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Procedures and Collaborative Information Seeking: A Study of Emergency Departments

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Abstract. Information seeking is a central and inherently collaborative activity in the emergency department (ED), which is the common entry point to hospitals for nearly all acute patients. In this paper, we investigate how ED clinicians' collaborative information seeking (CIS) is shaped by the procedures that they follow in the ED. Based on observations in two Danish EDs, we identify four procedures prominent to how CIS is accomplished: the triage procedure, the timeouts, the coordinating nurse, and the recurrent opportunities for information seeking at the whiteboard. We then discuss how CIS activities are impacted by these procedures and the challenges to effective CIS in these settings. We conclude with some thoughts about future studies of CIS in healthcare settings.

Keywords: collaborative information seeking, information behavior, work procedures, emergency medicine, healthcare

Introduction

The collaborative aspects of information seeking are receiving increasing research attention (Foster, 2006; Hertzum, 2008; Reddy & Spence, 2008; Shah, 2014), yet most of this research depicts collaborative information seeking (CIS) as a predominantly informal activity that often does not receive appropriate support because it is not viewed as part of the formal work activities. However, inadequate support increases the risk of breakdowns in CIS activities, and in healthcare settings such breakdowns may have adverse consequences for patient health (Hertzum, 2010). Instead, CIS should be made part of the procedures in the organization in order to promote safe and efficient healthcare practices. The triage procedure used in emergency departments (EDs) provides an example (Farrohknia et al., 2011). Tri-

age is used to determine the order in which ED patients receive care, but apart from classifying patients according to need it also involves and, importantly, shapes information seeking within a collaborative environment. It is, however, challenging to perform CIS activities effectively and efficiently in busy, information-intensive clinical settings. This raises the question of how healthcare providers in settings such as the ED accomplish their CIS activities.

To examine this question, we conducted a qualitative field study investigating the CIS activities in two Danish EDs. In particular, we were interested in understanding how CIS activities were shaped by ED procedures. We interpret procedures broadly, that is, as ranging from scripted procedures such as triage to loosely stipulated but recurrent work processes. Procedures also involve formally defined work roles and a collaborative division of labor.

The ED is the common entry point to hospitals for nearly all patients with acute problems. Consequently, EDs receive a large number of patients for whom initial information about their condition is often rudimentary, unclear, and incomplete. Additional information about the patients' condition must be acquired quickly, reliably, and often under time pressure. Furthermore, any oversight about a patient's condition may be detrimental to her health. However, this has to be balanced against the need to quickly see a number of patients. These work conditions make information seeking a central and inherently collaborative activity in EDs. Due to the large volume of patients, ED work involves procedures devised to structure the clinicians' information seeking into efficient collaborative work practices. The goal of this paper is not to enumerate all the ways in which CIS is shaped by ED procedures. Rather, we will present details of four procedures with the goal of examining the organization of CIS in relation to these procedures. By examining these examples, we aim to advance our understanding of how procedures shape CIS activities and what types of tools could best support these activities.

In the next section we describe the related work on collaborative information seeking. Then, in the third section, we describe our data collection and analysis methods. In the fourth section, we present the results of our analysis of how ED procedures shape the clinicians' CIS activities. We discuss, in the fifth section, what distinguishes collaborative information seeking in a proceduralized context from the predominant characterization of collaborative information seeking as an informal activity. We conclude with some thoughts about future research.

Related Work

Collaborative information seeking has been of growing interest to researchers in a variety of fields where collaboration is crucial, including education (Hyldegård, 2006), military (Sonnenwald & Pierce, 2000), web search (Morris & Horvitz, 2007), and healthcare (Reddy & Jansen, 2008). Furthermore, researchers in computer-supported cooperative work (CSCW) are interested in understanding how

information seeking is entangled with broader collaborative and coordinative activities (Ackerman, 2000). However, there are still a number of challenges that we must address to provide support for CIS activities. In this section, we discuss CIS broadly and then focus on CIS within the context of hospital work.

Collaborative information seeking

Foster (2006) defines CIS as "the study of the systems and practices that enable individuals to collaborate during the seeking, searching, and retrieval of information." Within organizations, CIS has been viewed primarily as an informal activity that takes place in response to either some breakdown in the formal work processes or to address a problem that arises in the course of the organizational work (Hansen & Järvelin, 2005; Hertzum, 2010). By informal, we mean that CIS activities are not incorporated as part of the formal organizational work. This has two consequences. First, there are few, if any, technical mechanisms implemented by organizations to support CIS (Foster, 2006). Second, there are few policies that integrate CIS into the procedures of the organization.

CIS researchers have investigated these issues through two broad streams of research – social and technical. In the social stream, researchers have been utilizing primarily qualitative research methods to investigate how people collaborate when seeking information in organizational and other settings (Prekop, 2002). For instance, we have obtained a better understanding of what triggers CIS activities (Reddy & Jansen, 2008) and of the different methods by which people interact when they seek information in face-to-face environments (Paul & Reddy, 2010) and when the interaction is mediated by technology (Menkov et al., 2000). There is also growing interest in understanding what constitutes CIS. Hertzum (2008) discusses how CIS consists of information-seeking activities and collaborative-grounding activities. He argues that it is not sufficient for individuals to work together to search for information but that they must also reach some common understanding of what that information means. Paul and Reddy (2010) take a similar perspective when they discuss collaborative sensemaking in CIS. In the technical stream of research, researchers have been investigating how to support CIS activities through technical mechanisms. These mechanisms include, for instance, CIS tools such as SearchTogether (Morris & Horvitz, 2007), CoSense (Paul & Morris, 2009), and Coagmento (González-Ibáñez & Shah, 2011). Both the social and technical streams of CIS have improved our understanding of CIS activities and mechanisms to support these activities.

CIS in healthcare

Information seeking is a fundamental aspect of healthcare. One of the primary tasks of healthcare providers is to find the right information at the right time in order to provide effective patient care (Reddy et al., 2006). As multiple studies have shown, healthcare is a highly collaborative endeavor. In information-intensive environments such as the ED or intensive care unit, information is available from a variety of resources. However, at the same time, the increasing number of information resources and systems has created a problem of *information fragmentation* (Bansler et al., 2011). Therefore, healthcare providers have to gather and integrate information from different resources to make appropriate patient care decisions. Consequently, healthcare providers in the course of their work have to collaborate when seeking and retrieving information to ensure that they get the right information (Bardram & Bossen, 2005). However, most previous studies of information seeking in hospitals have focused primarily on *individual* information seeking (McKnight, 2006). In addition, many of the information seeking studies have focused on identifying and categorizing the information needs of individual clinical providers (Gorman, 1995). Why is this the case? First, most current information seeking models, with a few exceptions (Karunakaran et al., 2013), focus on the *individual* information seeker and only represent the single user in the model (Kuhlthau, 1988). For instance, the information seeking models by Kuhlthau (1988) and Ellis and Haugan (1997) highlight the different stages and behaviors of an individual who seeks information. Information seeking is conceptualized in many of these models as an intrinsically individual activity (Leckie et al., 1996) for two major reasons: a focus on the conventional pattern of interaction between a single user and technology and the emphasis on individual rather than collaborative work.

Researchers who have focused on CIS in healthcare have examined a number of issues including how healthcare providers collaborate to find information in busy and information-intensive clinical environments (Reddy & Dourish, 2002) and the challenges of utilizing technologies to support CIS activities. Although an increasing number of researchers investigate CIS activities in healthcare, it still has not been widely investigated. Consequently, this research hopes to provide more insight into the CIS activities in hospitals, specifically EDs.

Method

This study is based on empirical data from a multi-year research project in the four EDs in Region Zealand, one of five healthcare regions in Denmark. While the overarching aim of the project was to evaluate the effects of electronic whiteboards on the clinicians' overview of their work and on the interdepartmental

communication, we also observed ED work more generally. The original motivation for these observations was to provide a background understanding for our effects measurements and to identify additional effects that emerged during extended whiteboard use. However, the observations also provided data for investigating collaborative information seeking in a context where patient safety and patient volume had motivated the introduction of procedures for making the clinicians' information behavior effective and efficient.

Research sites and participants

All four EDs in the region were part of medium-size hospitals and each ED received about 40,000 patients a year. The data presented in this study were collected at two of the EDs, referred in this paper as ED1 and ED2. We focused on ED1 and ED2 because we had collected observational data in those departments. Observational data can provide information about how CIS is concretely accomplished in the context of the myriad factors that constitute a work setting, including its procedures. For this reason, we considered observational data imperative for our study.

ED1 contained ten patient rooms divided into an acute area for patients arriving by ambulance or referred to the ED from their general practitioner and a fast-track area for walk-in patients. ED1 was staffed with 25 physicians and 35 nurses. We observed work in ED1 for a total of 116 hours. For most of the observations, we were stationed close to the control desk, which was the coordination center of the ED. From this position we could follow the activities and conversations of the clinicians working or briefly meeting at the control desk. Specifically, the coordinating nurse was almost permanently at the control desk. For further information about the observations in ED1, see Hertzum and Simonsen (2013, 2015b).

ED2 contained 21 patient rooms divided into two acute areas, a fast-track area, and a long-term area. ED2 employed 13 full-time physicians and 120 nurses. In addition to the full-time physicians, a number of physicians from other departments at the hospital were assigned to ED2 for part of their shifts. We observed work at ED2 for about 94 hours. These observations took place throughout the ED and included observing the timeouts during which the physicians met to walk through the admitted patients. It also included shadowing physicians and nurses by following them for periods of time (two hours) as they went about their work. For further information about the observations in ED2, see Hertzum and Simonsen (2015a) and Torkilsheyggi et al. (2013).

Data collection and analysis

We collected data by means of ethnographic field methods, primarily general observation and shadowing. The observations were approved by the healthcare region and the management of the EDs. Information about our data collection was provided in the departments' electronic newsletter ahead of the observations, at the clinicians' morning meetings at the beginning of the observations, and when needed during the observations. We obtained oral consent from each shadowed clinician prior to the shadowing.

We documented our observations in written field notes, which were subsequently analyzed using open coding. The analysis consisted of reading through the field notes to discover CIS incidents. Subsequently, we looked for regularities in how these incidents were handled by the ED clinicians. This led to the identification of departmental procedures as a pivotal element in many CIS incidents and, consequently, a focal point in our analysis. We, then, reread the CIS incidents to identify how the procedures shaped the clinicians' collaborative information seeking. This analysis produced the four themes presented in the next section.

Results

In the following section, we describe the four themes that resulted from our data analysis: the role of the coordinating nurse during CIS, the impact of the triage procedure on CIS, the timeouts, and the recurrent opportunities for information seeking at the whiteboard.

The role of the coordinating nurse during CIS

In a fast-paced, high-volume, expertise-dependent setting like the ED, a great deal of information resides in the mind of the healthcare providers and is often only recorded in writing after the actual work has been done, or sometimes is not recorded at all. Under such circumstances, identifying the right person to consult becomes an important aspect of information seeking. To support an efficient flow of information in the EDs that we studied, an experienced nurse had the specific role of a *coordinating nurse*. The coordinating nurse served as an information hub for CIS activities – she was receiving information from many sources, using it for a variety of coordinative purposes, and passing it on to others. For example, the coordinating nurse received phone announcements of upcoming patient arrivals, managed the ED part in the handover of ambulance patients from the paramedics to the ED, kept an eye on the number of walk-in patients in the waiting room, as-

signed nurses and physicians to patients, communicated with other departments at the hospital to order laboratory tests and patient transports, and prioritized and reprioritized the patients on the basis of continuous input from physicians and nurses.

In ED1, the coordinating nurse was stationed at the control desk, which was centrally located and contained the whiteboard that displayed selected information about each patient, such as room, triage level, working diagnosis, responsible physician, responsible nurse, ordered laboratory tests, and current treatment activity. The following excerpt from our field notes gives an impression of the coordinating nurse's role in the collaborative flow of information in ED1:

> An ambulance has been dispatched to a patient in response to an emergency. The coordinating nurse was notified about the patient 15 minutes ago and received initial patient information. She has selected a room for the patient but has not yet found a nurse and a physician who can examine the patient. Now the coordinating nurse sees that the paramedics are arriving with the patient and she informs the secretary working at the control desk about the patient so the secretary can fill in the form associated with admitting the patient. When the paramedics have wheeled the stretcher with the patient up to the control desk, the coordinating nurse says "Room 5" to the paramedics while she gives the secretary the last pieces of information about the patient. The paramedics inform the coordinating nurse that the patient got nitroglycerin and painkillers in the ambulance. This information must be passed on to the physician, but until the coordinating nurse has assigned a physician to the patient it is her responsibility to remember the information. The coordinating nurse is anxious to initiate the examination of the patient because he, as most ambulance arrivals, has not been seen by a physician prior to arrival and because the coordinating nurse knows from pulling the patient's records prior to his arrival that he suffers from a constriction of the aorta. Consequently, the coordinating nurse triages the patient as orange (the second most severe of the five triage levels), hurries to find an available physician, and proactively orders EKG for the patient. When the patient is wheeled to the room, the coordinating nurse updates the whiteboard with information about the triage level, the ordered EKG, and the assigned physician. She writes a question mark ('?') in the cell for the responsible nurse to indicate to the nurses that she is looking, in vain so far, for a nurse for the patient.

In a setting where most clinicians were constantly moving between patient rooms, clinician work areas, supply rooms, and locations outside the ED, the almost permanent presence of the coordinating nurse at the control desk was important. The coordinating nurse's predictable location allowed her to serve in an information-exchange role. Clinicians frequently delivered information to and obtained information from the coordinating nurse, rather than from each other. This behavior expedited the flow of information because it bypassed the need for locating the colleague to consult and decreased the risk that the colleague would be occupied and unable to provide the information. Passing by the control desk in between tasks would often be sufficient for the clinicians to obtain the information they needed, for example about whether the results of a laboratory test had become available, or to provide the information necessary to satisfy another clinician's information need.

The presence of the coordinating nurse broke the CIS activities among a multitude of actors down into a series of simple interactions between the coordinating nurse and individual clinicians. For example, in the field-note excerpt above, a CIS activity including the paramedics, physician, nurse, and secretary was replaced by a series of simple, one-on-one interactions between the coordinating nurse and individual clinicians. In addition, the coordinating nurse mitigated the temporal pressure on the clinicians' information behavior by holding the information until it could be shared among the persons who needed to know it.

The impact of the triage procedure on CIS

ED clinicians must continuously seek the information necessary to determine how urgently each patient needed care. While individual clinicians may obtain this information for different patients, it must be collaboratively grounded in a manner that allowed for patient prioritization. This information seeking task was constantly ongoing because a patient's condition may change dynamically and because the arrival of new patients can change the priority of the existing patients. The procedure for determining the urgency of a patient's condition is called *triage*. It must, for obvious reasons, be reliable but it must also be resource-efficient because of the large volume of patients (each of the four studied EDs received about 40,000 patients a year).

The triage procedure consisted of an assessment of the patient's airways, breathing, circulation, disability, and exposure (the ABCDE approach). For each of these five areas, the procedure specified a few vital signs to consider and gave threshold values. For example, the breathing category included the respiratory rate with the threshold values, from most to least severe: (1) above 35 or below 8 per minute, (2) above 30, (3) above 25, (4) between 8 and 25, and (5) no threshold specified. The thresholds divided the patient's response into five triage levels of varying severity. While a patient's responses for the different vital signs might not always unanimously indicate a triage level, the procedure simplified and expedited the information seeking involved in determining the urgency of a patient's condition by specifying the information to be obtained as well as the thresholds for interpreting it. The result of the procedure was a triage level of either red (life threatening), orange (seriously ill), yellow (ill), green (in need of assessment), or blue (fast track). The use of a shared triage procedure across clinicians established a common ground for the prioritization of the patients and thereby eliminated most discussions of whether a yellow patient really was in more urgent need of care than a green patient.

The triage procedure specified that each patient was to be triaged twice, immediately upon arrival and after having been examined by the nurse assigned to the patient. However, the practice in ED1 was more flexible. When the coordinating nurse was notified of upcoming patient arrivals, she would sometimes indicate

their triage level when she entered the patient information on the whiteboard. This practice was restricted to patients suspected to be in urgent need of care and served to alert the clinicians of the possibility of imminent reprioritizations of the patients. Upon arrival, patients were mostly triaged by the coordinating nurse. The basis for this triage was the information available to the coordinating nurse prior to the patient's arrival, the information provided by the paramedics in handing over the patient, and the coordinating nurse's impression of the patient when the paramedics wheeled the patient past the control desk. The triage level resulting from this assessment was preliminary because of the full or partial absence of actual measurements of the vital signs specified in the triage procedure. For red and orange patients, the triage procedure specified narrow limits for the time until the patient was examined by a nurse and a physician, and the coordinating nurse would await information about whether the examination led to a reassessment of the triage level. Sometimes a reassessment could be implicitly inferred from the absence of events associated with a specific triage level:

> The coordinating nurse records the new patient in Room 1 on the whiteboard and marks the patient as red. While she records the information, the nurse who has been assigned to the patient walks into Room 1. The clinician responsible for taking blood samples is standing at the control desk to figure out which patient she has been called to see and then enters Room 1 to ask whether she can draw blood from the patient. She returns and informs the coordinating nurse that the patient is in a bad state and throws up and that the patient's nurse has decided that blood samples and EKG must wait a bit. The coordinating nurse monitors the door to Room 1 and as the nurse in there does not call for a physician in the course of the next couple of minutes, the coordinating nurse changes the patient's triage level to yellow and says to the other clinicians by the control desk that it probably wasn't the heart anyway. Five minutes later a physician comes by the control desk to see which patient to attend next. After glancing at the whiteboard she asks the coordinating nurse whether she should take the patient in Room 1 but is told to take Room 4 instead.

Without the triage procedure, there would have been one patient who had been "kicked by a horse", another who had "a worryingly low blood pressure after a fall in her home", and yet another with "an unboiled piece of pasta stuck in his airways". A prioritization based on such diverse descriptions would lack grounding and invite discussion. The standardization inherent in the triage procedure supported the clinicians by directing their attention toward specified pieces of information, providing threshold values for interpreting them, and establishing a common ground for making comparisons across patients. This way, a recurrent and potentially complex instance of collaborative information seeking was transformed into a routine accomplishment, and the clinicians had more mental resources left for treating the patients.

Timeouts

The assignment of individual physicians to patients was a prominent aspect of the work in the EDs. This assignment was visible to everybody because it was recorded on the whiteboard. A physician could easily, and especially when busy, form an opinion about a patient on the basis of too little information or a too narrow interpretation of it. To counter these risks of individualization and premature conclusions, ED2 experimented with timeouts as a way of creating collaborative reflection on the patients' condition and the plans for their treatment. Twice a day the physicians suspended patient treatment for 10-15 minutes to meet at the whiteboard and discuss each patient in the ED.

The timeouts proceeded as walkthroughs of the patients, usually starting from the top of the whiteboard. In a few sentences, the physician responsible for the patient described the patient's condition and treatment status. Then the other physicians, especially the senior physicians, asked for clarifying information, checked whether potentially important issues had been considered, flagged additional issues to consider, and made recommendations about how to proceed. The information on the whiteboard was actively used by the physicians in assessing the patient. We observed the physicians tap on the blood-test icons on the whiteboard to open the pop-up window displaying the results of previously ordered blood tests. However, the timeout was mostly confined to a discussion of the meaning of available information; whereas additional information needs became future information-seeking tasks for the responsible physician. The discussion of a patient often involved changes in the patient information recorded on the whiteboard, for example when it was decided to order new laboratory tests or to transfer a patient to another department in the hospital for further treatment. To keep the timeouts brief, the changes were mostly noted by the responsible physician on a piece of paper, thereby creating the additional task of subsequently updating the whiteboard. Because many decisions important to the flow of the patients through ED2 were made at the timeouts, the coordinating nurse started to attend the timeouts during our observations.

As instances of collaborative information seeking, the timeouts maintained a rather consistent distinction between information seeking, which was performed before and after the timeouts by the physician responsible for a patient, and collaborative grounding, which was the predominant focus of the timeouts. The timeouts ensured that the complex information-seeking activities required for gaining an understanding of a patient's condition remained anchored in a practice that involved the physicians as a group even though most of the concrete treatment of the patients was delegated to individual physicians. A special rationale for this collaborative grounding of the information seeking and interpretation was that it enabled an organization of ED work in which the initial examination of the patients was performed by junior physicians. The timeouts provided a regularly recurring opportunity for the junior physicians to consult more experienced col-

leagues and for the senior physicians to supervise and offer expert judgment. That is, the organization of information seeking as a collaborative activity provided rich opportunities for in-situ training.

Recurrent opportunities for information seeking at the whiteboard

In ED1 and ED2, the whiteboards were located at an information hub that also included a work area for the clinicians to prepare for seeing patients and to document treatment after having seen them. This feature of the physical layout of the EDs meant that the physicians spent more than one quarter of their time in the vicinity of the whiteboard (Hertzum & Simonsen, 2013, 2015a) and could count on regularly meeting their colleagues there. In this manner, the whiteboard and the area around it provided recurrent opportunities for seeking information or opinion from experienced colleagues and for offering advice or reassurance to junior colleagues:

> A junior physician is standing at the control desk reading some papers about one of his patients. A senior physician walks up to the whiteboard and appears to conclude that there is nothing urgent for her to do. She asks the junior physician: "Is your patient having chest pain?" The junior physician confirms but with some hesitation, and the senior physician asks whether it is his first patient of this kind. He nodes and adds that he has sufficient time to read the patient record and think about how to proceed [i.e., he is not under pressure and the senior physician need not assign high priority to help him]. They discuss the patient's symptoms and background for 30-45 seconds and the senior physician draws attention to a couple of issues. Then the senior physician leaves the control desk, and shortly afterward the junior physician leaves too.

As the excerpt from ED1 illustrates, there was a fluid boundary between seeking and offering information. The senior physicians' supervisory role ensured that they made themselves available for consultation. The area by the whiteboard was well-suited for such consultations because the clinicians did part of their work there and thus were present when they needed information. Furthermore, multiple clinicians were often there simultaneously, thereby providing opportunities for keeping abreast by overhearing their discussions. This way, the area by the whiteboard extended the timeouts by providing recurrent opportunities for information seeking as well as collaborative grounding. Compared to the timeouts, the area by the whiteboard was more suitable for person-to-person consultations, especially lengthier ones.

Discussion

In this section, we discuss the challenges ED clinicians face in their CIS activities, the ways in which the four procedures shape collaborative information seeking, and the limitations of our study.

Challenges to collaborative information seeking in EDs

ED clinicians face multiple challenges in their collaborative information seeking. In the following paragraphs, we discuss three challenges that result from the specific characteristics of ED work.

The first and foremost challenge in ED work is the unpredictability of the number of patients arriving in the next hour and the severity of the patients' condition. This unpredictability has a profound effect on the clinicians' collaborative information seeking – it becomes driven by external events, fast-paced, and subject to dynamic reorientation when a patient's condition worsens or a new patient arrives. These circumstances explain the large number of interruptions faced by ED clinicians (Spencer et al., 2004). They also create a need for procedures that help create order rather than presuppose orderliness. The triage procedure is a widespread and successful example. Triage arose in military medicine to distribute healthcare systematically to wounded soldiers on the battlefield (Iserson & Moskop, 2007). Fortunately, EDs face less extreme situations but they still benefit from the resilience of the triage procedure in hectic situations and its effectiveness in creating some order. Still, CIS incidents in EDs are challenged during the periods where the available clinical resources cannot match demands and patients wait for hours before being seen.

Second, the four analyzed procedures are internal to the EDs but important parts of the clinicians' CIS activities extend outside the ED. For example, consultations about patients with severe symptoms involve physicians from other medical specialties, arrangements for transferring a patient to another department for a special examination are negotiated with the receiving department, and patient transfers are scheduled with the hospital porters. While CIS activities internal to the EDs are shaped and simplified by the procedures, the CIS activities that involve people external to the ED are largely handled by phone calls. These phone calls are often not answered and must therefore be repeated or can result in returned calls at inopportune times. In addition to these complications, the department boundary not only implies a physical separation between the collaborators but also a separation in medical specialty. These multiple levels of separation increase the risk of CIS breakdowns with potential adverse effects on patient health (Hertzum, 2010).

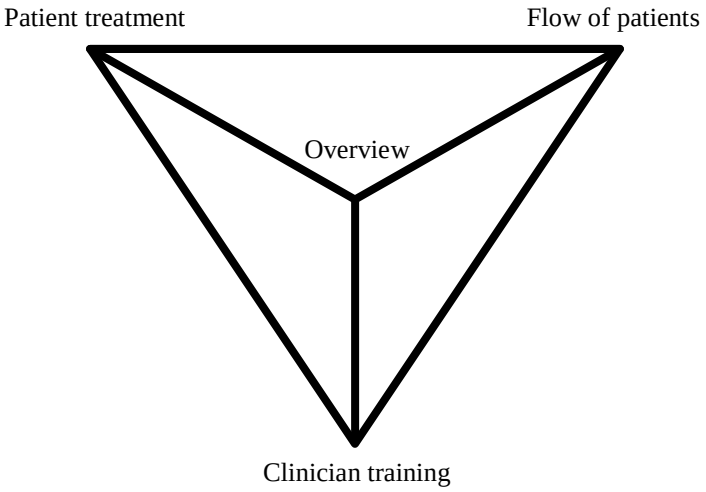

Figure 1. Interrelated purposes of CIS incidents in the ED

Third, the clinicians' collaborative information seeking serves multiple interrelated purposes. Four prominent purposes are to treat the patients, maintain the flow of patients through the ED, train the junior clinicians, and maintain the overview necessary to prioritize the patients and balance the purposes (Figure 1). An exclusive focus on one purpose has negative consequences for the others. The coordinating nurse is tasked with maintaining an overview, thereby enabling the other clinicians to focus more fully on their individual responsibilities. This makes the role of coordinating nurse demanding and pivotal to a well-functioning ED. Continuous collaborative information seeking is required for the coordinating nurse to keep everything organized and moving in the ED. Conversely, CIS activities about the actual treatment of a specific patient involve the physician or nurse responsible for the patient supported by senior colleagues and, possibly, a specialist from another department.

The challenges highlight the difficulties faced by healthcare providers to successfully collaborate during CIS activities. Yet, healthcare providers often find the information that they need to do their work. Why is this the case? We argue part of the answer lies in how CIS is shaped by various procedures as described in the next section.

Collaborative information seeking shaped by procedures

A CIS instance can be viewed as a specific configuration of components that have to be properly integrated to lead to success. These components include information needs, people, criteria, location, and time. In informal and ad hoc instances of CIS, the configuration may have to be re-established each time. Re-establishing the configuration incurs a risk of not succeeding because all the components have to be re-integrated. Conversely, when CIS is shaped by procedures, a part of the configuration is already established ahead of individual CIS instances thereby reducing the work involved in establishing a CIS configuration and increasing the chances of success. The four procedures analyzed in this study shape collaborative information seeking by pre-specifying different components of the CIS configuration:

- The *coordinating nurse* procedure pre-specifies the person with whom to engage in collaborative information seeking. The coordinating nurse may either provide the needed information directly or serve as a gatekeeper. Because the coordinating nurse performs the vast majority of her work at the control desk, CIS configurations involving the coordinating nurse are also pre-specified with respect to location (the control desk) and time (anytime).
- The *triage* procedure pre-specifies the criteria used to assess and prioritize patients. It also pre-specifies the time at which the procedure must be performed (upon arrival and after examination by a nurse) and the people normally involved (coordinating nurse and nurse assigned to patient). The collaborative grounding of the patients' triage level among the clinicians is important to the effectiveness and efficiency of work in the ED because the triage level is subsequently a valuable criterion in many other CIS instances.
- The *timeouts* constitute CIS configurations with a pre-specified time (twice a day, at fixed times), location (by the whiteboard), and group of people present (the physicians and the coordinating nurse). In addition, the timeouts are suited for some information needs but not for others because of their focus on assessing all the patients, their brevity, and their highly collaborative format.
- The *area by the whiteboard* primarily pre-specifies a location for CIS configurations. In addition, it partly specifies people and time because other physicians and nurses will often be in the area by the whiteboard. The area by the whiteboard is suitable for pursuing almost any CIS-related information need regarding the treatment of the patients. In this sense, the area by the whiteboard becomes a likely location for the informal CIS instances in the ED.

The way in which the procedures in the ED pre-specify part of the configuration of CIS instances resembles Hutchins' (1995) description of how a well-designed work configuration constitutes a pre-computation that enables actors to distribute part of the cognition required in their work to their environment. A well-designed work configuration replaces demanding cognitive tasks with simpler

tasks of aligning objects or activities with each other. Similarly, the timeouts replace the task of agreeing, on a day-to-day basis, on a suitable time, location, and agenda for a meeting involving all physicians with the simple task of showing up by the whiteboard at 10:15am. The other procedures simplify collaborative information seeking in similar ways. Such simplifications are important in a work environment where frequent interruptions complicate planning. Previous research has highlighted that ED clinicians are interrupted as much as an average of 15 times an hour (Spencer et al., 2004), often with the result that they fail to return to the interrupted task or hasten to complete it to compensate for the time 'lost' in interruption (Westbrook et al., 2010). The simplifications introduced by the procedures may reduce the number of interruptions because the clinicians, for example, know they will meet at the timeouts and postpone some of their collaborative information seeking until then.

Limitations

There are three major limitations to this study. First, we observed work in only two EDs and cannot claim that the same procedures are present in other EDs. In addition, our observations were restricted to the dayshifts and we refrained, for privacy reasons, from making observations in the patient rooms. While we do not claim that the same procedures are present in other EDs, we do contend that the procedures present in other EDs shape clinicians' collaborative information seeking by pre-specifying it in some of the same ways as those we have observed in ED1 and ED2. Furthermore, some procedures such as triage are common in all EDs. Second, we interpret procedures broadly. The broad approach resulted in the identification of multiple ways in which procedures pre-specify aspects of collaborative information seeking, thereby enriching our exploratory analysis. We acknowledge, however, the need for in-depth studies of how specific kinds of procedures, or single procedures, shape collaborative information seeking. Third, our analysis is based on observational data, which highlight what the ED clinicians do but can, at best, only indirectly reflect what they are thinking while they are doing this work.

Conclusion

Collaborative information seeking is an integral aspect of organizational work. However, much of the current research has depicted CIS as an informal and often ad hoc activity. Through this study, we have shown how CIS can be closely tied to the variety of more formal organizational procedures. Procedures shape CIS activities by pre-specifying, at least partially, the required configuration of information

needs, people, criteria, location, and time. We have specifically analyzed how the configuration required for CIS activities to succeed in EDs is shaped by four procedures: the coordinating nurse, the timeouts, the triage procedure, and the recurrent opportunities for information seeking at the whiteboard. By pre-specifying some components of the ED clinicians' CIS activities, the procedures reduce the effort involved in performing these CIS activities. Still, the ED clinicians must face the challenges that many of their CIS activities are driven by unpredictable external events, extend to hospital departments other than the ED, and aim to serve multiple interrelated purposes.

The present study provides an initial exploration of how procedures shape CIS activities. Future studies of the effect of procedures on collaborative information seeking should include interviews, diaries, or other means of obtaining data about how people perform the cognitive part of collaborative information seeking in the face of procedures. A potentially important actor in CIS activities in hospitals is the patient. Future studies of CIS in hospital settings like EDs should include the healthcare providers as well as the patient. Procedures facilitating the inclusion of the patients as actors in CIS activities may, simultaneously, reinforce a recognition among the healthcare providers of the patients as active participants in their treatment and recovery. Interventions to increase the frequency at which patients are treated as CIS actors could be a practically important contribution of future CIS studies.

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