# Breakdowns in Collaborative Information Seeking:
# A Study of the Medication Process

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**Abstract**. Collaborative information seeking is integral to many professional activities. In hospital work, the medication process encompasses continual seeking for information and collaborative grounding of information. This study investigates breakdowns in collaborative information seeking through analyses of the use of the electronic medication record adopted in a Danish healthcare region and of the reports of five years of medication incidents at Danish hospitals. The results show that breakdowns in collaborative information seeking is a major source of medication incidents, that most of these breakdowns are breakdowns in collaborative grounding rather than information seeking, that the medication incidents mainly concern breakdowns in the use of records as opposed to oral communication, that the breakdowns span multiple degrees of separation between clinicians, and that the electronic medication record has introduced risks of new kinds of breakdown in collaborative information seeking. In working to prevent and recover from breakdowns in the seeking and sharing of information a focus on collaborative information seeking will point toward collaborative, organizational, and systemic reasons for breakdown and areas for improvement, rather than toward individual error.

**Keywords**: Collaborative information seeking, collaborative grounding, healthcare, electronic medication record, medication incident

## 1    Introduction

Hospital work is profoundly collaborative and crucially dependent on clinicians' ability to seek and share information relevant to their treatment and care of patients (Strauss, Fagerhaugh, Suczek, & Wiener, 1985). This seeking and sharing of information is complicated by a diversity of patient conditions, a multiplicity of treatment options, an extensive base of recorded knowledge about diseases, a shift-by-shift replacement of the clinicians on duty, and a high likelihood of moment-to-moment changes in the information that requires clinicians' attention. Of the many activities involved in hospital work, the medication process is an example of a recurrent activity that encompasses a continual seeking and sharing of information among clinicians. The complexity of the medication process is apparent in findings that it contains 5.3 errors for every 100 medication orders (Bates, Boyle, Vliet, Schneider, & Leape, 1995). While only some medication errors result in patient injury, Thomas et al. (2000) find that during one year, 3325 medication errors resulted in patient injury in Utah and Colorado alone; and in 9.7% of these cases the patient suffered permanent disability. This makes the medication process a major source of adverse events at hospitals.

This study approaches the medication process as an instance of collaborative information seeking (Foster, 2006; Golovchinsky, Qvarfordt, & Pickens, 2009; Hertzum, 2008). That is, we focus on how clinicians obtain and exchange information in the process of ensuring that the right medication is given to the right patient at the right point in time. Data about the medication process is acquired from two sources. The first source is a study of the use of an electronic medication record introduced in one of Denmark's five healthcare regions; the second source is the national reports of five years of medication incidents at Danish hospitals. The aim of the study is twofold:

- To analyze how the electronic medication record mediates the clinicians' collaborative information seeking, and how it renders some kinds of breakdown more likely.

- To analyze how breakdowns in collaborative information seeking are a main contributor to medication incidents, and what characterizes these breakdowns.

Collaborative information seeking has been defined as the combined activity of information seeking and collaborative grounding (Hertzum, 2008). The core of this definition is that information is needed to inform a group of collaborating actors, who – through ad hoc decisions or an established division of labour – engage in a series of information-seeking and collaborative-grounding activities. Individually each of these activities may, but need not, involve the entire group; the crucial point is that the collective outcome of the activities is to inform the group. While information-seeking activities are necessary for collaborating actors to acquire new information (Twidale, Nichols, & Paice, 1997), reach an understanding of equivocal information (Fidel, Pejtersen, Cleal, & Bruce, 2004), and get creative input (Zipperer, 1993), these activities are often performed by individual actors or subgroups of actors. Therefore, information-seeking activities tend to increase the proportion of information and understanding held by individuals and subgroups relative to the information and understanding shared by the entire group (Hertzum, 2008). This necessitates collaborative-grounding activities, which involve the construction of a shared understanding and, thereby, shift the balance between individual and shared understanding toward a larger proportion of shared understanding (Karamuftuoglu, 1998; Schmidt & Bannon, 1992; Talja, 2002). Tools are being developed to support information-seeking activities (e.g., Twidale et al., 1997), collaborative-grounding activities (e.g., Conklin & Begeman, 1989), and both (e.g., Paul & Morris, 2009). The challenge of collaborative information seeking is to continuously acquire new information while at the same time avoiding a gradual disintegration of the actors' shared understanding. This involves dynamically and repeatedly rebuilding shared understanding through collaborative grounding.

This paper adopts Hertzum's (2008) inclusive, work-related definition of collaborative information seeking as the combined activity of information seeking and collaborative grounding. Similar definitions have been proposed by, for example, Karamuftuoglu (1998), who emphasizes that a central element of collaborative information seeking is the construction of a shared understanding that assimilates available information, and Fidel et al. (2004), who construe information seeking to include "all activities that were taken by actors to resolve an information problem". However, other definitions exclude activities such as information sharing and collaborative grounding from collaborative information seeking (e.g., Hansen & Järvelin, 2005) or assign them a borderline status (e.g., Prekop, 2002). These definitions reserve collaborative information seeking for the more restricted set of activities where people look for information together, while terms such as collaborative information behaviour are preferred for the broader set of activities that includes collaborative grounding. The medication process is, according to this study, a context in which it has analytic merit to avoid dissociating the acquisition of information from being informed by it. Thus, the medication process lends itself to construe collaborative information seeking as consisting of both information seeking and collaborative grounding.

Collaborative information seeking has been studied in multiple settings, including academic research (Talja, 2002), command and control (Prekop, 2002), design (Bruce et al., 2003), education (Hyldegård, 2006), and healthcare (Reddy & Spence, 2008). Within healthcare, Forsythe, Buchanan, Osheroff, and Miller (1992) examine physicians' information needs and find that a broad concept of information need is required to account for the empirical results. To handle their diverse information needs healthcare staff create organized, selective collections of information (Gorman et al., 2000), and they establish work rhythms to remain in command of required information (Nilsson & Hertzum, 2005). Moreover, information in patient records is repeatedly supplemented with oral exchanges of information, for example to unravel uncertainties, understand the context of recorded information, or simply obtain information quickly (Reddy & Spence, 2008). Due to the diverse information needs and extensive collaboration within and across professional groups, collaborative information seeking is ubiquitous in healthcare and so are opportunities for breakdown, which may have adverse consequences for patient health. In this paper a breakdown in collaborative information seeking is taken to mean that a clinician lacks information required to competently perform her or his part of the medication process. Such breakdowns are considered breakdowns in collaborative information seeking because the medication process is inherently collaborative with an established division of labour and frequent ad hoc interactions among clinicians (see Section 2). Two kinds of breakdown can be distinguished: Either all actors in the medication process remain unaware of the information (a breakdown in information seeking), or the information remains unknown to an actor who needs it to perform competently though other actors in the medication process are aware of the information (a breakdown in collaborative grounding). The risk of adverse consequences for patient health makes effective collaborative information seeking of central importance in healthcare, and it creates an obligation to learn from errors and incidents caused by breakdown in collaborative information seeking.

## 2 Electronic medication records

Many hospitals are currently involved in extensive efforts to substitute electronic records for paper records. In Region Zealand, one of Denmark's five healthcare regions, an electronic medication record (EMR) was deployed in 2003-2006 with a specific purpose of supporting collaborative information seeking. The region's

plan, from 2002, for the organizational implementation of the EMR states that the EMR is to support all clinicians – physicians as well as nurses – in obtaining and maintaining an overview of the medication process. To provide this overview, the EMR collects all information about patients' medication in one place. This is contrary to previous paper records, which were separate for physicians and nurses. Thus, the EMR addresses some causes for breakdown in information seeking and, in particular, collaborative grounding by aiming to improve the cross-disciplinary information exchange between physicians and nurses.

## 2.1 Empirical data

We have collaborated with Region Zealand since 2004 to evaluate the introduction of the EMR and other electronic records. The following analysis is based on data from Granlien and Hertzum (2009b), who report from a survey of the adoption of the EMR and follow-up interviews at two wards. The survey included questions about the extent to which different parts of the EMR were used as prescribed in the region's procedures for medication and about barriers to the use of the EMR. The survey was administered to all function managers, department managers, ward managers, and EMR coordinators at the hospital wards in the region; these staff groups include both physicians and nurses. At the time of the survey the wards had used the EMR for between 1.5 and 4 years. Thus, work practices had had time to stabilize. We received 232 responses, for a response rate of 54%. The follow-up interviews were conducted with a physician and a nurse from each of two wards. The interviewees were asked about the process of adopting the EMR and associated work procedures at their ward, with special focus on barriers to the adoption and use of the EMR and how they had been counteracted. The analysis is supplemented by observational data about the use of the EMR at one ward. These data are drawn from Granlien and Hertzum (2009a), who studied the effect of interventions directed toward the nurses' use of the EMR. The previous analyses of the data have focused on the organizational implementation of the EMR by investigating its partial adoption, the barriers to its adoption, and selected ways of overcoming these barriers. For the purpose of the present study, information about how the EMR affects collaborative information seeking has been extracted from the survey, interview, and observation data in order to provide an understanding of the medication process as an instance of collaborative information seeking.

## 2.2 The medication process

The main activities of the medication process are ordering, dispensing, and administration. The ordering of medication is the physicians' responsibility, and they are also responsible for recording the orders in the EMR. Physicians make, adjust, and cancel medication orders in connection with their ward rounds and when dynamic changes in a patient's condition call for a change in medication. Thus, medication orders may be created, adjusted, and cancelled at all times. The dispensing and administration of medication is the nurses' responsibility. Some medication orders require immediate action from the nurses; in these cases the physician informs the nurse orally about the order as well as records it in the EMR. The remaining medication is dispensed and administered on the basis of information the nurses obtain from the EMR. Each medication is dispensed and signed for individually in the EMR, and when the medication has subsequently been administered to the patient, the nurse records the administration of each individual medication in the EMR.

The EMR is central to the exchange of information between physicians and nurses. Medication-related information obtained by a physician or nurse is entered into the EMR and thereby becomes available to the entire group of physicians and nurses. The use of the EMR (and other records) is necessary to counter the ephemeral nature of oral communication and to sustain the medication process across shifts, which involve a change of staff. The medication process is, however, supplemented with recurrent oral communication. For example, the physicians in most cases inform the nurse responsible for a patient when they make adjustments to the patient's medication, and the nurses inform the physicians when medication has not been administered as ordered or patients have responded to their medication in unexpected ways. Thus, physicians as well as nurses perform information-seeking activities, and they collaboratively ground obtained information orally and through the EMR.

While the responsibilities of physicians and nurses in the medication process comprise a regulated and tightly-coupled activity, other groups of actor are involved in more loosely-coupled and ad hoc ways. These other groups include clinicians at other hospital departments, healthcare professionals external to the hospital, and the patients. The influence of these additional actors on the medication process is largest when patients are admitted or discharged, including when they are temporarily transferred to another department for treatment.

## 2.3 Effects of the EMR on collaborative information seeking

The clinicians generally consider the EMR and its associated procedures sensible. A physician noted, however, that the EMR has not led to a reduction in the number of medication errors but merely changed the kinds of

medication error that occur. Below, we describe four ways in which the EMR has affected the medication process and introduced new risks of breakdown in collaborative information seeking.

First, medication is by default dispensed and administered four times a day, creating a division of the medication process into four daily timeslots. This is done to help structure the nurses' work and to reduce the number of times patients are disrupted. At the beginning of each timeslot, the nurses consult the EMR to see the list of medication orders for each patient. Thus, if a physician creates a new medication order for a patient effective from the time of creating the order (e.g., an infusion running continuously), the medication will not be administered until the beginning of the next timeslot. To avoid this gap the physician has to create two medication orders: one that orders the immediate administration of the first dose of the medication and another that ensures the continuation of the order during subsequent timeslots. It is not intuitive that the former order is necessary, because the latter order states the time from which the order is effective. Thus, physicians sometimes forget to make the first order, especially during periods of high workload. In addition, the physician has to orally notify the nurse about the first order. If the physician forgets this, because the order has already been recorded in the EMR, which is sufficient for communicating the majority of medication orders to the nurses, the nurse will remain unaware of the order.

Second, the physicians sometimes inform the nurses orally about a new medication order but forget to record it in the EMR. Such omissions frequently concern modifications of already existing medication orders, and they weaken collaborative grounding because the nurses are not presented with the right information when they consult the EMR. The consequences of these omissions are aggravated by the design of the EMR, which prevents the nurses from recording the dispensing and administration of medication for which no order exists. Moreover, the nurses cannot remedy these situations by recording or modifying an order on behalf of a physician because only physicians are allowed to order medication, and this rule is implemented in the EMR by making it impossible for all other groups of clinician to record medication orders. Whereas omission and disallowance of recording affect collaborative grounding directly, it also erodes the basis for subsequent information seeking, increasing the risk of breakdowns.

Third, certain kinds of medication are cumbersome to record in the EMR. This includes infusions that run for extended periods of time and are subject to frequent adjustment of, for example, the infusion rate and the medications included in the infusion. It is time-consuming to make recordings that support collaborative information seeking at this level of detail, and the introduction of the EMR has shifted some of this work from the nurses to the physicians by requiring more detail in medication orders. This has been done purposefully to reduce error during the dispensing of medication but implies that the physicians spend more of their time on collaborative grounding to detail their orders. Conversely, the nurses have, in principle, been relieved of the work involved in calculating the composition of infusions. In practice, the physicians often lack the time to make the more detailed orders, and the EMR has created some frustration among physicians, who experience that their time is not well spent with the new division of labour, and among nurses, who experience complications in their work when the physicians fail to comply with the new division of labour. This illustrates how collaborative information seeking may be affected by the formal division of labour.

Fourth, the EMR contains information about medication only; patients' diagnoses, lab tests, and other non-medication information are documented in other electronic and paper records. This implies that the introduction of the EMR has dissociated information that was kept together in the paper-based patient record. Specifically, information about medication and symptoms are no longer in one place. This complicates information seeking and integration. While this state of affairs could be considered transitional, hospitals' transition from paper to electronic records has already lasted years and will continue for several more years. Thus, the transitional state has become a longstanding characteristic of hospital work. When the records dissociate information that must be integrated in forming an understanding of the effect of a patient's medication, it is left to the clinicians to accomplish the integration. This increases the demand on their ability to seek and collaboratively ground information among each other through oral exchanges.


## 3    Medication incidents

Since January 2004, the clinicians at Danish hospitals have been under an obligation to report accidents, errors, and other incidents to a national database. The aim of this reporting system is to collect knowledge for use in the prevention of future incidents. In support of this aim, clinicians who are involved in incidents are not blamed for their behaviour. A no-blame guarantee is a prerequisite for creating a practice where clinicians actually report their errors. The annual increase in the number of reported incidents since 2004 (see Table 1) suggests that the clinicians are gaining trust in the system and experience no negative consequences of reporting incidents. The National Board of Health has issued an annual report about the incidents reported to the database during each of the five years 2004-2008 (National Board of Health, 2005, 2006, 2007, 2008, 2009). The reported incidents

come from all five Danish healthcare regions, including the one whose medication process was investigated in Section 2.

Incidents relating to the medication process comprise 34-50% of the reported incidents (Table 1) and are the most frequent of the nine categories into which incidents are classified. The National Board of Health rates the risk to patient safety of each incident by determining its Safety Assessment Code (SAC, Bagian et al., 2002; Bagian et al., 2001). Since 2006 the annual reports have, for each category of incident, given the number of incidents at the maximum SAC level (3). Fortunately, the percentage of medication incidents at SAC level 3 is low, see Table 1. The annual reports for 2008 and 2007 contain short descriptions of all incidents at SAC level 3, for a total of 22 and 24 descriptions, respectively. The annual reports for 2006, 2005, and 2004 contain similar descriptions of sample incidents from a set of subcategories of medication incident, for a total of 9 descriptions for each of the three years. The 73 descriptions are an average of 359 characters long. This is considerably more than the 200 characters used as the minimum length of incident descriptions included in the study by Bagian et al. (2002).

### 3.1 Coding of incident reports

The 73 incident reports were analysed in two steps. First, the reports were examined sentence by sentence. This bottom-up analysis, combined with the definition of collaborative information seeking (Hertzum, 2008), provided the input for creating a coding scheme. Second, the reports were examined again and categorized according to the coding scheme. The coding scheme consisted of five questions:

- Was the incident a breakdown in collaborative information seeking? This was a yes/no question and served to investigate how important collaborative information seeking is to an error-free medication process.

- Who was aware of the information? This question concerned the information-seeking part of collaborative information seeking and was coded by one of seven categories of information holder: nobody, a physician, a nurse, a healthcare person at another department at the hospital, a healthcare person outside the hospital (e.g., a home-care worker), the patient, and an unspecified healthcare person.

- Who remained unaware of the information? This question concerned the collaborative-grounding part of collaborative information seeking and was coded with the same seven categories as the previous question.

- Where did the breakdown occur? This question identified where in the mediation between the person who was aware of the information and the person who remained unaware of it collaborative information seeking broke down. The seven categories used in coding this question appear in the leftmost column of Table 3.

- Did the incident report propose a remedy for the breakdown? This question was included to assess the extent to which the reports reflected an understanding of the incidents as breakdowns in collaborative information seeking. Five categories were used in coding this question: no remedy proposed, more information and training, new or revised procedures, revision of electronic or paper records, and other.

The five questions concern different aspects of collaborative information seeking; they do not involve an analysis of the medical aspects of the incidents. Rather, the below analysis may complement analyses of the medical aspects of the incidents.

### 3.2 Results

Sixty (82%) of the 73 incident reports concerned breakdowns in collaborative information seeking. This shows the importance of effective practices of collaborative information seeking, and thereby emphasizes that procedures and tools aimed at supporting collaborative information seeking are central to the medication process. One incident was described as follows:

> A report concerned a patient who was being treated with the drug Innohep to prevent the formation of blood cluts. Upon discharge from the hospital, the home-care service was not informed about the treatment. A few weeks after discharge the patient was readmitted with blood cluts in the lungs.

This incident is a breakdown in collaborative grounding because some of the actors in the medication process were aware of the pertinent information but it was not communicated to those needing it. When a patient is discharged, it is the responsibility of the hospital clinicians that information about the patient's current medication orders is up to date and, for some patients, the responsibility of the home-care service that current medication orders are continued. In this case, hospital clinicians were aware of the need to prevent the formation of blood cluts but the home-care service remained unaware of the treatment with Innohep and did not continue it. Table 2 shows that 52 (87%) of the 60 breakdowns in collaborative information seeking were breakdowns in collaborative grounding; in only eight incidents nobody had sought the information. The table also shows that

the physician is the category of person who most frequently was aware of the pertinent information, while the category of person who most frequently remained unaware of it was the nurse. It may be tempting to read this as though the nurses are the cause of 48% of the incidents, but that would disregard that what breaks down is a process of collaborative information seeking involving not just the nurses but an ensemble of collaborating actors. The combinations of who was aware and who remained unaware indicate that the breakdowns involved different degrees of separation between the collaborating actors:

- As many as 22 (37%) incidents involved a physician who was aware of information and a nurse who remained unaware of it. In these incidents the separation is between staff groups at the same department but with different professional backgrounds and different responsibilities in the medication process.

- Six (10%) incidents were between a physician or nurse at the department and healthcare persons at other departments of the hospital. The departmental separation may complicate collaborative information seeking because one of the actors is external to the medication process and the ongoing treatment of the patient.

- Seven (12%) incidents were between a physician and a healthcare person outside the hospital. This separation is partly between the narrow specialties of hospital physicians and the broad tasks of general practitioners, home-care workers and the like, and partly between a tightly regulated hospital environment and caring for patients in the context of their day-to-day activities.

- Five (8%) incidents were between a healthcare person and the patient. This is a separation between a specialist and a lay person. Moreover, the patient is often distressed, bewildered, and affected by illness or medication.

Of the remaining incidents, five involved an unspecified healthcare person and only seven (12%) were between actors from the same category of person.

Table 3 shows that in only five of the 60 incidents the breakdown in collaborative information seeking occurred during oral communication. A main reason for this is that the medication process is to a large extent mediated through recorded information. In spite of the clinical staff's extensive experience with recorded information, 11 breakdowns consisted of records that were misread or record content on which clinicians failed to react. One incident reads:

> *A patient allergic to penicillin got penicillin. The patient record contained information about the patient's allergy. Penicillin was ordered by recommendation of the local microbiology department. The physician placed the order by phone to the nurse on the department. Neither the nurse nor the physician consulted the patient record.*

In this case, the pertinent information had previously been sought and recorded in the records by other clinicians but the clinicians who needed the information failed to consult the records and react on the information. This is a breakdown in collaborative grounding, and it occurred in spite of much attention to allergies in medication-process procedures and in spite of the prominent position of allergy information in the records. The use of records was further complicated by the simultaneous presence of several parallel records. Of the ten breakdowns involving parallel records five were transcription errors where information was lost or distorted in the process of manually transferring information from one record to another. The other five breakdowns involving parallel records consisted of patients not getting their medication because the physician entered the medication order in one record but the nurses consulted another, of patients getting their medication too late because the medication order was not noticed until it had been transferred from one record to another, and of patients getting too much medication because the same order was recorded and administered multiple times. One incident reads:

> *A patient got double the intended dose of Marevan. The drug was ordered in the electronic medication record as well as on a separate chart of Marevan orders.*

In this case collaborative grounding broke down because multiple recordings of the same medication order was incorrectly interpreted by the nurses responsible for administering the medication as multiple medication orders. The duplicate recording of Marevan on a separate chart was in place to carefully monitor the amounts administered but resulted in the administration of too much medication. Notably, the correct information was recorded and reacted upon, but the double way in which the recording was made caused a breakdown in collaborative grounding. Another ten breakdowns involved errors or incompletenesses in the records. For example, one incident concerned a patient who for two days received ten times the intended dose of the drug Cisordinol (an antipsychotic) because the medication order was inadvertently recorded as "10 tablets" rather than "10 mg" in the electronic medication record. The nurses had no reason to suspect an error, and the physician had no reason to check the recorded information – until the patient had symptoms demanding close examination and monitoring. An example of an incident involving incomplete records reads:

*A report concerned a patient for whom the physician ordered Ciprofloxacin but did not approve the order in the electronic medication record. Therefore, the drug was not dispensed and administered to the patient, who got cystitis (a bladder infection).*

While the order was recorded its status was "pending approval" because the physician did not complete the order by clicking the "Approve" button. Thus, no information about the order was communicated to the nurses because it did not appear on the list of medication to be dispensed and administered. This breakdown in collaborative grounding appears to be related to suboptimal design of the interface of the electronic medication record.

The remaining breakdowns involved failures in identifying the right patient, drug, dose, or route. One incident involving the administration of a wrong drug occurred in an ambulance, an environment characterized by uncertainty, time-pressure, and other stressors. While one drug was ordered by the cardiologist on duty at the hospital, another drug was administered by the ambulance crew. It contributed to this breakdown in collaborative grounding that the ambulance crew did not possess the medical knowledge to assess whether the drug they administered was appropriate in the situation. The report reads:

*A report concerned an injured patient who was picked up by ambulance. The cardiologist on duty ordered that the patient should have 10000 IU Heparin. Immediately after administering the medication the patient got ventricular tachycardia and went into cardiac arrest. [It was later] realized that instead of Heparin the patient had inadvertently been given 20 ml Adrenalin in a concentration of 1 mg/ml intravenously.*

The report goes on to state that to avoid similar failures in the future a new procedure has been implemented. This procedure stipulates that only selected staff is allowed to dispense and administer medication in ambulances. Thus, to reduce the risk of a breakdown in collaborative information seeking in these situations, collaborative grounding is made less critical by demanding that all the actors that are involved in these situations individually possess the knowledge required to assess the appropriateness of the medication they are using.

A total of 21 of the 60 incident reports included proposals for remedies of the breakdowns in collaborative information seeking. Ten reports proposed more information and training, seven proposed new or revised procedures, three proposed revisions of the electronic or paper records, and one proposal was in the "other" category.


## 4    Discussion

The breakdowns in collaborative information seeking investigated in this study led to medication incidents. That is, a breakdown is not merely a matter of who knows what but involves adverse effects on patient health. This work-related definition of breakdown goes beyond several previous studies (e.g., Reddy & Spence, 2008). Below, we discuss the impact of including collaborative grounding in collaborative information seeking, the interrelations between records and oral communication, and implications of a focus on collaborative information seeking for research and design.

### 4.1    The impact of collaborative grounding

An important consequence of defining collaborative information seeking as the combined activity of information seeking and collaborative grounding is that collaborative information seeking becomes an integral aspect of clinical work. While this approach accords with other studies of collaborative information seeking in the healthcare domain (e.g., Gorman et al., 2000; Reddy & Spence, 2008), it differs from a number of studies that define and investigate information seeking as an individual activity performed in relative isolation from the information seeker's other activities (Wilson, 1999). The inclusion of collaborative grounding in the definition of collaborative information seeking entails that the collaborative aspect of the activity may occur during both information seeking and collaborative grounding or during collaborative grounding only. Reddy and Spence (2008) talk about this as an iterative practice of searching-sharing-searching. Allowing for information-seeking activities performed by individuals, who subsequently report to a group, extends collaborative information seeking to include many important and frequent situations.

The empirical data suggest that for the medication process the main challenge in collaborative information seeking is collaborative grounding. Most of the reported medication incidents are breakdowns in collaborative grounding. This implies that some clinician usually knows the pertinent information. While it is unavoidable that information is unevenly distributed, because individual clinicians have different responsibilities and are constantly obtaining new information, there are some patterns in the breakdowns in collaborative grounding. First, the medication process involves collaboration across multiple degrees of separation, such as different

professional backgrounds and being at different hospital departments. These degrees of separation reduce the amount of shared context among clinicians and thereby increase the risk of breakdown. Second, electronic medication records create opportunities for new kinds of breakdown, for example by introducing timeslots and preventing nurses from recording the dispensing and administration of medication for which physicians have not recorded the order. Oral orders are especially likely during busy periods, which also increase the risk of inaccuracies when orders and their dispensing and administration are later recorded, or of altogether forgetting to record the medication. Third, information is distributed across multiple records and people. This fragmentation of information entails that a single source is often insufficient to answer an information need, and that breakdowns may result from failing to consult a source that implies an interpretation different from the interpretation implied by the sources that are consulted. Thus, collaborative information seeking is also required to mediate between the multiple, interrelated records (Reddy & Spence, 2008). The yearlong transition from paper toward electronic records adds to the fragmentation as well as leads to parallel recordings of the same information and extra work to keep these recordings consistent.

The overall organization of the medication process involves that large volumes of information about medication orders must be communicated from physicians to nurses, who may spent as much as 40% of their time dispensing and administering medication (Hughes & Blegen, 2008). It is, therefore, unsurprising that collaborative grounding sometimes breaks down because the nurses remain unaware of information. While it is easy to blame the nurses for carelessness when no medication, a wrong drug, or a wrong dose is administered to a patient, this overlooks that the administration of medication is part of a larger process and that the reasons for error are more often collaborative, organizational, or systemic than individual (Reason, 1990, 2004). It may be noted that the proposals for remedies included in the incident reports tend to target the individual level by mainly suggesting more information and training and new procedures. A focus on collaborative information seeking can help identify the contextual conditions that make individuals err.

### 4.2    The use of records and oral communication

Electronic and paper records are prominent in the medication process. This reliance on records is a result of the safety-critical nature of hospital work and the need to share medication information across shifts, and it appears to reflect a belief in unambiguous specification and competent, correct reading. While the records are indispensable to effective collaborative information seeking among the clinicians, repeated oral communication is also necessary. One reason for this is that the records specify what should be and have been done but contain little information about why it is done. Such explanations must mainly be sought orally, and they may be critical to understanding the recorded information – or challenging it. Another reason is that physicians and nurses need to make each other aware of changes and deviations to ensure that they are noted. This often involves orally reiterating information that is also in the records, but the redundancy serves to direct colleagues' attention to possibly important information and thereby support their competent reading of the records. A related reason is that oral communication is fast and provides instant assurance that the information has reached the recipient, whereas entering information into the records involves uncertainty about when the recipient becomes aware of the information. This is especially relevant when the information may require immediate action, and it therefore increases the amount of oral communication for critical patients and during busy periods.

In the medication process the use of records and oral communication complement and supplement each other. This is similar to some studies of engineering (e.g., Hertzum & Pejtersen, 2000), while other studies tend to assign primacy to oral communication (King, Casto, & Jones, 1994; Reddy & Spence, 2008). Common arguments against extensive records are that they are of little use to those primarily involved in an activity because they know the pertinent information and tend to consider extensive records superfluous, and that making records understandable to people beyond those primarily involved requires too much work from people whose time is better spent on other activities. In relation to the medication process the first argument does not apply because the pertinent information and the staff on duty change repeatedly, and oral communication is too ephemeral to make up for this without introducing a number of errors. The second argument is partly correct in that physicians and nurses spend much time on record keeping and, consequently, have less time for the patients. This has caused some frustration after the introduction of the EMR, especially among the physicians. It appears, however, that the source of the frustration is not records as such but an experience that they spend more time on record keeping after the transition from paper records to the EMR.

The medication process is an example of tightly-coupled work with an established division of labour between physicians and nurses. This strongly affects the role of the EMR in relation to collaborative information seeking in that the EMR prestructures collaborative information seeking around the three activities of ordering, dispensing, and administering medication. In addition, the use of the EMR involves several mandated work procedures. The EMR is indispensable to the medication process but mainly supports a regulated, but important and complex, subset of the clinicians' collaborative information seeking. For ad hoc information needs, the

EMR provides less support and the clinicians tend to prefer oral communication. This role of the EMR differs from tools such as CoSense (Paul & Morris, 2009), which makes no assumptions about users' search processes in its support for collaborative web searching. Such tools attempt to support ad hoc activities, often by providing a shared log of the users' search process and by enabling users to annotate this process. A frequent characteristic of the clinicians' ad hoc information needs is temporal urgency. One way to extend the EMR with more support for ad hoc information needs could be a facility for on-the-spot initiation of collaborative reading of EMR content by clinicians who are locally distributed within the hospital. Such a facility could replace or supplement phone conversations and thereby reduce the risk of breakdown in collaborative information seeking during busy periods and across multiple degrees of separation.

### 4.3    Implications for research and design

This study has several implications for research on collaborative information seeking. First, including collaborative grounding in the definition of collaborative information seeking provides a focus that integrates collaborative information seeking in its work context. Research in this direction may enrich studies of collaborative information seeking with insights from computer-supported cooperative work. Second, the number of breakdowns in collaborative grounding, as opposed to information seeking, suggests that the sharing of acquired information among collaborators is a prime difficulty in collaborative information seeking. This points toward a different set of research issues, compared to the research that restricts collaborative information seeking to the information-seeking activities. Third, this study shows that being competent at collaborative information seeking involves an acute awareness of how records and oral communication complement and supplement each other. More research on collaborative information seeking is required to understand and avoid breakdowns in the shifts between written records and oral communication.

For the design of electronic medication records this study appears to have three implications. First, it points at information seeking and sharing as areas that appear an important supplement to a medical focus in efforts to avoid errors in the medication process. Second, a focus on collaborative information seeking points toward collaborative, organizational, and systemic reasons for breakdown and areas for improvement. This appears different from the main trend in the proposals for remedies included in the incident reports. Third, as a concrete example of an improvement, nurses could be allowed to make delegated medication orders of selected drugs. This would enable recording of the dispensing and administration of these drugs even when physicians have only ordered them orally and would thereby prevent some breakdowns in collaborative grounding. We have empirically evaluated this improvement, which involves a formal change in the division of labour between physicians and nurses (Granlien & Hertzum, 2009a).

## 5    Conclusion

When defined as the combined activity of information seeking and collaborative grounding, collaborative information seeking captures an important and integral part of collaborative work. An illustrative example of collaborative information seeking is the medication process, which is central to hospital work. This study shows that breakdowns in collaborative information seeking is a major source of medication incidents and, thereby, that the consequences of a breakdown in collaborative information seeking may extend beyond who knows what and include adverse effects on patient health.

The contribution of this paper is its exposition of multiple different kinds of breakdown in collaborative information seeking. First, most of the breakdowns in this study of the medication process are breakdowns in collaborative grounding rather than information seeking, suggesting that collaborative grounding is the part of collaborative information seeking most in need of further attention from researchers and practitioners. Second, most of the breakdowns concern the use of records rather than oral communication, partly reflecting the extensive use of records in the medication process and partly that the electronic medication records, which are replacing paper records, appear to prevent some breakdowns but also to introduce risks of new kinds of breakdown. Third, the risk of breakdown appears to increase with the degree of separation between actors. Apart from calling for increased caution at large degrees of separation, this suggests that an important role of electronic medication records is to provide a shared and readily available context for collaborative information seeking. Fourth, the fragmentation of the information needed in the medication process entails a risk of breakdown that cannot be dismissed as merely transitional because the fragmentation appears to derive from the complexity of the work, not from any temporary condition. Rather, additional collaborative information seeking is required to assemble the required information from the multiple records and from other clinicians. Fifth, an electronic medication record presumes a certain division of labour and a certain work procedure among the clinicians; the risk of breakdown increases when clinicians deviate from procedures to get by busy periods or work around impracticalities in the electronic medication record. This shows that in its support for collaborative

information seeking the electronic medication record must strike a fine balance between the predictability created by well-established procedures and the extra attention required to coordinate work in a less prestructured, more ad hoc work setting.

Oral communication complements and supplements the use of records; many breakdowns in collaborative information seeking are prevented by the clinicians' competence in avoiding the limitations of electronic medication records through oral communication, and vice versa. Specifically, the clinicians prefer oral communication for many of their ad hoc information needs and for collaboratively grounding temporally urgent information. A more general result of this study is that even in a work domain where errors may have severe consequences and actors are careful in their conduct of their work, breakdowns in collaborative information seeking occur with some frequency. This suggests that breakdowns cannot be avoided and that it is, therefore, important to make it unlikely for breakdowns to remain unnoticed and to enable clinicians to quickly recover from breakdowns. A focus on collaborative information seeking will support such goals by pointing toward collaborative, organizational, and systemic reasons for breakdown and areas for improvement, rather than toward individual error.

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**Table 1**. Medication incidents at Danish hospitals.

| Year | Total no. of reports | Reports about medication | | Medication reports at SAC level 3 | |
|------|----------------------|--------------------------|------|-----------------------------------|------|
|      |                      | *N* | % | *N* | % |
| 2008 | 19866 | 6783 | 34% | 22 | 0.32 |
| 2007 | 19217 | 6781 | 35% | 24 | 0.35 |
| 2006 | 12370 | 4356 | 35% | 16 | 0.37 |
| 2005 | 9096  | 3666 | 40% | - | - |
| 2004 | 3626  | 1804 | 50% | - | - |

SAC – Safety Assessment Code. Source: National Board of Health (2005, 2006, 2007, 2008, 2009).

**Table 2**. Distribution of incidents involving breakdowns in collaborative information seeking onto who was aware and who remained unaware of the pertinent information.

| Category of person | Who was aware? | | Who remained unaware? | |
| --- | --- | --- | --- | --- |
| | *N* | *%* | *N* | *%* |
| Nobody | 8 | 13% | - | - |
| Physician | 38 | 63% | 17 | 28% |
| Nurse | 4 | 7% | 29 | 48% |
| Healthcare person at another department | 2 | 3% | 4 | 7% |
| Healthcare person outside the hospital | 4 | 7% | 3 | 5% |
| Patient | 1 | 2% | 5 | 8% |
| Another, unspecified healthcare person | 3 | 5% | 2 | 3% |
| Total | 60 | 100% | 60 | 100% |

**Table 3**. Categories of breakdown in collaborative information seeking.

| Category of breakdown | *N* | % |
|---|---|---|
| Oral communication is ephemeral | 5 | 8% |
| Misreading record or failing to react on record content | 11 | 18% |
| Parallel records | 10 | 17% |
| Error or incompleteness in record | 10 | 17% |
| Failure in identifying drug, dose, or route | 11 | 18% |
| Failure in identifying patient | 9 | 15% |
| Other | 4 | 7% |
| Total | 60 | 100% |