Peri-operative Coordination and Communication Systems: A Case of CSCW in Medical Informatics

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ABSTRACT
Medical Informatics has traditionally been concerned with optimizing the acquisition, storage, retrieval, and use of information in health and biomedicine. These systems have hence often paid little attention to supporting the collaborative nature of most medical work. In this position paper, we want to introduce our ongoing work on CSCW research in a healthcare context. Particularly, we want to present the design, implementation, and use of a new class of systems for use in hospitals. We call these systems for ‘Peri-operative Coordination and Communication Systems’ or PoCCS for short. By using computing technology not only for information retrieval and storage but for coordination and communication purposes, we show that work efficiency and quality in a hospital can be significantly improved.

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H.5.3 Information Interfaces and Presentation: Group and Organization Interfaces—Computer-supported cooperative work; J.3 Computer Applications: Life and Medical Science—Medical information systems

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Design, Human Factors

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INTRODUCTION
Medical Informatics (or ‘Health Informatics’) deals with the resources, devices and methods required to optimize the acquisition, storage, retrieval and use of information in healthcare. Medical informatics tools include not only computers but also clinical guidelines, formal medical terminologies, and information and communication systems. In essence, Medical Informatics is targeted at information processing of large sets of health data, including e.g. electronic patient records1. As such, Medical Informatics is deeply rooted in a Information Systems (IS) research tradition, just applied on healthcare.

CSCW as a research discipline was formed exactly as a reaction to the lack of focus on peer-to-peer collaboration and coordination in IS research. And hence; from a CSCW perspective it looks like systems build on a Medical Informatics (or IS) approach often completely ignore the collaborative nature of medical work.

For example, the core challenge in MI has been to transform paper-based medical records into electronic ones. In MI the electronic health record (EHR) is defined as a longitudinal collection of electronic health information about individual patients or populations2. Such records may included a whole range of data in comprehensive or summary form, including demographics, medical history, medication and allergies, immunization status, laboratory test results, radiology images, and billing information. However, from a CSCW perspective the paper-based medical record is a highly collaborative tool which mediates collaboration across different clinicians, roles, locations, specialities, time shifts, etc. Seen from this perspective, the record is not merely a ‘record’ of medical data, but is a rather sophisticated mediator in a complex work setting [13]. Moreover, the medical record is deeply interwoven into a complex web of other artifacts inside a hospital [2].

The main argument – or concern – is that if not healthcare systems are designed with this collaborative perspective in mind, there is a danger that systems like the EHRs will only be good at storing data, but really not useful for the highly collaborative work taking place daily inside hospitals. And this concerns is genuine, since many countries right now are investing heavily into building and deployed EHRs. In the US alone, the Office of the National Coordinator for Health Information Technology (ONC) estimated that more that $17.2 Billion will be used on EHRs as part of the Obama administration’s effort on healthcare.

In this position paper, we want to introduce our current work on taking concepts and designs rooted in CSCW research into the field of healthcare. Particularly, we want to present and discuss the use of a new class of systems for use in hosp-

1See e.g. the wikipedia entry on Medical Informatics
2See e.g. the wikipedia entry on EHR, or the HiMMS definition at http://www.himss.org/ASP/topics_ehr.asp
Based on years of design, development, and deployment of a PoCCS system we have been able to show that such a system helps clinicians increase productivity (or utilization) at the operation suite, without sacrificing work quality and satisfaction. We think that these results come from focusing on classical CSCW topics like awareness, communication, coordination, and embedded use, and would not have been achieved if a more classical Medical Informatics perspective on information management had been applied.

COORDINATION AND COMMUNICATION AT OR SUITES
Caused by the proliferating demands for healthcare services combined with a constant lack of trained clinicians, there is a growing pressure on hospitals for increasing productivity in the operating room (OR) suites. From a MI perspective, this demand for increasing productivity is typically translated into a demand for creating optimized operation plans that maximize the efficiency of use of operating room time [6, 11] Productivity is hence optimized through tight scheduling in order to reduce the exchange time between operations; making schedules which plan for a higher utilization of critical resources like ORs and surgeons; and by subsequently executing the plan according to the schedule.

However, from a CSCW perspective we know that plans in a collaborative workplace work more like a resource rather than a determining factor. But unfortunately this insight rests merely on qualitative (ethnographical) studies, and very few studies have provided quantitative insight into the extend of this phenomena. From a MI (and more generally from a healthcare) perspective, this lack of quantitative evidence of the degree of this phenomena is problematic.

For this reason we conducted a study, aiming at investigating to what extent the operating schedule (the “plan”) deviates from the actual work done “by the end of the day” at an OR suite [4]. The results include that:

- Only 56% of all operation are planned ahead. The remaining 44% are acute and thus scheduled ad-hoc.
- 8% of all operations are cancelled.
- 31% of all operations are shortened or prolonged more than 30 minutes.
- 67% of all planned (“elective”) operations are substantially changed.

Taken together, these figures imply that only 18% of an operation schedule is enacted as planned. Therefore, creating so-called “optimized” schedules can only be sub-optimal since they only encompass a little more than half of the operations. Moreover, if all resources were planned tightly, including nurses, equipment, and operation technicians, then it would be impossible to accommodate the acute operations – there would simply not be the resources available to handle them.

Hence, plans are constantly changed in order to accommodate contingencies in medical work. In OR suites, for example, disruptions related to lack of information, inaccurate information or status changes impact the operating schedule, which in turn require collaborative efforts on the part of all components of the system to formulate or reformulate a plan [12].

Large publicly available whiteboards in OR suites have proved to be essential in the handling of plans and coordination [1, 18, 15, 16, 19]. Figure 1 illustrates how whiteboards typically are used to render visible the schedule of the day and the status of the flow of work (from [11]). As illustrated, the charge nurse is critical to this information system because it is his/her responsibility to maintain the board as accurately as possible, while constantly communicating changes and notifying people using the telephone. In doing so, persuasion and politics are often utilized to negotiate an “acceptable” plan for the day, satisfying all the many constrains involved.

However, relying on whiteboards and telephones for coordinating a contingent, hectic, ever changing, and life- and time-critical execution of operations is inefficient, error-prone, stressful, and do not scale. Therefore, new technologies supporting the coordination and communication at a surgical ward is needed.
tems aiming at facilitating the often hectic coordination of operations during the day of execution.

Rooted in our work on conducting and applying CSCW research in a hospital environment, we have been working towards formulating what constitutes a PoCCS system (see e.g. [3, 5, 7, 4]). There are, however, also a few other systems which aim at providing support for coordination and communication at an OR suite. For example, the Resource Coordination System for Surgical Services (RCSS) [17] from 1997 is an early design. RCSS was mainly designed to support reliable registration of utilization data for analysis and predictive (re-)scheduling of resources, like ORs, staff, space, and equipment. As such, RCSS still focused on OR suite utilization. However, a part of the system was deliberately designed to support distributed real-time replanning and communication of adjustments by collecting and making visible OR-specific data to other units. And - as they argue:

“Patient management decision can be based on an appreciation of the overall hospital situation, which should improve the reactive coordination of personnel, space and equipment” [17][p. 128].

Similarly, LiveData has build a system for peri-operative situational awareness [10]. This system provides an overview of relevant patient data including the patient status inside the OR, but does not as such explicit focus on coordination and communication outside the OR. Finally, the Video Board System (VBS) [8] provides real-time live video from ORs which conveys patient status and major events like patient entrance, surgery started, and surgery finished.

A peri-operative communication and coordination system (PoCCS) is designed to support real-time coordination of the execution of operations at a large OR Suite. A PoCCS system typically have the following main characteristics:

- It provides a distributed situational awareness of the unfolding of work at the OR Suite. This includes providing social awareness about clinicians and patients, where they are, what they are doing, and what their plans are; a spatial awareness about what is going on in specific places; a temporal awareness about what has happened, was is happening now, and what is going to happen; and an activity awareness of the status of a particular surgical activity.

- It provides support for communication between clinicians, patients, and locations.

- It provides an overview of the unfolding of operations by showing an always up-to-date operation schedule, and status information on each operation.

- It provides real-time location information about clinicians, patients, and equipment.

- It is distributed across the whole hospital to departments, locations, and people who are involved in the execution of the daily operations and provided timely notification of changes to relevant persons.

Our current implementation of a PoCCS system has five main components. The first component of the PoCCS system is a set of large public and interactive displays. These displays can be tailored to shows all sorts of overviews of e.g. operations, clinicians, patients, and operating rooms. Furthermore, they can be tailored according to the context in which they are deployed. Hence, the view inside the OR is significantly different from the view in the coordination central which again is very different to the view on a specific patient ward.

The second component is a set of mobile hand-held devices like PDAs and mobile phones that provides access to relevant information. The third components is a message-based communication system which is able to route messages between public displays and mobile devices, depending on their location and who is using them. This communication components can also notify and alert clinicians about important events. For example, notifying a nurse to attend to the patient when he is on his way to the recovery department.

The fourth component is an in-door location tracking system which provides real-time location information on clinicians and patients. This information is available on both the public displays and the mobile devices. The fifth component is a real-time video porthole system, which mediates live video feeds from different locations like the ORs. These video feeds can be shown on the public displays, and still images from the video feed is accessible on the mobile devices.

This systems runs on large interactive displays situated in key locations around the hospital. Typically, dedicated displays are situated in the operating rooms, the coordinating centre at the OR suite, the patient wards, the recovery department, the intensive care unit, the reception, and the sterile department. Figure 2 shows how the PoCCS system is
deployed as an array of large touch screens in the coordination central at the OR suite, and Figure 3 shows how the system is installed on smaller displays in some of the remote locations. Moreover, the system runs on mobile devices like smart phones and PDAs, which are carried around by key personnel at the hospital.

It should be noted that a PoCCS system would typically not be responsible for operation scheduling and booking. This would be handled by a booking and scheduling system designed to create optimal plans for operating room utilization. OR schedules are made days, weeks, and months ahead. A PoCCS system, on the other hand, is designed to support the coordination of the execution of operations on the day of surgery. Often a PoCCS system would take as an input the operating schedule and use this as a baseline for the day. But as our studies show, this schedule is subject to significant change during the day; changes which is handled via the PoCCS system.

POCCS SYSTEMS IN USE
Our PoCCS system has been in daily use at a medium-sized\textsuperscript{4} Danish hospital for more than 2 years. The OR suite hosts operations from three different surgical departments; the departments for organ, orthopedic, and gynecology/obstetric surgery. Around 150 clinicians work at the operating department, and in average 22.4 operations are executed every day, summing to ca. 8,000 operation pr. year.

The Centre for Public Health in the Central Region of Denmark has done a Health Technology Assessment (HTA) of the PoCCS system as used at the hospital \cite{9}. The study shows that Cetrea Surgical results in both higher efficiency at the operating suite, as well as improves the quality of work.

These studies showed that

- the utilization of operating rooms using the PoCCS increased from 82\% to 88\%.
- the utilization of operating room using the PoCCS is 15\% higher compared to operating rooms not using the system
- the likelihood of canceling an operation was reduced to only 33\% after putting the PoCCS into use
- the likelihood for starting the operation as scheduled increased by 50\% when using the PoCCS

In the qualitative study, 11 interviews with 16 persons were conducted, including operation coordinators, nurses, anesthesiologists, surgeons, and management. The interviews were done as semi-structured interview following an interview guideline that had a broad focus on the working environment at the operation ward, including the use of technology.

Amongst many thing, these qualitative studies revealed that:

- 70\% of all clinicians working at the operating suite agreed that the PoCCS system provided easier access to the information that are important and relevant for their work
- 87\% agreed that they had a better overview of the work to be done during the day after the system was deployed.

In conclusion, the result from this HTA study shows that the PoCCS system provides the technological basis for better utilization of the operating room capacity and for optimizing the work on a operating suite. In addition, this increase in efficiency does not harm then quality of work – on the contrary, the system was reported to improve on the working environment by reducing interruptions and stress.

CONCLUSION
In this paper, we wanted to initiate a discussion of how to approach the design of computer systems for healthcare from a CSCW rather than a Medical Informatics perspective. In particular we have discussed the design, implementation, and use of a new type of computer system for use in OR suites; Peri-operative Coordination and Communications Systems – PoCCS. A PoCCS system is designed to support the coordination of operations in an OR suite. In contrast to medical informatics systems which focus on acquiring, storing, and retrieving patient health information, a PoCCS system is design to support ad-hoc juggling of operation schedules that constantly needs to be adjusted to the contingencies of this highly collaborative, hectic, and life- and time-critical work environment. Continuous rescheduling is supported by enabling easy and context-aware communication between involved staff and locations.

The deployment and use of our specific implementation of a PoCCS system has revealed that it leads to higher efficiency.

\textsuperscript{4}Ca. 270 beds, 150 doctors, and 550 nurses.
and utilization on the OR suite while at the same time increases work quality and reduces stress and annoying interruptions.

We would argue that central to this success it the shift in perspective from handling medical information to supporting contingent collaborative work, i.e. shifting from a medical informatics to a CSCW perspective. As such, a PoCCS system is – in our opinion – a good example of how computer systems for healthcare may be designed differently by focusing on the scientific insights of CSCW of what constitutes close collaboration in a workplace.

REFERENCES


