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Usability Evaluation of a Guideline Implementation System for Cardiac Rehabilitation: Think Aloud Study

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Abstract. Guidelines on cardiac rehabilitation (CR) state that a patient-tailored, comprehensive CR programme should be constructed for each patient based on a structured needs assessment procedure. We performed a usability evaluation with seven end-users of the MediScore CARDSS 2.0 system which implements such a procedure based on the Dutch guidelines. The analysis showed that users deviated strongly from the predefined data entry order; could not complete all subtasks for a complete needs assessment procedure, and needed more navigation actions than minimally required. We conclude that the design model of systems which implement guidelines requiring data entry should adapt to users' mental model concerning data entry to guarantee complete data collection.

Keywords. Usability Evaluation; CCDS; Cardiac Rehabilitation.

Introduction

Cardiac rehabilitation (CR) is a multidisciplinary therapy to support heart patients recover from a cardiac incident or intervention, and aims to improve their physical and psychological condition [1]. Consistent with international guidelines, the Dutch guidelines for CR state that patients should be offered an individualized rehabilitation programme based on their medical, physical, and psychosocial needs [2]. Traditionally this programme is formulated during a 30 to 60 minute clinical patient interview. To structure this interview the guidelines include a paper-based clinical algorithm for an extensive needs assessment procedure (NAP) [3]. This algorithm was designed in collaboration with CR professionals and is used in practice by rehabilitation nurses and physiotherapists [4]. It consists of fifteen numbered flowcharts across five domains, each describing how to select rehabilitation goals and therapies based on 155 to 175 collected patient data items (including eight questionnaires). During the interview with the paper-based NAP the order of data collection is flexible and can be adapted to professionals' own preferences. Complete data collection is important though to construct a patient-tailored, comprehensive rehabilitation programme according to the guidelines. A structured NAP should reduce interpractice variation in the offered health care and is in line with recommendations from the Chronic Care Model. This model is widely used to improve quality of care for chronic patients [5].

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To stimulate implementation of the CR guidelines in the Netherlands, an electronic patient record system with computerized decision support facilities, called MediScore CARDSS 2.0, was recently developed by ItéMedicel BV, a Dutch commercial vendor in healthcare IT. The system has evolved from an earlier system, developed in 2004 by the University of Amsterdam that was based on similar but less extensive guidelines. In a cluster randomised trial, it was shown that the previous system increased adherence of healthcare professionals' decisions with guideline recommendations [6].

To assess the new system's design for performing the CR NAP on usability, a beta version of MediScore CARDSS 2.0 was made available for an evaluation with potential end-users. The aim of this study was to evaluate 1) task efficacy of the system with respect to completeness of data collection; 2) fit between the system's design model of predefined data entry order with the users' mental model, and 3) task efficiency of the system with respect to users performing all subtasks needed to complete a CR NAP.

1. Methods

The MediScore CARDSS 2.0 system's design model implements data entry in the exact order of the flowcharts of the Dutch paper-based clinical algorithm for CR. The system concerns registration of administrative patient data, entry of clinical and health-related patient data, and finally selection of goals and therapies for a patient-tailored rehabilitation programme. The entry of clinical and health-related data is partially static, e.g., standard questionnaires for quality of life and lifestyle assessments, and partially dynamic, i.e., flow through data items depends on previously entered data. To support complete data collection during the NAP, the system guides users in 53 screens through all domains of the algorithm. Figure 1 shows one data entry screens in the system.

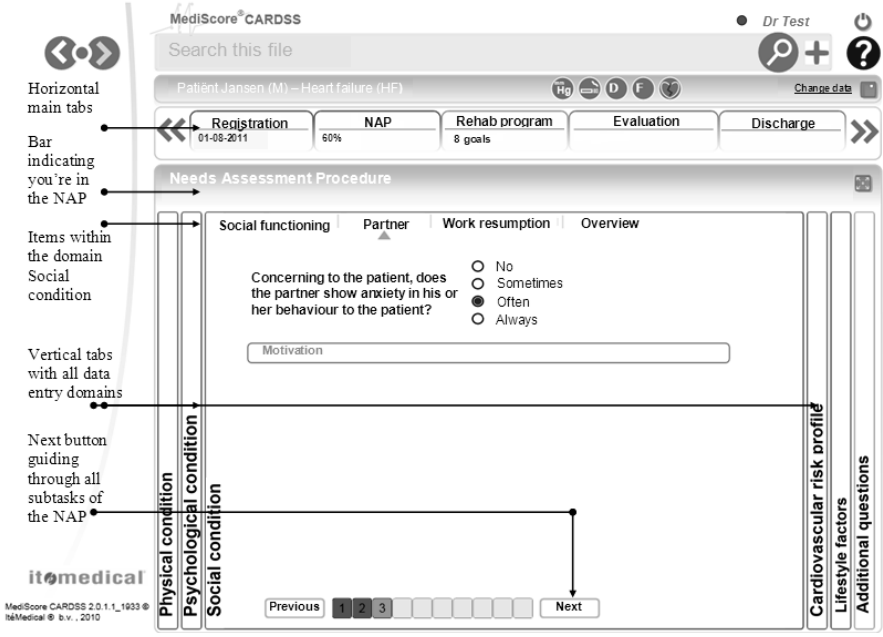

Figure 1. Screenshot MediScore CARDSS 2.0: NAP data entry concerning the patients' social condition.

Flow through the system is supported with a 'next button' on each screen. Alternatively, navigation controls such as vertical tabs displayed on both sides of the computer screen can be used to deviate from the predefined data entry order. After entering all available data the system provides its users with a patient-specific, guideline-based rehabilitation programme, consisting of recommended rehabilitation goals and therapies. For each goal and therapy users can either select that they adhere to the recommendation or that they deviate from it because of e.g. professional expertise, patient preferences, or lack of resources. Furthermore the programme incorporates an electronic patient record for CR, background information from the guidelines and some functions specific to the working procedures in the multidisciplinary outpatient care setting.

We used the think aloud method to evaluate problems end-users encountered in interaction with the system [7]. Seven representative, potential end-users familiar with paper-based NAP and with explorative system experience performed a CR NAP on their own workstation. They entered data from 1) a fictitious patient case and 2) a real patient case from their own clinic. In both cases basic system functionalities were covered by asking the users to complete seven main tasks: patient registration, entering data concerning the patient's physical condition, psychological condition, social condition, cardiovascular risk profile and lifestyle, and finally selecting goals and therapies for a patient-tailored rehabilitation programme (see Table 1). Each main task is itself composed of several subtasks, e.g. defining the patient's social condition requires the entering of data about social functioning, the partner and work resumption. We identified a total of 41 subtasks. For the system usability evaluation with the fictitious patient case, users received all patient data in the predefined system data-entry order. In the real patient case, users were asked to perform the NAP by entering data derived from a paper record from a patient recently treated in their own clinic.

We used a mobile 'usability lab' consisting of a laptop with Morae™ software to capture screen, mouse gestures, keystrokes and the participant's facial expressions and verbal reactions. Participants first performed a practice task to get accustomed with talking aloud before starting with the two cases. All recorded data were analyzed with the Morae™ software. We assessed the: 1) the number of tasks and subtasks successfully completed by each user; 2) the frequency with which users deviated from the system's predefined route through the CR NAP, and 3) the difference between the theoretical minimum and actual number of mouse clicks users needed to complete each of the subtasks successfully. A task was considered completed when each of its subtasks was completed; partial completion of tasks was not possible. Associations between the number of mouse clicks, deviation from the predefined data entry order, and task completion was investigated by linear regression analysis.

2. Results

All seven end-users had more than three year of general computer experience, five of them were female, and four of them had used the previous version of the system. Besides four nurses, a social worker, secretary and physiotherapist were involved. Table 1 shows that on average users successfully completed 2.2 out of the 7 main tasks (30%) needed to perform a complete CR NAP. Concerning the subtasks they completed 30 out of the 41 (73%) successfully. The subtasks concerning patient registration had the highest completion rate (86%). Subtasks with the lowest

completion rates were entering patient data concerning the cardiovascular risk profile (62%) and lifestyle (64%). Fewer subtasks were completed when users entered the data of a real patient case (63%) compared to data entry of the fictitious patient case (82%).

On average, users deviated in 41% of the steps taken from the predefined next system step. The deviation was larger during the data entry process of the NAP for the real patient case using the interview report in the paper record (45%), than in the data-entry process for the fictitious patient case (38%). Regression analysis showed that users who deviated from the predefined data entry order also completed fewer tasks. On average, each 40 deviations were associated with one task less being completed.

For completed subtasks for the NAP for one patient, users needed on average 321 mouse clicks: 146% (range 108% - 245%) of the minimum number of mouse clicks (241). For the fictitious patient case this was 156% (range 125% - 245%) of the minimum, and for the real patient case 136% (range 108% - 179%). Regression analysis showed that users with the highest number of mouse clicks had higher deviation rates from the predefined order of system tasks than users who followed the predefined order. On average, each deviation was associated with six mouse clicks.

Table 1. Results of the usability evaluation: Tasks and subtasks completed and mouse clicks needed.

	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	TOTAL
# subtasks per task / # mouse clicks minimally required	4 49	6 85	7 59	5 23	7 29	8 40	4 54	41 339
Fictitious patient case								
Task completion	6/7	0/7	6/7	4/7	2/7	1/7	1/7	2.9/7
Average subtask completion	96%	83%	98%	89%	73%	70%	75%	82%
Average mouse clicks needed for completed subtasks	151%	114%	109%	164%	240%	131%	182%	156%
Real patient case								
Task completion	4/7	0/7	2/7	2/7	0/7	0/7	1/7	1.3/7
Average subtask completion	75%	62%	61%	71%	51%	59%	75%	63%
Average mouse clicks needed for completed subtasks	145%	108%	139%	131%	194%	117%	115%	136%

3. Discussion

Computer-based guideline implementation systems that provide patient-specific recommendations based on data entry can improve guideline adherence and patient outcomes [8]. To stimulate optimal implementation of these systems and the underlying guidelines, the systems' design model ("the way the designer represents the system's functionalities to the user, including screen presentations, interaction structure, and object relationships") should match the user's mental model ("the way that the user perceives that the system works based on his mental processes") [9]. In this study we found that the MediScore CARDSS 2.0 system's model of predefined order of system data entry tasks for the CR patient NAP did not fit the mental model of users as they deviated strongly from this order. They could not complete all data entry tasks as defined in the CR guidelines and needed more navigation actions than minimally

required to perform a complete NAP. Particularly when users entered data concerning a real patient case, they deviated from the predefined data entry ordering sequence.

We used the new construct 'deviation from the predefined data entry order' to analyze the fit between the system's design model of predefined data entry order and the mental model of users. However, additional analyses of the think aloud data to reveal underlying causes for user problems, should provide more information to this construct and its usefulness. Our study has several limitations. The Dutch clinical algorithm for the CR NAP the MediScore CARDSS 2.0 is based on, was revised in 2010 and is not yet completely implemented in most CR clinics. The usability issues revealed may likewise be caused by users' unfamiliarity with the content of the algorithm. Also we were not able to test end-users' interaction with the system in daily practice during clinical interviews with real patients. Evaluation of MediScore CARDSS 2.0 after its implementation may therefore reveal additional usability issues concerning mismatches with CR professionals' workflow.

The results of our study have been handed over to the developers to adapt the final MediScore CARDSS 2.0 system to the mental model of its users. To attain this goal, the navigational structure will be organized in a more flexible and transparent way, potentially leading to fewer screens. During the think aloud users frequently mentioned that they preferred a grouped data entry of all static, standard questionnaires before entering the dynamic data patient data (i.e., the flow through data items depends on previously entered data). After attuning the data entry order during the NAP to users' preferences, complete data collection will be maintained by showing users which data entry steps are finished and which steps still need additional data entry. We advise to apply cognitive methods to analyse end users' mental processes during task performance in the requirements analysis phase of system design. The system's design model may then be made consistent with these mental processes of future system users and ultimately lead to more efficient and effective system use [9;10].

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