiently considered user needs in the evaluation of the system. The approach was divided in three stages. The first stage was the evaluation in the usability laboratory, where participants performed a series of tasks based on the IMC dementia team workflow description provided by the users in earlier UCD workshops. This test enabled users to give useful feedback and first impressions about the GUI, functionality and interactions with the system. The second stage included a questionnaire (SUS) with 10 questions related to user satisfaction after task solving. It showed that, overall, participants were generally satisfied with the use of the system. The third stage included post-evaluation semi-structured group interviews that allowed participants to discuss the main findings with the research team and spontaneously make any suggestions. This stage gave the opportunity to participants to make comments and exchange impressions in a group, rather than individually, what presented the research team with new situations to learn from and which were not previously considered (e.g., slight reluctance to final implementation due to potential integration problems with coexisting systems and user work overload).

Several lessons were learned during the UCD process that can be transferable for the development of solutions for other clinical assessment workflows (RQ2). Firstly, the creation of clinical systems requires active and continuous involvement of the end-users in the design and evaluation of the solution. Secondly, the circumstances for the context of use may change over the study's time span. The nature of this research was linked to a Norwegian research project with the time duration of four years.

The key requirements for the system that were gathered in a field study and several user workshops in an early project phase changed as the project evolved. For instance, new functionalities provided and included in the collaborative information system were, during the project time, also implemented in parallel in existing systems. At the end of the project, this resulted in a reduction of end-user interest in using the new system because they reported that improvements were already in place in existing systems. In addition, due to recent law changes, shared access across municipal borders was now allowed improving information flow and electronic communication. Thirdly, new system integration with existing systems is vital to, at least, not increase user workload. This is a logical consequence of the previous lesson.

There were some limitations associated to this study, such as the use of a simulated test environment and a reduced number of end-users. Firstly, although the laboratory setting realistically simulated the work environment and representative end-users carried out the tests for validation of the system, the study was performed in a simulated instead of real environment. This should be seen as a first step in the validation, complemented by a test of the system in real clinical settings through a field trial would be recommended before final implementation. Secondly, the reduced number of participants in the usability evaluation might be seen as an impediment of the applicability of the findings in a larger scale. However, the participants meaningfully represented the end-users of the system and in qualitative usability studies, a small number of participants can be sufficient for having valid results (Nielsen, 1994; Nielsen and Landauer, 1993).

6 CONCLUSIONS

This study was framed inside the project *eHealth-extended Care Coordination*, which aimed to develop a collaborative information system to be used in dementia assessment to improve the information flow between the members of an inter-municipal team. The system would ideally be the core for IMC health care teams, potentially adaptable for other clinical workflows. A UCD process was employed throughout the whole duration of the project, in which all the versions of the system were evaluated and tested. The usability evaluation, together with graphical assessment and group interviews of the system, identified

refinements in order to improve the functionality and effectiveness of the solution before implementation. The SUS questionnaire showed a high score of user satisfaction.

The time span of the project, to which this study belonged, was four years. This period represents a substantial amount of time in clinical environments, usually associated with an increased demand for technological solutions that quickly and easily adapt to continuously evolving workflows, requirements and existing systems. Therefore, when implementing a new system, functionality should not duplicate the one from existing systems. In addition, there is a need of rapid development of new ICT capable of integration with other parallel activities and systems. These systems are typically used within organisations facing continuous changes as in the health care services.

The initial GUI of the CIS for dementia assessment established the foundation for the user-centred design and development of an information and management system for remote telemedicine monitoring of COPD patients at home (Smaradottir et al., 2015a), which has been implemented in the FP7 EU project United4Health (United4Health, 2015), currently being successfully used in 3 inter-municipal telemedicine centres in Norway.

Future research would include a full implementation of the system, with its corresponding evaluation in the field from a usability and operational perspective. In addition, a comparison of the new and the already existing system would provide useful results.

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