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Collaborative information seeking: A field study of a multidisciplinary patient care team

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Abstract

Multidisciplinary teams are an essential aspect of modern organizational work. These teams often work in information-rich environments but little is known about their collaborative information seeking (CIS) behavior. We have been studying the CIS behavior of teams in the context of medical care. We conducted an ethnographic field study of a multidisciplinary patient care team in an emergency department to identify (a) team information needs and (b) situations that trigger collaborative information seeking activities. We identified seven categories of information needs as expressed by questions asked by team members. The majority of questions focused on medical information, but there were a larger than expected percentage of questions focusing on organizational information. We also identified three triggers for CIS activities. These triggers are: (1) lack of expertise, (2) lack of immediately accessible information, and (3) complex information needs. The questions and triggers highlight the importance of face-to-face communication during CIS activities and how CIS activities could lead to interruptive workplaces. We also discuss organizational and technical implications for supporting CIS behavior of teams.

Keywords: Collaborative information seeking; Multidisciplinary teams; Healthcare; Field study

1. Introduction

Information seeking and management activities are a prominent aspect of everyday work. In organizations, information plays a vital role not only in decision-making but also in coordinating, contextualizing, and providing awareness of others' activities (Berg, 1999). Consequently, organizations are paying more attention to their information seeking and management practices. Within these settings, information seeking is conceptualized as essentially an individual, rather than a collaborative activity (Ellis, 1989; Hansen & Jarvelin, 2005; Sonnenwald & Pierce, 2000). However, individuals rarely work independently in modern organizational settings. Instead, the dominant setting for information work in these environments is interdisciplinary or

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multifunctional teams (Baggs, Ryan, Phelps, Richeson, & Johnson, 1992; Gorman et al., 2000; Hansen & Jarvelin, 2005). These teams are critical to an organization's ability to implement its goals. One key element to team success is their ability to work together to seek information efficiently and effectively. Increasingly, researchers are starting to examine information seeking as a collaborative activity in a wide variety of team settings including design (Bruce et al., 2002), education (Hyldegard, 2004), and military command and control (Sonnenwald & Pierce, 2000). We define collaborative information seeking (CIS) as "an information access activity related to a specific problem solving activity that, implicitly or explicitly, involves human beings interacting with other human(s) directly and/or through texts (e.g., documents, notes, figures) as information sources in an work task related information seeking and retrieval process either in a specific workplace setting or in a more open community or environment." (Hansen & Jarvelin, 2005).

We have been investigating the CIS behavior of teams in the context of hospital work (Reddy & Dourish, 2002; Reddy, Pratt, Dourish, & Shabot, 2002b). Although a number of organizational settings involve teams and team work, few settings are as rich in detail as hospitals (Bardram, 2000). Because of the increasing complexity of patient conditions and treatments, hospitals are turning to patient care teams as a means of managing their patient population. These teams are highly multidisciplinary – consisting of physicians, nurses, pharmacists, physical therapists, and other healthcare workers (Gorman et al., 2000). Similar to teams in other settings (Fidel et al., 2000), a patient care team brings together healthcare workers with different backgrounds and expertise to focus on a single patient and the patient's problems. Although each team member may have different concerns, work, and motivations (Strauss, Fagerhaugh, Suczek, & Wiener, 1985), they must collaborate and coordinate their activities to provide effective patient care.

In particular, we conducted an ethnographic field study of CIS behavior of a multidisciplinary patient care team in an emergency department (ED) of a small rural hospital. The ED is, arguably, one of the most information-intensive and collaborative settings in a hospital. In addition, team members in the ED often work under tremendous time pressure because of the critical status of the patients and the need to treat all waiting patients.

In this environment, team members face numerous challenges to finding needed information in order to provide effective patient care. First, patient information is often located in multiple resources. For instance, the digital images may be in one resource and the lab results in another resource. Therefore, team members must find all the different pieces of information and weave them together. Second, they must quickly treat patients because of the constant backlog of waiting patients. Thus, they need to find information as rapidly as possible. Finally, team members cannot afford to make mistakes so they must insure that the information they use is accurate. Because of these challenges, collaboration during information seeking activities is an integral aspect of the work in the unit.

Through the field study, we were interested in answering two research questions: (1) what are the information needs of the multidisciplinary patient care team? (2) What triggered their CIS activities? By answering those two questions, we hope to gain a better understanding of CIS behavior. The paper is organized as follows: in the next section, we provide some background about collaborative information seeking. In section 3, we describe our research methods and study site. We then present results from our field study in Section 4. Section 5 discusses information breakdown and needs, CIS behavior, and consequences of CIS activities. We also discuss organizational and technical recommendations for supporting collaborative information seeking behavior. Finally, we conclude with remarks about collaboration, information seeking, and work.

2. Background

Although information seeking is viewed as an important aspect of collaborative work activities (Cicourel, 1990; Hansen & Jarvelin, 2005; Paepcke, 1996), there has been only limited research in understanding CIS behavior.

Most current research in CIS behavior has focused on understanding how team members collaborate during information seeking activities. The most extensive study of CIS to date has been conducted by a team of researchers from the University of Washington (Bruce et al., 2003; Fidel et al., 2000; Fidel, Pejtersen, Cleal, & Bruce, 2004; Poltrock et al., 2003). They studied the collaborative information retrieval practices of two design teams – one from Boeing and one from Microsoft. In their studies, the researchers examined how team members actively worked together to identify information needs. Using the Cognitive Work Analysis framework,

they found that team members collaborated extensively when developing information seeking and retrieval strategies to address an information problem within the team. Their research revealed factors such as communication patterns and work activities that influence the need for information and for collaboration during information retrieval. Similarly, Hansen and Jarvelin (2005) found that awareness that workers have of each other's work activities plays an important role in the success of the CIS activities.

To understand CIS behavior in different contexts, researchers are studying teams in a variety of domains such as military, education, and health care. In a study of information behavior in a military command and control environment, Sonnenwald and Pierce (2000) described information seeking as a dynamic activity in which "individuals must work together to seek, synthesize and disseminate information" and placed information seeking within the wider context of the group communication process. In education, Hyldegard (2004) looked at collaborative information seeking from the perspective of extending Kuhlthau's Information Search Process model. The author was interested in examining how well the model explained CIS behavior in students. She found that the model needed to be extended to support collaboration. In a survey of CIS behavior among academic researchers, Spence, Reddy, and Hall (2005) found that researchers used a variety of tools ranging from e-mail to video-conferencing to support their collaboration during information seeking activities.

In the medical domain, Reddy and Dourish (2002) described the role that work rhythms played in team members' collaborative information seeking practices in an intensive care unit. When team members understood the rhythms of the unit, they also knew when information was needed. Team members could then collaborate to find needed information in a "just in time" fashion (not too soon and not too late) based on the rhythms of the unit. In her study of a patient care team, Forsythe, Buchanan, Osheroff, and Miller (1992) examined information needs of the team. Their focus was on the questions that these members asked to satisfy their needs. In another study of an intensive care team, Gorman et al. (2000) looked at how team members worked together to find and share needed information. They discussed the importance of tying different sources of information together to answer team members' questions.

A few researchers are also exploring collaborative information seeking from a technical perspective. Twidale and Nichols (1998) suggested that support tools must provide a visualization of the search process which can be changed and talked about by the users. In addition, they argued, "information retrieval systems should acknowledge the existence of collaboration in the search process." Furthermore, they believed that collaboration can improve the users learning and understanding of the systems. Focusing more on communication, Krishnappa (2005) designed a collaborative information seeking and retrieval prototype – MUSE (multi-user search engine). During the evaluation of the prototype, she found that the collaborative features in MUSE, specifically the chat function, played an important role in enhancing the information seeking and retrieval process for the collaborative work teams. The use of chat led to a better understanding of both the search process and the findings.

The literature examining CIS and the information tools designed to support CIS activities has begun to provide us more insight into understanding CIS behavior. These studies have also helped us better understand the opportunities and challenges in developing collaborative information retrieval systems. Yet, there are still a number of open questions concerning the information needs in teams and what triggers CIS behavior.

3. Research site and methods

3.1. Emergency Department of Regional Hospital

The ED at Regional Hospital is a 25-bed unit that treats people suffering from a wide range of illnesses. The unit is particularly busy because it is the only major ED in a thirty mile radius. It deals with everything from children with fevers to severe motor vehicle accident victims. Most days, the ED team sees approximately 80 patients, but often more than 100 patients per day in the winter months. The unit is staffed 24 h per day by a team of specially trained healthcare professionals. In order to care for a wide range of patients, the ED is equipped with sophisticated technical equipment including digital physiological monitors, web-based applications included on the hospital intranet, and a computerized patient record system similar to systems used at other hospitals (Reddy, Dourish, & Pratt, 2001). The average length of stay per patient in the unit is 3 h and 20 min.

The ED is divided into two main areas, urgent care and convenient care. Convenient care has five rooms and offers non-emergency walk-in care, 7 days a week, 12:00 p.m. to 12:00 a.m., for minor illnesses and injuries. It is staffed by a family nurse practitioner and a registered nurse. The second main area of the unit is urgent care (Fig. 1). The urgent care is open 24 h/day, 365 days/year. While the majority of patients admitted to urgent care arrive by ambulance following injuries, accidents, or sudden traumatic illness, walk-in patients are also treated when immediate attention is needed. At any given time, urgent care is staffed by, at minimum, a physician, a charge nurse, a technician, two registered nurses, and a unit secretary. The urgent care area includes 20 rooms (beds), three nursing stations, a charge nurse desk, a physician station, medication dispensing preparation room, an emergency medical services (EMS) desk, and a unit secretary desk. We focused our study primarily on the urgent care component of the unit.

3.1.1. ED patient care team

The ED team is physically co-located within the unit and consists of both clinical and non-clinical staff members.

The physician staff plays a central role in making medical and plan of care decisions in the unit. Physicians must make decisions rapidly, not only because of the patient's condition, but also because of patient volume. They are ultimately responsible for the patient's treatment. One to two ED physicians are on duty at all times.

The unit contains 23 full-time registered nurses. Each nurse is assigned to three or four ED beds (rooms). Along with providing care, nurses serve as patient advocates. In addition, they are responsible for assessing and recording symptoms, assisting physicians, and administering medications. Because of the continued contact and interaction with patients, the nursing staff has the most knowledge about the patient's status and the patient care tasks that have been or need to be performed. Each shift also has a charge nurse who oversees the nurses and helps make decisions regarding patient flow in the unit. In addition to nurses, the staff includes paramedics. Usually, one paramedic is assigned per shift and works under the supervision of a registered nurse in the same capacity as a registered nurse. A paramedic's assessments and triage notes must be co-signed by a nurse. Paramedics are allowed to perform intubations in the ED.

The ED also has ancillary support personal such as technicians and unit secretaries. Technicians help set up various patient care procedures as well as perform tests such as electrocardiograms and blood draws. In addition, technicians are responsible for room preparation and cleaning, as well as the stocking and dispensing of supplies. The unit secretary provides clerical support to the ED clinical staff with responsibilities that include entering physician orders, gathering appropriate documents, organizing charts, and participating in the collection of statistical data. The unit secretary also acts as receptionist for the unit.

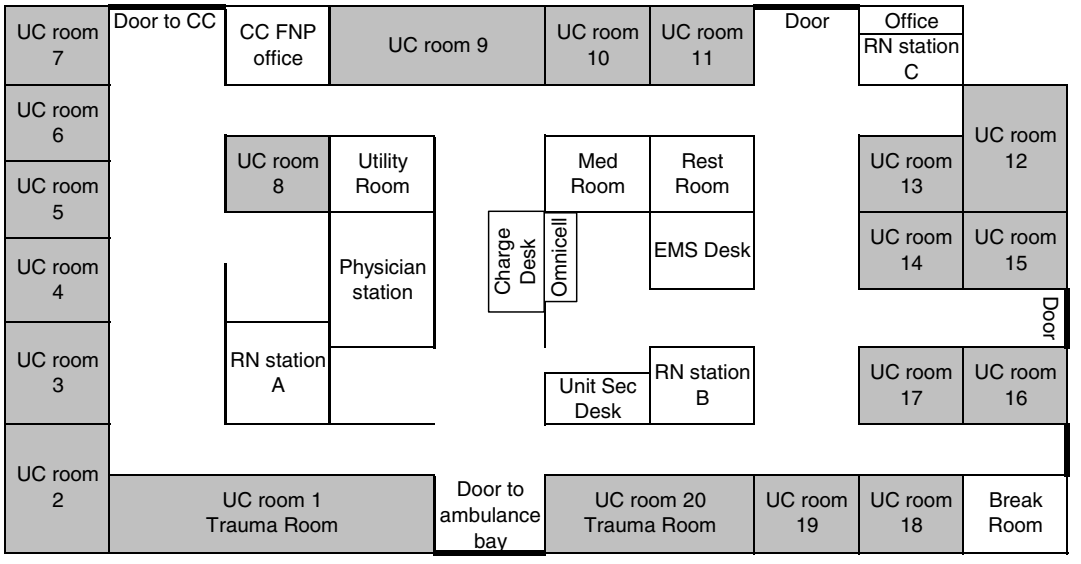

Fig. 1. Urgent care layout.

3.2. Research methods

Studying collaborative information seeking can be done only through careful observation and questioning. It is important to interview and observe multiple people in order to discover how people collaborate in their daily work activities when seeking and managing information. Since people often cannot tell a researcher what they actually do in practice (rather than what they are supposed to do), it has been found more useful to both interview and observe study participants. Accordingly, we used standard ethnographic techniques (Miles & Huberman, 1994; Strauss, 1987) for observing and interviewing people. The second author spent over 100 h during the summer of 2005 observing the work of the ED patient care team. She "shadowed" different team members during their shifts to get an in-depth understanding of their information needs and how they collaborated with each other to find needed information. She also conducted a number of formal and informal interviews focusing on the information seeking practices of the team members and collected artifacts such as screen shots and organizational policies. The observations and interviews yielded more than 100 pages of transcribed field notes and interviews for analysis.

After transcribing the field notes and interviews, the data was analyzed using Grounded Theory (Strauss & Corbin, 1998). The underlying assumption of Grounded Theory is that a deep understanding of social phenomena can only occur from real-world observations. However, Grounded Theory does not provide a theoretical perspective because it does not provide a particular worldview through which to look at the data; rather, it is a way of doing ethnographic analysis of data from interviews and observations. Grounded Theory foregrounds this data and helps create an evolving hypothesis through systematic coding of the data. In the course of this coding, patterns become visible giving rise to hypotheses that in turn are strengthened or dismissed through further coding. The strength of Grounded Theory lies in the interaction between the data collection and the coding. The coding is a continual process that occurs not at the end of the data collection but during it; categories (e.g. themes or variables) *emerge* from the data and are strengthened, modified, or discarded as more data is collected.

For our analysis, not only was each interview, field note and artifact reviewed and analyzed, but these items were also compared (interview-to-interview, interview-to-field notes, interview-to-artifacts, field notes-to-field notes, etc.) looking for similarities and commonalities. The data was analyzed paragraph by paragraph, and at times, line by line and even word by word, to identify categories, and their properties, from the data. At this point, initial hypotheses about categories and particularly about relationships between categories emerged from the data. Further analyses were done to strengthen or dismiss these initial hypotheses. In addition, a deeper review of literature was performed once hypotheses were formed and strengthened (Strauss & Corbin, 1998). We used a qualitative data analysis software, N6[1], to assist in the analysis. All data was imported into the software as documents. Even artifacts were created as "external" documents with a rich description of their use and contents. Then, as data was reviewed and compared and categories emerged, nodes were created in the software and the text was "coded" on the respective node(s). This allowed for easy comparisons of text coded on the same node and across nodes. As analysis progressed, memos of emerging hypotheses were documented within the software at both the document and node level. As hypotheses were tested and strengthened, nodes were modified (ordered, combined, collapsed, etc.). The software allowed this functionality without any loss of coding.

Clearly, there are some limitations to the methodology used in this study. One limitation is the small population size, which limits our ability to generalize our findings. However, because of our interest in the details of the collaborative interactions, we felt that qualitative techniques was the most appropriate method for what we were trying to achieve – identifying characteristics of collaborative information seeking behavior. Another limitation of this study was the use of a single observer in the ED. Therefore, we were unable to document all the actions performed during our observation period. However, we believe the observations that we did gather and document were representative of the actions taken by team members during the course of their work. Furthermore, the single observer approach was necessitated by the space in the ED. Multiple observers, while collecting more data, could have potentially interfered with the work in the ED. The single observer was unobtrusive in the unit.

[1] Qualitative Solutions and Research (QSR International), Doncaster, Australia, copyright © 2002, www.qsrinternatinal.com.

4. The work in the ED

To provide an understanding of the collaborative ED environment, we briefly describe the objectives and primary goals of the ED patient care team.

The ED is often a patient's first introduction to the healthcare system and is a quintessential example of a high-reliability organization (Weick & Roberts, 1993). In these organizations, errors cannot be tolerated because of the extreme consequences of the mistakes. In the ED, a mistake can lead to the death of a patient. Therefore, the ED team must have a clear understanding of the patient's condition and adequate information to make appropriate patient care decisions.

In a study of a surgical-intensive care unit (SICU), Reddy and Dourish (2002) described the two driving goals of that unit as patient stabilization and bed management. The ED is in many ways similar to the SICU. For instance, patients often need constant monitoring in the ED much like in the SICU. However, the work in the ED is also driven by two different primary goals: problem identification and surge management.

4.1. Problem identification

In the ED, similar to the SICU, the goal is not to cure the patient of her problems. However, unlike in the SICU, where the patient's condition is often well known, many patients are admitted to the ED with unknown problems. Therefore, one of the primary clinical responsibilities of the ED team is *problem identification*. Clearly, people come to the unit for a wide variety of reasons. In some cases, the problem is well known (e.g., broken arm, heart attack), but in many cases patients come into the ED and complain of vague symptoms that the team must first identify and then treat.

> An ambulance brings a trauma patient into the unit who was involved in a car accident. The team is not sure about the patient's condition. Therefore, they want to eliminate as many problems as possible. The doctor assisted by the nurse and the paramedic start working their way through possible problems. The patient is awake and responsive. The team is quickly able to eliminate injury to the neck and spine. They continue this process until the doctor determines that the patient is not in any immediate danger. He orders some more X-rays, prescribes some medication and moves on to the next patient.

Team members have to identify the problems that the patient might have as a result of the car accident. In the ED, team members must quickly and accurately assess the patient's condition. Their primary goal is to ensure that the patient does not have any immediate life threatening injuries and that his condition is stable.

Problem identification is central to the work of the patient care team and is closely related to the organizational goal of surge management.

4.2. Surge management

Closely coupled with problem identification is *surge management*. Emergency departments are becoming overwhelmed with an ever-increasing volume of patients. Unlike other units in the hospital such as an SICU, which can regulate the movement of patients into the unit, the ED, by law, must see all the patients who come to the unit. Patients come to the ED for a wide variety of reasons. Some are brought to the unit because of life threatening conditions. However, many others come to the unit because they cannot afford to see a primary care physician. As a result, the ED team must constantly manage this flow of patients, making triage decisions based on the severity of the condition and capacity of the unit. This is a challenging task.

> There was a large car accident. An ambulance calls the ED with a report that they have two trauma patients. Immediately following that call, two more ambulances call for a total of six patients inbound on ambulances. Within minutes, the first ambulance arrives with two patients, quickly followed by the other two ambulances. Since the ED is currently at capacity, the charge nurse and unit secretary work together to determine where to place the patients. The patients who are not seriously injured are told that their wait may be longer because of the trauma cases. The less seriously injured trauma patients are

doubled-up in rooms. The team members are quickly working on all trauma patients, but are worried about the backlog being created in the ED waiting room.

As the vignette illustrates, the charge nurse is responsible for insuring that all the patients are seen. She must decide what order they will be seen and where they will stay in the unit. When an accident occurs such as the one described above, it creates tremendous management challenges for the team to ensure that all the waiting patients are seen.

5. Results

The challenges of problem identification and surge management in the information-intensive, rapidly paced environment of the ED require team members to work together. One important aspect of that work is identifying and satisfying their information needs as they arise during their activities. Much of the work in the unit deals with quickly gathering relevant pieces of information to make and implement decisions. In this environment, team members must often work together to find needed information. Yet, these team members do not just suddenly decide to collaboratively seek information. Rather, the information needs can ''trigger'' collaborative information seeking activities. Once started, team members use various methods to facilitate collaboration to find the needed information.

5.1. What are the information needs of the multidisciplinary patient care team?

To identify the information needs of the team, we captured questions asked by team members during a one-month period. We organized these questions into seven categories as highlighted in Table 1.

Unsurprisingly, the largest number of questions pertained to medically needed information regarding patient specific information (57.8%) and plan of care (12.3%). These categories comprised 70% of the noted questions. However, somewhat surprising was the number of questions that focused on organizational issues in the unit (26.1%). For instance, a large number of questions dealt with coordination issues in the unit. Retrieving answers to these questions was of the utmost importance since the answers allowed team members to more effectively coordinate their activities. A coordination question such as ''Can the patient receive their X-rays in radiology, or must the radiologist technician take the X-rays in the patient's room?'' is an important one in the unit. In many cases, the patient needs X-rays to aid in the diagnosis of the medical problem. Some patients can be sent to the X-ray department, but other patients have to stay in the ED. Therefore, the team must determine whether to move the patient to X-ray or bring a portable X-ray machine to the patient.

Team members must not only organize their own work, but also coordinate the work of other team members and healthcare professionals. Interestingly, the organizational and clinical information needs in the ED

Table 1
Question categories

Question categories	Questions ($n = 602$) 100%	Meaning	Example
Patient specific	348 (57.8%)	Details about the individual patient	Is the patient's blood pressure up?
Organizational	157 (26.1%)	Policy, procedural, coordination, and capacity management issues in the unit	Is there a seizure protocol?
Plan of care	74 (12.3%)	Action plan the team is implementing for the patient	Can we do anything else to ease the patient's symptoms?
Miscellaneous	13 (2.2%)	Unable to correlate to other categories	Is it okay with the patient if the home health equipment comes from this agency?
Further details	4 (0.7%)	Continued data gathering on some patient related issue	What is the size of the catheter you have been trying to insert?
Teaching	4 (0.7%)	Learning or training questions	How do you apply an aluminum splint to a finger?
Medication	2 (0.3%)	Pharmaceutical issues in the unit	Can we substitute medications for this patient?

are closely related. For the team, it is not sufficient just to find clinical information because the clinical information by itself does not always allow them to complete their activities. So, for instance, the question, "Is the patient's blood pressure up?" has both a clinical and organizational component. Clinically, the physician wants to know if the patient's blood pressure is under control, or whether they need to administer more medication. Organizationally, he wants to know whether they need to keep her in the ED or release her.

Team members often asked *organizational* questions about each other's work in order to coordinate the *clinical* care of the patient. The clinical work of the unit occurred within a particular organizational framework. The organizational and clinical questions asked by patient team members created situations where team members must collaborate to find the information needed to answer their questions.

5.2. What triggered CIS behavior?

Although some questions were answered without difficulty, there were certain situations when team members had to collaborate to find needed information. In particular, we were interested in what *triggered* the event. We define a trigger as an external event within the environment that initiates collaborative information behavior amongst a formal or informal group of people. In this study, the triggers were found to be (1) a lack of expertise (2) a lack of immediately accessible information, and (3) complexity of information need.

5.2.1. Lack of immediately accessible information

With the wide variety of information resources in the ED, information was often available when team members needed it. In these cases, there was little need to collaborate. However, information was not always available "at the right time at the right place" (Reddy & Dourish, 2002). Furthermore, although the wide variety of information resources provided team members greater access to information, they also caused the information to become more fragmented. Team members often had to search multiple resources to find the needed information. Therefore, CIS activity was triggered when the information was not available when it was needed or was unable to be quickly located.

> The ED doctor, PK, is waiting for lab results for a patient in room 5. Normally, upon completion of the lab work, the results print directly to the unit secretary's, DF's, printer and placed on the patient chart or in the appropriate slot in the rack on her desk. However, the needed results are not in either location. PK asks DF about the labs, but DF has not seen the results either. Therefore, DF checks the status of the results in the patient record system, while PK calls the lab directly to check on the results. The patient record system shows the lab results as status of 'pending,' while the lab tells PK that it will be at least 15 min before the results are ready. PK and DF share the information that they each collected. PK decides to wait until the results are finalized in the system before implementing a plan of care.

The information needed by PK (the lab results) was not available when he thought it would be available. He did not find the lab results on the chart or in the slot for room 5 in the rack at the unit secretary's desk. At this point, the physician enlisted the help of the unit secretary. Because each of them knew different ways to access the information, they divided-up the search, with the unit secretary using the information system and the physician calling the lab directly. Both determined that the labs were not yet available, but the physician also discovered that the labs would take another 15 min to complete.

This division of labor is common in CIS practice and is characterized by an iterative practice of searching–sharing–searching until the needed information is located. For instance, in the ED, the process starts when team members begin looking for information (search). As a participant finds pieces of the information, he communicates these findings with other participants (share). Based on what is found, the participants will continue to look for more information (search) until they have the all the information.

5.2.2. Complexity of information need

Often, team members have to deal with an information need that has multiple components. Diagnosing a patient's condition involves not only understanding the symptoms but also determining appropriate care and medication. Furthermore, the information need may have multiple, yet seemingly unrelated components that have to be addressed. For example, deciding how to treat a patient may depend on not only the medical

condition of the patient but also on how many other patients are waiting for treatment. Therefore, team members split the information seeking tasks, each focusing on a different component of the information need.

> A patient's pain is severe enough that the nurse, AM, starts a treatment protocol. However, she does not believe that the suggested medication is strong enough for the patient. Before deciding on a pain medication, the doctor, PK, wants to know the patient's weight, current pain level rating, symptoms and pain location. Although AM has some of this information documented, the pain level rating is not up-to-date. Therefore, another nurse, SP, volunteers to talk with the patient about the pain rating, while AM reviews the Emergency Department Flowsheet. Once the needed information is found by AM and SP, they share it with each other and PK. The gathered information is then used by the team to determine that Demerol should be administered for the pain.

PK, AM, and SP had to work together to determine which pain medication to administer to the patient. The physician initiated this collaboration because the information need had many components (weight, pain rating, symptoms, and pain location) that he could not easily find by himself. Therefore, the nurses, who each knew where to look for these different pieces of information (e.g. asking the patient, checking the flowsheet), were drawn into the search. By working together, they were able to put all the different components of the information need together to make a decision about how to treat the patient.

5.2.3. Lack of expertise

One of the problems that team members face is the extensive and ever-growing body of knowledge surrounding patient care (Osheroff et al., 1991). Healthcare professionals have a difficult time keeping up with the expanding information base within their specialty. Therefore, it is almost impossible to monitor information in other fields. For instance, an ED physician is expected to have the latest knowledge about emergency care, but is probably not up-to-date on the latest knowledge in other fields. Because of the difficulty of understanding all aspects of patient care, team members rely on each other to find and provide needed information.

> The ED doctor, PK, is reviewing X-rays of a patient and sees some irregularities that he does not recognize. He contacts a radiologist, BM, for his expertise. PK shows BM the X-rays and tells him that he is not sure if the fracture in the shoulder is old or new. BM asks PK a series of questions about the patient's age and presenting condition. While BM reviews the X-rays, PK returns to the emergency department to ask the patient about possible past shoulder injuries. After reviewing the X-ray, BM tells PK that the fracture looks old because the edges of the bone are rounded, not sharp. PK is able to support the diagnosis with the information gathered from the patient – he had hurt his shoulder about 11 months earlier. PK and BM discuss the issue further and decide to have the patient see an orthopedic doctor.

PK lacked the expertise in radiology to make a confident diagnosis. Therefore, he turned to a radiologist for help. This collaboration answered the question that the ED physician had about the condition of the patient. Another interesting aspect of this process, and one that was common in many of these interactions, was the constant verbal communication between team members. There was constant discussion amongst the team members concerning the information they were trying to find. The communication allowed them to advise each other of the information that they found, clarify the information need, or discuss any problems they have in finding the information.

The different team members bring their own particular expertise and perspective to the team. When a member seeks information outside her domain of expertise, she can often turn to another team member for help. These different expertises play an important role in the collaborative information seeking activities of the team.

6. Discussion

Our fieldwork highlighted team information needs in the ED and triggers for CIS activities. We now turn our attention to discussing what creates the information needs in the ED, how team members interact when searching for information, the primary sources of information in the unit, and the consequences of CIS activ-

ities in workplaces. We end our discussion with a few organizational and technical implications for supporting CIS behavior.

6.1. Information breakdown

The *unimpeded* movement of information is essential for the successful completion of activities and tasks (Spence et al., 2005). However, this does not always happen in practice. CIS activities often occur because there are breakdowns in the flow of information.

We identified three reasons for the breakdown in the flow of information in the ED. First, the information was not available when it was supposed to be available. For instance, a lab result was not ready when the physician expected it and he had to ask the unit secretary about the results. Second, the information was either incorrect or incomplete. Therefore, team members had to ask questions to find the correct or complete information. Finally, the information was delivered to the wrong person. These breakdowns often lead to team members' information needs.

Information needs can, clearly, occur for numerous reasons that have little to do with information breakdown. For instance, team members making a decision about a patient's condition might require more information than they thought that they previously needed. In this situation, there was no breakdown in the information flow; rather team members wanted extra information. Furthermore, questions can signal more than an information need. They can also be used in the context of training or simply affirming a decision (Cicourel, 1990). However, in many cases, team members were asked questions because they were looking for information that they should have had but did not for some reason. In these situations, the questions served as alerting mechanisms to team members of a potential breakdown in the flow of information. To repair the breakdown, team members worked together to find the needed information.

6.2. Face-to-face interaction

In the ED, the team was often physically co-located. Furthermore, the pace of work in the unit was quite fast. Therefore, the most convenient way to collaborate when seeking information was in-person. The face-to-face interaction provided two advantages during CIS activities. First, in an open environment like the ED, a team member may ask a question out-loud without really knowing who could answer the question or help them find the needed information. Because they were face-to-face, they could get help much quicker when searching for information. Second, the face-to-face interaction allowed team members to acquire information they would not otherwise have been able to obtain. For instance, this could include detailed background and circumstances surrounding the activity. When a team member found herself needing information, she sought out the person or persons she thought would most likely have, or know where to find, the needed information. Often times these discussions took place at the collaborators' point of contact – whether that was in the hallway, at the nurses' station, or as they assessed the patient in their room.

> An ambulance arrives with a patient complaining of confusion. As the patient was wheeled into a room and moved from the gurney to the bed, the attending nurse, TS, begins to fill out the Emergency Department Flowsheet. TS and the paramedic then step out of the room to discuss the patient's condition. TS needed to know how the patient acted at the scene, what prescriptions the patient was taking, general symptoms and presenting condition of the patient, and the patient's history. TS and the paramedic spent the next 15–20 min discussing the patient's condition. TS also asked the patient's spouse about the patient's medical history and list of medications.

In this example, TS needed information in order to treat her new patient. However, the paramedic does not document this information until after the patient is handed over to the hospital. Although suitable for official documentation, this is obviously too late for the needs of the attending nurse. The easiest way for the nurse to find this information was to talk, face-to- face, with the paramedics and the patient, or in this case, the patient's spouse. The advantage of the face-to-face discussion was that it offered a convenient and fast way to gather the needed information, allowing the flow of work to continue.

6.3. The role of "informal" information sources

Medical settings are designed to provide as many "formal" sources as possible to meet the needs of information seekers. In the ED, these sources included electronic patient records, drug reference books, and other documents. These formal sources played an important role in providing information. Yet, in an extremely busy unit such as the ED, team members did not always have time to search for information in these formal sources. Furthermore, the time critical nature of the work often leads team members to search for satisficing or "good enough" answers rather than the optimal solutions. Therefore, the first resource most often utilized when a collaborative search was "triggered" was not an electronic or paper resource, but rather a human or "informal" source (Forsythe et al., 1992): another team member. In a team setting, this is not unusual because various team members bring their particular expertise and perspective to a question (Cicourel, 1990). For instance, nurses are important information sources because they maintain close contact with the patient, the patient's family, and the patient's other healthcare providers. Nurses serve as information conduits between these different caregivers and the ED team.

As part of their work, the ED team must coordinate all the activities of a patient's numerous healthcare providers. Therefore, team members want to know not only what was done but why it was done. Often, this *context* is not written down. Rather, it is in the minds of the individuals who were involved in the situation. For example, a physician might verbally tell a nurse about a medication but not write the rationale for it in the chart. Therefore, only the physician and nurse could provide information about why the medication was given. More "formal" sources, such as the patient record, would not contain this information. In a complex, fluid work environment such as the ED, individuals play an important role in providing contextual information.

Informal sources are essential for supporting a team's collaborative information seeking activities. Team members usually turn to each other for information before accessing other resources. Furthermore, individuals are much better than more formal sources for providing important context for an event. These informal sources play an important role in providing the "local knowledge" necessary to accomplish a particular task.

6.4. CIS and interruptive workplaces

As stated previously, the physical co-location of team members means that human sources are more available and easily accessible to information seekers in the ED. Therefore, the collaborative information seeking activities of physically co-located teams can lead to an "interruptive" workplace. Hudson, Christensen, Kellogg, and Erickson (2002) describe how managers try to control their interruptions by discouraging it during certain times of the day and encouraging it during other times.

In an environment such as the ED, there is less ability to control these interruptions. First, clinical questions are often complex and poorly defined. Therefore, the exchange of information and ideas with a colleague during conversation is often the simplest way to find a solution to the issue. So, team members often interrupt each other to ask questions and "pick each other's brain." Second, the physical location invites interruptions. The ED, much like an air traffic control tower (Bentley et al., 1992), is designed as an open space. Team members can see what each other is doing and often congregate around the nurse's station (Fig. 2) to fill out paperwork and discuss issues. The nurses' station plays a pivotal role as a site of information exchange. Team members can have extended discussion at the station without interfering with other members' work. Finally, because of surge management issues, patients have to keep moving through the ED. Therefore, team members need to answer questions and deal with issues quickly in order to keep the process from slowing down.

However, an interruptive work environment can lead to loss of attention, forgetfulness, and errors (Baddeley, 1986; Reason, 1990). Therefore, team members have developed clear protocols for signaling when they do not want to be disturbed. For instance, putting their head down while they are writing notes is an indication that they are busy and do not want to be interrupted. On the other hand, one of the main benefits of an interruptive workplace is that team members can talk to each other without scheduling a meeting. This allows for easier exchange of information about on-going activities.

Fig. 2. ED nurse's station.

6.5. Organizational and technical design implications

A key organizational challenge is supporting collaborative information seeking activities when the emphasis has largely focused on developing policies and procedures for individual information seeking. Organizations need to develop methods to improve and support team members' information seeking abilities. For instance, as they go through their various training programs, healthcare workers are taught how to individually look for information (Northup, Moore-West, Skipper, & Teaf, 1983). However, they are provided very little guidance on how to work with each other when searching for information. Thus, teaching future members of patient care teams how to collaborate when seeking information is one way, organizationally, to change the focus. This can be done in a variety of ways. For example including information seeking and sharing exercises as part of the group-oriented work activities of medical residents is one way to teach this important skill.

Organizations also have to deal with the challenges of designing information retrieval tools that support collaboration. Current information retrieval tools provide a variety of basic and advanced features that ease the retrieval of information from the available resources. Some advanced features are (Marchionini, 1995):

1. Advanced search options – more details regarding the search can be specified to filter the results and get the needed results.
2. Advanced keyword search – users can choose from the various options related to keywords or misspelled keyword.

Still, users of these systems face major limitations (Twidale, Nichols, & Paice, 1997). For instance, although collaboration is an important aspect of the information seeking and retrieval process, these information retrieval tools do not support communication between users. This becomes a greater problem when we think about physically co-located teams versus geographically dispersed teams. In a physically co-located team, all the members are in one location and are able to interact with each other, for the most part, face-to-face when seeking information. Therefore, they do not necessarily need computer-mediated communication support.

Although physically co-located teams allow face-to-face interaction, teams can have members who are geographical dispersed. For these teams, technical support becomes even more important because the advantages of physical co-location disappear (Reddy et al., 2001). Therefore, we have to develop information tools that support team information seeking activities much as we have already done for individual information seekers. These tools could include features, for instance, that allow members to use chat to exchange ideas or opinions while collaboratively searching for some information.

Whether teams are physically co-located or geographically dispersed, current information retrieval tools are not designed to support the collaborative aspects of information seeking.

7. Conclusion

In our study in the ED, we found that team members have both organizational and clinical information needs, that their information needs often arose from breakdowns in the information flow in the unit, and that specific situations triggered collaborative information seeking activities. Although information needs can be expressed in a number of different ways, we found that team members asked questions when they did not have needed information. Our investigation of collaborative information seeking activities as an integral aspect of team work is supported by other research studies (Gorman et al., 2000; Poltrock et al., 2003; Sonnenwald & Pierce, 2000). This perspective challenges the traditional view of information seeking as a typically individual activity (Wilson, 1996). As our observations point out, information seeking practices are distributed throughout a team; members work together throughout the process of searching, interpreting, contextualizing and assessing information.

The study has two important consequences for the design of information retrieval systems. First, most systems have been developed for individual information seeking. Twidale and Nichols (1998) argue that "information retrieval systems should acknowledge the existence of collaboration in the search process." We echo their argument. We need to develop features that support collaboration within these systems. Second, collaborative information seeking happens within the context of team members' daily work. Information seeking is not an isolated activity that takes place separately from the work (Reddy & Dourish, 2002, 2002b). Thus, we must design systems that support collaborative information seeking activities within the context of team members' work.

Although information seeking has often been viewed as a predominantly individual activity, there is growing interest in examining information seeking as part of collaborative work. This interest shifts our focus from how individuals search for and retrieve information, to focusing on how people work together to find needed information.

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