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# The Avoidable Misfortune of a Computerized Patient Chart

**Inger Dybdahl Sørby, Gry Seland, Øystein Nytrø**

*Department of Computer and Information Science, Norwegian University of Science and Technology (NTNU), Trondheim, Norway*

**Abstract**

*The implementation of clinical information systems is demanding, particularly in hospitals, where reliable and well functioning information and communication tools are critical. In this paper we present different approaches to understanding and identifying challenges concerning the implementation of new electronic patient chart functionality. The context of the study was the development and implementation of the new system, which was withdrawn shortly after deployment in a medium-sized University Hospital. One year prior to the deployment we performed an observational study of current information and communication system usage in two hospital wards. Eight months later we conducted a usability test of the new functionality in a laboratory configured as a hospital ward. Four months after system deployment, the studies were followed up by interviews with healthcare personnel, members from the hospital implementation project group, and vendor representatives. The results of the studies show how the different approaches identify and reveal important issues that, if they had been taken into account, could have increased the chance of successful implementation of the system.*

***Keywords:***

Clinical information systems, Observational study, Usability testing, System implementation.

## Introduction

Several large Norwegian University Hospitals are in the process of implementing new patient chart functionality to be integrated with their existing electronic patient record (EPR) systems. The new functionality, which includes prescription and administration of medications, will replace central parts of current paper-based patient charts. Implementation of the new functionality into existing systems and clinical practices is an expensive, high risk process. Errors in the medication process might jeopardize patient safety, and usability problems of the system might lead to a disproportionate use of health care provider time on the system [1]. It is therefore crucial to reveal and realize potential risks and problems when designing the system and planning the implementation process.

In this paper we present different approaches to understanding and identifying the challenges related to deployment of new patient chart functionality in a Norwegian hospital. First, we present an observational study performed as an initial investigation of current information and communication system usage in two hospital wards. Secondly, we present results from a usability test of the new functionality conducted in a laboratory configured as a hospital ward. The studies were followed up by interviews conducted four months after deployment - and withdrawal - of the new functionality. Healthcare personnel, members from the system implementation project, and product owners from the vendor organization were interviewed. The findings and results from the interviews, the observational study, and the usability studies are summarized and discussed.

## Background and Motivation

### The patient chart - a collaboration and communication tool

The paper-based patient chart is a central collaboration and communication tool for health care personnel, particularly regarding medications. Physicians use the patient chart for prescribing medications, while nurses administer the medications to the patients and sign the same chart. The presentation of the patients' previous, current and administered medications gives both physicians and nurses a fairly good overview of each patient's medication status. In addition, the chart includes information about the patient's most recent laboratory and test results, and plans for further treatment [2].

Potential benefits of computerizing the patient chart (i.e. enhancing the quality and efficiency of health care and reducing the number of medication errors) are well recognized. It is the objective of both health record system developers and other healthcare stakeholders to replace the paper with a similarly efficient interface to the computerized patient record, and several attempts - however few successful - have been made to replace the paper-based chart with electronic versions.

### Usability of Clinical IT Systems

Usability can be defined as the "extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" [3]. In hospitals, the usability of the clinical systems is of particular importance. In the health industry, where the demands for effectiveness is increasing, the introduction of new technological solutions can potentially be lethal for the patients if the systems are poorly designed or if they are not tailored to the specific context of use in each hospital. For exam-

ple, Koppel et al. found a number of problems related to cumbersome medication charting and fragmented computer displays in a widely used commercial computerized physician order entry system [4]. Kjeldskov and colleagues found that usability problems may persist in time, as problems with an EPR system still remained after one year of extensive use [5]. Although usability testing is a well known and established method, it is a method that has to be adapted to the usage domain [6, 7].

## Study Context

The focus of the study presented in this paper is the development and deployment of new patient chart functionality in a medium sized university hospital with 650 beds and approximately 5000 employees. Due to the complexity of the functionality and the workflow processes related to the chart, the new functionality was limited to medication issues, i.e. prescription and administration of medications. The new functionality was fully integrated with the existing EPR system.

The new functionality was deployed at the same time as the hospital moved to a brand new hospital building. The new locations implied organizational changes and new technical solutions. The new medication system was designed to function in the new hospital wards and with new routines for prescribing and administering medications. A brand new pharmacy automation system was intended to handle single-dosage medications prescribed via the new medication functionality in the EPR, and sending the medications by the pneumatic dispatch to the wards if they were available in the pharmacy automation system. The administration part of the system was intended for use with laptops on trolleys in the patient rooms. The system was integrated with bar code readers that could be used to identify patients and medications during drug administration.

## Methods

The observational study was performed one year prior to the deployment of the new system. The usability study presented in the paper was conducted four months before the system deployment, and the follow-up interviews were performed four months after the system implementation and withdrawal.

**Study 1: Structured Observations**

Study 1 was performed to investigate and identify clinicians' information and communication behaviour in typical ward situations.

The approach is based on a previously developed method for performing structured observation of clinicians [8]. The observations were conducted by three senior medical students. The students performed non-participatory observations of physicians and nurses during various clinical situations, such as preround meetings, ward rounds, medication prescription and administration, and discharging patients.

The observers followed one main actor (i.e. a physician or a nurse) at a time. They recorded context information like situation type, trigger, co-actors, and roles, and sequences of information and communication acts. These sequences consisted of co-actors/information sources (e.g. colleagues, patient chart, patient record, EPR, physician's desk reference (PDR)) and information types (e.g. medication, diagnosis, findings and examination results). The data was recorded by means of paper forms consisting of both pre-defined codes and free-text fields, and subsequently transcribed to and processed in Microsoft Excel. The free-text fields would typically include explanations or the reason for choice of information source.

During the study, the observers spent a total of 24 days (appr. 150 hours) in two hospital wards, where patients with pulmonary diseases such as Chronic Obstructive Pulmonary Disease were treated. Six physicians (4 residents and 2 interns) and five nurses were followed. More than 3170 information and communication acts were recorded.

**Findings – Observational study**

Figure 1 shows how the distribution of the different information types the nurses and physicians used the paper-based patient chart to retrieve information about. The results show that nurses use the paper based patient chart mainly to retrieve information about medications (87,8 % of the time) and examination results (12,2 %). Physicians, on the other hand, review medication information in half of the cases (48,9 %), they review test and examination results in 45,6 % of the cases, and they also use the chart for other purposes like planning. This demonstrates that the physicians use the chart to get an overview of the patient and as a planning tool, including prescription of medications, while nurses mainly use the chart almost exclusively as an information source for administering medications.

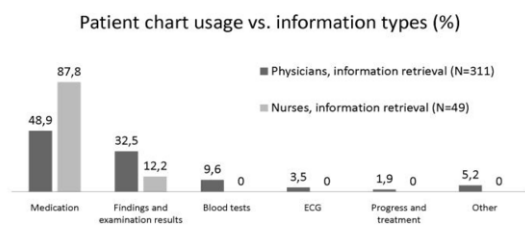


*Figure 1 - Percentage distribution of patient chart usage*

Figure 2 shows how the different information sources/systems are used by physicians and nurses to retrieve (upper part of figure) and to register (lower part) medication related information. The results further show that physicians use a wide variety of sources to inquire about medications: The paper-based chart (51 %), the patient (11,4 %), nurses (7,4 %), EPR (9,4 %), and the Physicians´ Desk Reference (PDR) (13,1 %). Nurses mainly use the chart (70,5 %) for information about medications, however physicians (21,3 %) and the EPR (6,6 %) are inquired as well. These results confirm the different tasks and information needs of different user groups like physicians and nurses. Physicians enquire different sources to get an overview of the patient's condition, confirm and re-check a

patient´s medication. Nurses use the chart when administering medications, and inquire physicians with questions about for example medication dosages. In addition to administering medication, nurses perform a control of the medications prescribed by questioning its correctness.

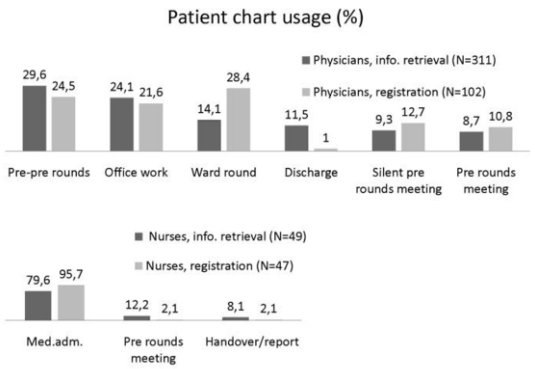


*Figure 2 - Percentage distribution of medication related acts*

Figure 3 shows how the patient chart is used in different situations by the physicians (upper part) and nurses (lower part). The results show that the nurses mainly use the chart when administering medications, while the physicians use the chart in several different clinical situations.

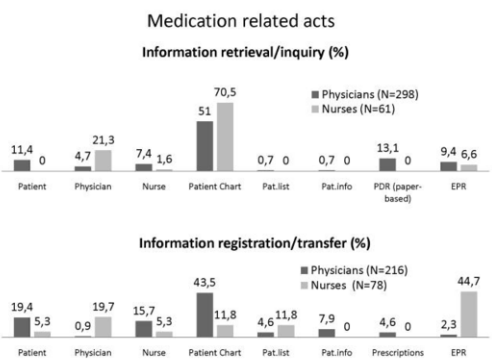


*Figure 3 – Patient chart usage in different clinical situations*

**Study 2: Usability Testing of Patient Chart Functionality**

The usability testing of the new EPR functionality was conducted during two one day workshops in a Usability Laboratory at The Norwegian EPR Research Centre. The usability laboratory is 80 square meters, and during the tests it was configured as a section of a hospital ward with two patient rooms, one office, and a hospital corridor. Video recordings of the participants and the system in use during the tests were done from the adjacent control room.

Two nurses and two physicians were recruited as test participants, three of them from the hospital deploying the new functionality. Health informatics researchers and two nurses from a local hospital acted as patients during the tests. Researchers functioned as facilitators, and one representative from the EPR system vendor was present at the second workshop. The vendor representative remained in the control room during the usability tests, but took part in the discussions following the tests. Data from two patient cases (personal, medication, physician and nurses' notes) were entered into the system prior to the tests, and the "patients" were instructed in their medical history.

During the tests, the physicians and nurses worked in pairs. They were instructed to perform their usual tasks during a preround meeting, a ward round, and medication administration, by means of the new chart functionality. The instructions were deliberately of little detail, in order to drive the scenarios by the medical problems in the patient cases. Prior to the test the participants were given a short introduction to the system, and after the tests there was a focus group discussion where the participants (including the "patients") summarized and discussed their experiences. The discussions were led by the facilitators. The tests and the discussions were captured on video for later analysis. After the focus group discussion of the second test, the participants could explore and test the system more informally, without the "patients" present.

**Findings – Usability Test**

A number of important usability issues were identified during the test and discussed in the debriefing sessions. The findings spanned from user interface problems to architectural issues and resulted in both suggestions for improvement of the system and recommendations related to the implementation process. The main findings are summarized below.

***Lacking overview***

The main problems revealed in the test were related to the lack of overview of the patients' medications. The physicians experienced that it was difficult to get an overview of the patient's current medications. Little space was given to the list of medications in the user interface of both the order entry part and the administration part, resulting in a lot of scrolling both horizontally and vertically in order to view important information.

Another problem perceived by the nurses was that when a medication was given to a patient and registered in the system with the bar code reader, the entry disappeared from the 'Current medications' list and re-appeared in the historic overview. The users found this little intuitive and cumbersome, as it was not immediately possible to see what medications the patient had been recently given.

***Functionality problems***

When the bar code reader was used, the system had to be set to ‘bar code reader mode’. This was perceived as an unstable system state, and the implication of the mode shift was difficult to understand.

Another problem occurred when one of the physicians wanted to stop a patient's medication for a short period of time. Since this function was placed in the medication administration

view, the physician was not able to locate it. However, the physician considered stopping a medication temporarily to be an order entry task, not a medication administration task, and the functionality should therefore be available in the order entry part of the system.

***Implementation, training and use of the system***

Some of the medication administration functionality was complicated, particularly related to the bar code reader. We therefore emphasized to the hospital that it was important that all nurses were trained in practical use of administration of medications using bar code reader, patient identification bracelet, and medications.

The medication user interface did not have separate menu choices for unexpected events, such as 'patient vomits drug'. There existed a general 'cancel' function, but the usage of the function appeared unclear in the usability test.

The results from the usability study were communicated to the hospital project group and the system vendor through a report. However, no changes in the system were made prior to the implementation.

## Intermezzo: A Predictable Death?

The system tested in the usability laboratory was put into operation when the hospital moved to the new hospital building, but due to a number of problems during the start-up period, the system was withdrawn after a short period of use. The reported problems were related to among others logistic problems with deliveries of medications, organizational changes, and high workload in connection with the migration to the new buildings. However, the triggering factor was a protest from the physicians regarding lacking functionality and the poor usability of the system.

## Post Mortem: Retrospective Interviews

In mature software engineering industry, it is common to gather, analyze and learn from projects by performing 'Post-mortem analysis' (PMA) [9, 10]. Such analysis includes gathering project metrics and evaluating performance, and is mainly performed as an internal exercise for the development team, who will be able to improve their practice in future projects. Users and stakeholders are normally not involved in the PMAs directly because the correspondence between a functionality or non-functionality of a system and the underlying development process is not always evident. In our study, however, we wanted to understand the reasons, from a user perspective, for the dismissal and rollback of the system. We therefore interviewed different stakeholders of the system: One nurse and two residents from the hospital where the system was deployed, two consultants from the hospital system implementation group, and two project leaders from the system vendor. The nurse and one of the physicians also participated in the usability test presented in this paper. The interviews with the nurse, the physicians, and the project leaders were individual, while the two consultants from the implementation group in the hospital were interviewed together.

The interviews lasted from 15 – 45 minutes and the main topics were 1: *What challenges were revealed through the methods described in this paper, and what challenges appeared at the hospital after system deployment,* and 2: *What were the main challenges when the system was in operation*?

According to one of the physicians, the main problems experienced with the user interface of the new system was the difficulty of getting an overview of the patients' medication status, medication actions, and changes.

One of the physicians also explained that they quite early decided to use the old paper chart in addition to the electronic system. When the system was in operation, they experienced that the nurses did not always administer the prescribed medications. A medication was not visible to a nurse if he or she opened the administration module shortly after the task was due. The result was that the patient was not given medication, accompanied by discussions about who were responsible for the mistake.

The interviewees also identified some major problems regarding medication delivery that affected the work of the nurses: the pharmacy automation system did not always deliver the ordered drugs; hence the nurses had to check the local storage, and possibly order the drugs from the pharmacy. They also experienced that medications were sent to wrong wards, due to a cumbersome routine for updating the EPR system. This caused delays and increased the workload of the physicians.

## Results and Discussion

We are interested in whether the system rejection could have been predicted, or indicated, from the usability and observational studies. We have grouped findings from observations, usability tests and interview results into broad categories of issues, which can be summarized as belonging to lack of detail or content in different aspects of requirements, models, and implementation.

**Information co-occurrence in user interface:** whether information or functions that are needed together have high proximity in time or effort.

*"The main problem was that it was difficult to get an overview of changes in the medication. (...)You ´open´ [a window for a] patient, who has been at the hospital for a few days, and have no idea about what has happened to the patient" (Resident 1)*

This issue was discovered in the usability test, but became more salient when the system was deployed. From the observational study we found that physicians often review medication and examination information simultaneously.

**Context of use:** whether the different modes of use, user roles or usage situations are paid attention.

*"The user interface was predominantly designed for nurses performing administration" (Resident 2)*

Stopping a medication for a short period was only possible in the medicine administration interface (not used by physicians). Results from the observational study show that the physicians use the chart in a wide variety of clinical situations,

**Interaction**: whether the user interface is sufficient in ease of use and functionality.

*"We are used to have a sheet of paper which states the patient's medication. It is not necessarily the right or the best solution, but it works to get a quick overview of the medications the patient has taken. If you have to move back and forth in four computer windows before you find the information, then you become unfocused. -- At least I do." (Nurse)*

**Work processes:** whether variation, or uniformity, mishaps and deviation can be handled by the system.

The new chart functionality only supported medication prescription and administration, but no other tasks supported by the paper chart.

*"You only understand the diagnosis when you see the paper chart. That overview was not possible in the IT system" (Resident 1)*

This issue was identified in the usability test, but became a more obvious problem after system deployment. Data from the observational study show that physicians and nurses review medications and other information in the chart before prescribing and administration respectively.

In addition to these issues, other important issues identified in the analysis are related to temporality, work content, and collaboration

**Could the misfortune of the patient chart have been avoided?**

In this study both the usability test and the observational study indicated some of the major issues experienced after system deployment. Many of the problems pointed out in the interviews were indicated from test and observation findings. The findings from the observational study reflect the complexity of clinical work. In particular, they show how the patient chart is used in various clinical situations and contexts, and that the physicians use the chart for several other purposes than the nurses. It was therefore not a surprise that the physicians were less satisfied with the new system than the nurses, who mainly use the chart for medication administration. The usability test revealed the importance of getting an overview of the patients´ medications, which was also supported by the observational study.

The problems related to medication delivery and logistics issues were not identifiable in our studies, as they could only have been revealed by extensive testing of the entire system chain in the hospital.

## Conclusions

Both studies presented in this paper pointed out crucial issues that, if they had been taken into account, could have increased the chance of successful deployment of the patient chart system. Usability laboratory tests reveal important and possibly problematic issues related to the user interface of the new system, while structured observations allow focused and quantitative grounding of use-cases, role models and stakeholder analysis. A combination of such methods is able to detect and elaborate on challenges, problems and discrepancies in a way that no single method can do.

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**Address for correspondence**

Inger Dybdahl Sørby, Dept. of Computer and Information Science, Norwegian University of Science and Technology, NO-7491 Trondheim, Norway, e-mail: inger.sorby@idi.ntnu.no