A Finger on the Pulse: Temporal Rhythms and Information Seeking in Medical Work

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ABSTRACT

Most cooperative work takes place in information-rich environments. However, studies of "information work" tend to focus on the decontextualized access and retrieval problems faced by individual information seekers. Our work is directed towards understanding how information management is seamlessly integrated into the course of everyday activities. Drawing on an ethnographic study of medical work, we explore the relationship between information and temporal coordination and discuss the role of temporal patterns or "rhythms" in providing individuals with the means to coordinate information and work.

INTRODUCTION

Information plays a central role in organizational life and everyday activities. Terms such as "information technology," "information age," and "information revolution" have become familiar additions to our daily vocabulary; information seeking and management issues are becoming ever more prominent in everyday work. Increasingly, for instance, computer users report that their primary daily activity is handling electronic mail – a means of moving information from one place to another [9]. Therefore, information and its uses are a focus of research investigations, dealing especially with the content, structure, and organization of information [5]. In collaborative environments, information plays a vital role not simply in decision-making but also in coordinating work activities and providing awareness of others' activities. Consequently, information and information practices are an interesting topic for researchers studying cooperative work and technology.

We have been investigating the problems of information and work in the context of hospital care. A hospital is an almost paradigmatic example of an information-rich environment, and is a natural site for investigation. Most studies of the role of information in medical work focus on information needs and information records, and how the two can be brought together successfully to answer

questions that the medical staff might have. For example, Gorman et al. [15] describe how medical staff members create different types of "information bundles" to successfully meet their information needs. Nygren et al. [21] describe the information conveyed by the layout and structure of medical forms and charts. Studies such as those of Bardram [3, 4] and Xiao [31] have looked at the information resources that support work coordination in medical teams. In a study of intra-departmental coordination in a hospital, Symon et al. [27] examined the radiological request form used to schedule radiology examinations and found that the form usually provided incomplete information requiring a number of work-arounds by the staff to find the needed information. In these studies, information is seen as being central to medical work, and yet the work itself is backgrounded. Information is often viewed as something *required for* the successful conduct of work, yet at the same time *separate from* the work itself.

Here, we take a somewhat different approach. Our concern is with information seeking as an aspect of the competent practice of hospital staff. We do not see information as distinct from other features of the environment in which medical work is conducted nor "information work" [26] as separable from other working activities. Rather, we want to investigate how information seeking is seamlessly integrated into, and appears as a feature of, the practical everyday work of medical workers.

One analytical approach we have taken to this problem is to utilize the concept of rhythms. In his classical study of social rhythms in a hospital, Zerubavel [32] described the cyclical nature of work to highlight the role of temporality in work. Similarly, Peter and Trudy Johnson-Lenz [18] described how daily activities occur in regular patterns or rhythms in our lives. In our research, we use the concept of rhythms in a slightly different manner. Our interest is not only in the temporal patterns of medical work, but in how these patterns provide individuals with a resource for seeking, providing, and managing information in the course of their work.

In this paper, we present a field study of information seeking in medical work. Specifically, we highlight the role of work rhythms as an orienting feature for information seeking in the information-rich environment of an intensive

care unit. The structure of the paper is as follows. In the following section, we describe in greater detail information seeking in collaborative environments and related work. Next, we present our field study: the research site, staff, and examples of daily work activities specific to the unit. We then discuss information and work and describe various work rhythms in the unit. Next, we discuss the role of rhythms in information seeking. We also present some remarks about the relationship between rhythms and trajectories. Finally, we highlight some issues for the design of systems supporting collaborative information work.

INFORMATION SEEKING IN COLLABORATION

Information seeking and retrieval is a topic of active and extensive research (e.g. [2]). Traditional models of information seeking are focused on the individual information seeker; they background understandings of collaboration and the broader context of work into which information-seeking activities are incorporated [29, 30]. So, while information seeking is viewed as an important aspect of collaborative work activities [7, 13, 22], we have very little empirical knowledge of how individuals collaborate to find needed information. Within CSCW, information has largely been viewed as a topic of organizational interest rather than in the context of practical work activities; Fidel et al. suggest that CSCW researchers have focused more on information flow than information seeking in collaborative situations [12].

However, a few researchers have begun to explore the collaborative aspects of information seeking. In a study of information behavior in a military command and control environment, Sonnenwald and Pierce [24] describe information seeking as a dynamic activity in which "individuals must work together to seek, synthesize and disseminate information." Twidale et al. [29] argue that, "It is our belief that collaborative actions are central to the information search process." The conventional view of the individual as *the* information seeker is being challenged in collaborative settings. Still, researchers who have focused on information seeking in collaborative environments have, for the most part, focused on designing systems to support the information seeking activities rather than examining the phenomenon itself [25, 28, 29]. There are only a handful of detailed, empirically based field studies explicitly examining information seeking in collaborative environments (e.g. [1, 19, 24]).

Traditional approaches to information processing present "information" as given, well-defined and stable. This reduces the problem space to access and retrieval; the key becomes the design of better technologies to provide easier access to the information. Studies of information practice, however, reveal a more complex picture. Information seekers do not simply gather information from some external sources; instead information is created by interaction between individuals. Dervin [8] describes information as an interactionally created artifact, encouraging us to turn our analytic attention away from problems of "access" and towards the ways in which information is created in the course of collaborative work.

FROM "ER" TO THE SICU

Our fieldwork was conducted in the surgical intensive care unit (SICU) of a large metropolitan teaching hospital. A setting such as the SICU is an intriguing environment for studying information seeking. Medical work is conventionally viewed as information intensive, incorporating an array of diagnostic procedures and physiological evidence to determine a diagnosis and a treatment regime. However, at first glance, one remarkable aspect of SICU work is that certain paradigmatic features of conventional medical work are not as prevalent in this setting.

In particular, although the twin notions of *diagnosis* and *cure* are the most familiar elements of medical work to the layperson, SICU work demonstrates remarkably little of either. The reason for this lies in the role of the SICU in the hospital. The goal of the SICU is not to *cure* patients, but rather to *stabilize* them so that they can be moved to a traditional hospital ward. Patients leaving a SICU usually require further in-patient care before they can be discharged. So, the work of the SICU staff is to render the patient capable of non-intensive care in the hospital; *cure*, in the conventional sense, is not a natural feature of SICU work. Similarly, although diagnosis is central to the conventional conception of medical work, it is a less prominent aspect of the work of the SICU. Almost all patients are there because their post-operative recuperation requires close monitoring and attention. So, while "diagnosis" conventionally suggests solving the puzzle of a patient's condition, the reasons why the patient is in the SICU are usually not mysterious. Clearly, during the time that the patient will spend in the SICU, conditions may develop and issues arise that call on the medical staff to adopt a diagnostic stance towards the patient, nonetheless this is a not the primary mission of the SICU.

The relevance of these topics is that the process of diagnosis and cure sets the expected pattern of information needs in a medical context. Since SICU work does not display this conventional character, we need to look more deeply to find the role that information plays for this particular unit. Given that the role of information is different in the SICU than is conventionally expected in medical work, how does the SICU staff seek, use and manage information in their daily work?

RESEARCH SITE AND METHODS

The SICU is one of nine intensive care units in the hospital. The first author observed work in the unit for approximately seven months during 2000-2001. He collected data through 30 formal interviews, as well as a number of informal interviews, and observations. The formal interviews were taped and transcribed. He also had access to internal communications, including written policies, procedures, and meeting notes.

In comparison to regular hospital wards, intensive care units have a higher nurse/patient ratio (1:2 rather than a more usual 1:6), allowing for more intensive patient monitoring and medical care, more comprehensive electronic monitoring of the patient, and stronger collaboration among healthcare providers to respond quickly to rapid changes in the patient's condition.

Specifically, the SICU that we studied is a 20-bed unit that treats the most seriously ill surgical patients, including those who have suffered major trauma, or undergone liver transplant or other major elective surgery. It is an extremely busy unit with 15 of the 20 beds occupied on a daily basis. Patients usually stay in the unit for 5-6 days and are treated by a team of health-care workers. The SICU is also a complex technical environment. It is equipped with sophisticated equipment including digital physiological monitors, web-based applications [10], and a fully computerized patient record system [23]. In most cases, patients are in such critical condition that any minor change in their condition could have rapid and severe implications. The specialized equipment and staff in the SICU allows early detection of even small changes in a patient's condition, thus permitting rapid changes in treatment to prevent problems from developing.

SICU Staff
The SICU staff includes surgical critical care nurses, pharmacists, physical therapists, social workers, respiratory therapists, surgical residents, critical care fellows, and faculty. We focus on three groups: physicians, nurses, and pharmacists, who carry out the majority of collaborative work activities in the unit.

Physicians
The physician staff plays a central role in making medical and organizational decisions in the unit. As the hospital is a teaching institution, the physician staff consists of three rotating surgical residents, two critical care fellows, and four attending physicians. The residents are physicians-in-training. Each resident is assigned a certain number of patients and provides primary medical care. The fellows supervise and monitor the residents' activities on a day-to-day basis. They also lead the daily rounds in the unit and are considered a back-up to the residents. The attending physicians supervise fellows and residents to ensure that they receive proper training as well as maintain a high standard of patient care.

Nurses
The nursing staff has more than fifty registered nurses certified in critical care, supervised by a SICU nurse manager. The nurses' responsibilities range from patient assessment and monitoring to medication administration. Because they are constantly by the patient's bedside, nurses interact on a regular basis with the patient's various healthcare providers.

Pharmacists
A pharmacist is assigned to the SICU on a regular basis. The medical staff, especially the residents, relies heavily on the pharmacist's knowledge to help them make the appropriate medication decisions. She is also the primary resource for the nurses for any questions concerning drug dosage or usage. The pharmacist participates in the SICU team's rounds each morning and is familiar with the conditions and medications of all the SICU patients.

THE WORK OF THE SICU
As we have already indicated, the primary function of the SICU is to provide intensive monitoring and medical management of patients, typically following major trauma or surgery, preparing them to go to the regular hospital wards. This sets up two major working concerns, one medical and one organizational. We refer to these as *stabilization* (preparing patients for regular medical care) and *bed management* (balancing the resources of the unit with the demand of new patients). Although stabilization is primarily a medical concern and bed management is primarily an organizational one, they cannot be conducted in isolation; the practical work of the unit is continually oriented towards both, and much of the work of the unit concerns the dynamics of this relationship.

Patient Stabilization
Again, the primary goal of the SICU staff is to *stabilize* not *cure* the patient. This is an important distinction in understanding the work in the unit. The staff's work activities center around the concept of stabilization and its assessment. For instance, daily rounds are one mechanism for monitoring the patient's stability. During rounds, a multi-disciplinary team led by a fellow and consisting of three residents, attending physician, pharmacist, and nurse visits each patient [23]. In determining whether a patient is stable, the team has to make two important decisions: first, what are the important issues concerning the patient that will affect her stability and, second, what does "stability" mean for a particular patient. The following vignette highlights the difficulty in determining these issues.

A patient was admitted to the SICU because his liver was failing, and he was a potential candidate for a liver transplant. During morning rounds, the team began discussing whether the patient should get dialysis or not to improve his renal functions. One of the fellows, WK, told the attending physician, MS, that the patient was not currently a candidate for a liver transplant because he did not have any insurance and was an alcoholic. The nephrologist (who does the dialysis) wanted to know what the goals were for the patient. No one was sure about the patient's chances for surviving without a liver transplant. During the discussion, the other fellow, TK, started to visibly get upset. He stated that too much attention was being paid to whether the patient will be getting a liver transplant or not instead of dealing with the critical issues that the patient is currently facing (improving his renal condition through dialysis). TK told the team that if the patient could get over the current problems, the patient could stop drinking and get MediCal (insurance) and be eligible for a transplant in 6 months. He didn't want the team to focus so much attention on the distant future. MS agreed and told them not to worry about the transplant issue but focus on getting the patient on dialysis.

The difficulty that the team members faced was in determining what "stability" meant for this patient. For many team members, it meant that he needed to get a liver transplant and anything short of that would not be useful

because the patient would face the same set of problems again. However, TK had a different view of stabilization. For him, it involved improving the patient to the point that the immediate medical issues cease to be a problem or are manageable outside the SICU. TK was reiterating to the team that the goal of SICU care is not finding a long-term cure for the patient but rather dealing with the patient's immediate medical problems.

Patient stabilization is the primary medical concern of the SICU staff and is closely related to the organizational issue, bed management.

Bed Management

Space in the SICU is a critical organizational resource. When all the beds in the SICU are filled, non-emergency surgeries for the entire hospital are often cancelled. Canceling surgeries has serious repercussions for patients in terms of their medical needs and for the hospital in terms of lost revenue and anger from patients and surgeons. The patient may have been preparing for this surgery for months and to have it postponed is not only disappointing but also can be very upsetting. For surgeons, a postponed surgery has a ripple effect on the rest of their surgical cases. Therefore, the SICU staff must ensure that sufficient beds are available to allow surgeries to take place. The flow of patients in and out of the unit is an omnipresent concern for SICU staff.

The first step in the bed management process is deciding on the admission of new patients to the unit. The SICU triage nurse is responsible for determining how many beds will be needed for that day. The triage nurse attends a bed management meeting in the morning. At this meeting, the nurse along with representatives of floor units discusses the surgery schedule for the day. They attempt to determine how many SICU and non-SICU beds are needed. Because a SICU patient is usually not directly discharged home, a non-SICU bed must be available for the patient. Also, if the SICU is full, a patient has to be released from the unit before a new patient is admitted. In some cases, the patient might need specialized monitoring even outside the SICU. For example, a patient on a ventilator for breathing support can be discharged from the SICU but must go to a special "vent unit." During these bed management meetings, the triage nurse finds out how many beds she needs to make available in the SICU and how many beds she has available for the unit's discharged patients.

After this meeting, the triage nurse and the SICU on-call resident discuss the number of beds that will be needed. The on-call resident is responsible for determining whether the patient meets the medical criteria for admission to the SICU. In most cases, if the patient's surgeon wants the patient admitted to the unit and there is space, then the patient will be admitted. However, if there are more requests for admission than there are beds, the SICU staff attempt to determine the priority for admissions. The following vignette highlights this interaction.

During morning rounds, BM, the triage nurse for the shift approached HS, the on-call resident, and TK, a fellow, about the day's admissions. BM had just been to the morning meeting and found out that two patients will be coming out of surgery and need to be admitted. As BM walked into the unit, TK noticed him and asked, "how many requests [for beds] do we have?" BM checked his triage notebook, which had the patient transfer sheet in it. On the transfer sheet is listed all the patients to be admitted and discharged written in pencil (easier to add and delete items). BM told them that there are two requests for admissions. TK was surprised stating, "We only have two transfers?" BM assured him that there would be no more admissions. TK was relieved because the unit was full and even dealing with two admissions would require discharging a patient. HS, who will be admitting the patients, checked his patient summary sheet and asked TK, "can the trauma [patient] go to the floor?" TK told him if they need room, then the patient can be discharged.

As the vignette illustrates, bed management requires both administrative and clinical decision-making. BM finds out how many patients are likely to be admitted and has already negotiated the bed availability for patients leaving the SICU. TK, and HS must balance the patient's medical condition with the need for beds. So, after checking the patient summary sheet, which lists all the patients and their conditions, HS chooses a patient he believes is the most ready to be discharged and asks for TK's confirmation as his supervisor. Under other circumstances this patient might remain in the SICU but to ensure that they have enough beds for the new admissions, TK is willing to approve the release.

The scarcity of available SICU beds is a constant source of concern for hospital management, and bed management will remain a central collaborative activity for the staff.

INFORMATION AND WORK

Clearly, the problems of assessing patient stability and managing bed flow are tightly coupled. The stabilization of a patient is not only a goal of the team's medical treatment but also an opportunity to open up a bed space for another patient. Assessments of patient stability are made in the context of understanding current demands for beds, and anticipated patterns of patient flow depend on the recent progress of current patients. The work of the SICU involves the continual assembly and collective interpretation of a heterogeneous collection of information. It is precisely because the work of the unit involves constantly balancing a diversity of competing constraints – in terms of medical care, bed pressure, organizational interdependence, staff and resources, etc. – that we argue for a view of information as inseparable from the work that it supports and generates. Information is not a separate focus of concern, but is woven seamlessly into the work of the unit.

Seeking and Providing Information

Returning to the question of information seeking, then, the question we want to ask is, how does information seeking feature as an aspect of the collaborative work of the members of the SICU?

As physicians, nurses, and pharmacists collaborate in the SICU, information is sought and provided in a variety of ways. In our initial explorations, following an "information

needs" model, we looked at explicit acts of information seeking – most notably, questions and answers. Questions are often a useful way of trying to understand the information seeking behavior of individuals [13, 14]. In our analysis of the questions asked in the SICU, we found two interesting features. First, clinical and organizational issues were intertwined in the unit. For instance, the question "She has to stay in the SICU?" has multiple meanings to the information seeker, an attending physician. Clinically, the physician is trying to find out what the team had decided for the patient's plan of care. Organizationally, he needs to ascertain whether her problems were serious enough to keep her in the SICU. Underlying many of the clinical questions was the bed flow management issue. The staff had to constantly evaluate the patients' conditions against the need for beds. Second, the first information source that a staff member turned to when they had a question was another staff member. In his discussion of medical work rounds, Cicourel [7] describes how team members provide contextualizing information to each other. We found a similar situation in the SICU. Staff members could provide context that was, for example, not written down in the chart.

Although the focus on questions and answers provides some insight into the variety of information sources and information needs at work in the unit, it clearly provides only a limited view of information seeking. In particular, it fails to account for the unproblematic ways in which information is seamlessly incorporated into the work of members of the unit.

Clearly, and especially in the context of a teaching hospital, questions can play many roles – not simply as blunt enquiries for information, but as commentaries upon action, as requests for help, as displays of competence, as tests of understanding, etc. These fundamentally indexical properties of speech in interaction are well known. However, setting this aside, we can observe that even in cases of "blunt information enquiries," questions may be thought of as indicative not only of information needs, but also as symptoms of *failures to find information*.

TK, a fellow, looking at an x-ray of a patient noticed a white mass on the left side of the lung. He read the radiologist's report to find out about the mass. However, the mass was not mentioned in the report. He then told a resident to call the radiologist and ask him about the white mass because it was not noted in the report.

In an information-rich environment such as the SICU, the critical property of information is that it is available at-a-glance to the members of the unit. Information permeates the environment, in forms that are both explicit (such as in charts, tables, reports, graphs, read-outs, displays, and monitors) and implicit (such as in the configurations of people and equipment). Information is available to parties at-a-glance. Explicit information needs – such as those indicated by questions – arise when the environment *fails* to provide an answer.

From this view, information seeking practices are associated with managing and maintaining an information environment. This provides us not only with a different view on questions asked, but also with a different view on answering them. If we think of answering questions as responding to an information need, then we can see that an important way to respond to an information need is to ensure that the information is available, at-a-glance, in the environment, when it is needed.

While some information requests and responses might be coordinated in terms of questions and answers, most requests and responses are decoupled in time and mediated through the environment.

A nurse, EM, was entering the nursing admission notes into the computerized patient record system for the patient in Bed 1. She was reading the written patient notes, medication orders, post-operative summary as she was entering her admission notes into the system. When asked why she was so meticulous about her notes, she stated that other nurses and doctors looking for information about the patient later might read the admission notes.

This alternative view turns the question of collaborative information seeking from one of "questions and answers" to one of "making information available at the right place at the right time." In doing so, it introduces the issue of temporal organization of activities into information practices and work. If most information work is to provide "the right information at the right time," then how is the work of the unit oriented towards determining what "the right time" might be?

RHYTHMS OF WORK IN THE SICU
One approach that we have found valuable in analyzing the role of information as part of the work of the SICU is to consider the rhythm of the work. By rhythm, we mean the broad temporal pattern of the work iterated over time.

The most important feature of the unit's working rhythms is that *multiple* temporal patterns characterize the work in the unit. These rhythms can be more or less regular, and operate on a large or a small scale. Many different rhythms contribute to the regular temporal organization of work in the SICU.

Large-Scale Rhythms
The broad pattern of work in the unit is governed by a set of large-scale rhythms, e.g. nursing shifts, rounds, movement of patients through the SICU, bed management meetings, arrival of patients from the operating room, and SICU residents' work.

Nursing shifts
The nursing shifts have three major periods of intensive activities. These periods are spread throughout the nurse's 12-hour shift but are fairly predictable. The first period of intense activity is at the beginning of the shift. The nurse going off duty "gives report" to the incoming nurse taking over for her. During this information exchange, which usually lasts for 30 minutes, the incoming nurse, has to rapidly assimilate all the information about the patient and the daily plan of care for the patient. Immediately after shift

report, the nurse ensures that all the medications are available and checks on the patient. The next intense period of activities follows the SICU team morning rounds. The nurse implements or helps the physicians implement the plan of care decisions made during the rounds. The final intense period of activity occurs at the end of the shift. The nurse makes sure that all her work for the shift is done and gathers all the information that she will have to give her replacement. Obviously, how busy a nurse will be during a shift is affected by the condition of her patient.

Nursing coverage in the unit is split into two 12-hour shifts with shift changes occurring at 7 am and 7 pm. There are major differences between the rhythms of the day shift and night shift nurses [32]. During the day, the nurses deal with admissions, discharges, and procedures ordered for the patient. Day shift nurses have access to more varied information sources because of the availability of physicians and other healthcare providers but the night shift nurses do not have the same access to these information sources. Night shift nurses also perform basic patient care functions that cannot be done during the day, e.g., bathing the patient.

Morning Rounds
As we have already mentioned, the SICU team engages in a daily "conference" on the progress of each patient, known as "rounds." Morning rounds are the major daily event for the physicians and for determining the progress of care. They start at 8 am and continue for two to three hours [23].

There is a sequential regularity to the rounds. First, the team views the x-rays of the patients. They then examine each patient. When they get to a patient, the resident responsible "presents" the patient. She first tells the team about any major events overnight concerning the patient and then gives an overview of the patient's current condition. This overview covers all the major systems (e.g., cardiac, pulmonary, renal, neurological). After the resident's presentation, the fellow will physically examine the patient and then the team will decide on the plan of care for the day for the patient. The team examines all the patients in the unit in turn.

The movement of patients through the SICU
The SICU is short-term care unit. If the regularity of admissions and discharges of patients in the unit are thrown off, it can affect the work in the unit. Patients are in the unit for an average of only 5-6 days. In many cases, it is the first day or two that is the most important to the patient's recovery. For instance, following a liver transplant, the first 24 hours are the most crucial to a successful outcome; if the patient makes it through those first 24 hours, she has an excellent chance of surviving. The SICU is arranged to provide this sort of intensive, short-term monitoring. If a patient stays in the unit for an extended period of time, it is not only a drain on the resources of the unit but is very expensive. In one case during our fieldwork, a patient stayed in the unit for six weeks; it was estimated that it cost $500,000 to provide care for her in the SICU.

Bed management meetings
Bed management meetings take place three times during the day. These meetings include the nursing managers from the various wards and ICUs in the hospital. It is in those meetings, especially the morning meeting when the SICU triage nurse finds out how many requests there are for SICU beds. The outcome of these meetings affects the work routine of the unit for the day. As the bed management vignette showed, the bed management meetings are important for the SICU staff because it allows them to gauge how many open beds they will need and in turn, how many patients need to be discharged to allow them to admit new patients to the unit.

The arrival of patients from the operating room
Most surgeries begin early in the morning. Early surgeries allow surgeons to visit their other patients in the afternoon. Although most surgeries only take a few hours, others (e.g., liver transplants) can be much longer. Consequently, post-operative patients tend to come into the SICU in two waves: early afternoon and early evening. The unit gets very few patients in the morning and almost no patients during the night (except for emergency surgeries). Because patient admission is a labor-intensive activity, the general pattern of patient admissions permits the SICU staff to anticipate when they will be busy and adjust their schedules (such as lunch) accordingly.

SICU Residents' Work
The residents provide most of the hands-on physician care for the patient. The unit's three residents work every day and each resident is on-call for overnight coverage every third day. The residents' day starts at 6 am with "resident's rounds" when they check on their assigned patients and collect information for morning rounds. During regular morning rounds, residents discuss and decide upon a daily plan of care for each patient with the rest of the SICU team. Therefore, they need to have all information pertinent to a particular patient available for morning rounds. After morning rounds, the residents implement patient care decisions made during rounds. Between 3 and 4 pm, afternoon rounds begin. During afternoon rounds, they check to make sure that the patient's plan of care for the day was implemented and no new problems have emerged. Afternoon rounds are more informal and not as information intensive as morning rounds. Following afternoon rounds, the residents complete any unfinished activities and go home around 5 pm.

Finer-Grained Rhythms
We can use this same notion of rhythm to also characterize much finer-grained patterns of work within the unit such as lab results, medication administration, and drug responses.

Lab results
A key monitoring feature of the SICU is the various tests performed on the patient. For instance, a common occurrence in the SICU is patient infection. A common lab test to check for infection is measuring the white blood count. A high count indicates that the body is fighting an

infection. There are two ways to get this count. A "stat" lab means that the medical staff will receive the information within a half-hour, and a "regular" lab will return a result within a few hours. Therefore, the staff knows depending on the type of lab test, when the results should be ready.

Medication administration
The staff tries to administer medication on a regular schedule for the patients (e.g., every 2 hours). There are few medications that are ordered as "p.r.n" (*pro re nata* – "according to circumstances"). Because the medications are given on a known schedule, the nurses can arrange their other activities around the patient's medication [32]. They also try to accommodate the patient's schedule when planning medication administration. For instance, on the night shift, barring special orders, the nurses try to give the patient's oral medication only when the patient is awake and might hold off on giving the next dose until the patient wakes up.

SICU patients also receive medication intravenously. The nurses follow a schedule in preparing and refilling these intravenous "drips". These drips are titrated (set) to give the patient a certain amount of medication over a pre-determined period of time. Based on this setting, the nurses know when the next refill of the drip is needed.

The scheduling of medication administration has a regularity that allows the nurses to know when the next dose is needed without necessarily checking the medication orders.

Drug response times
To test the effectiveness of a treatment plan, the staff has to wait for a prescribed period of time for the medication to take effect. Although each individual might react somewhat differently, most medications take effect after a well-known period. Thus, the staff knows that, for example, they cannot expect a patient to immediately show improvement after being given a medication. The physicians' knowledge of how long a drug takes to be effective plays a role in their medication decisions and in their ability to assess the effectiveness of a treatment.

THE ROLE OF RHYTHMS IN INFORMATION SEEKING
The relevance of these working rhythms is that they orient members of the unit towards likely future activities and information needs in the course of doing their work. Current activities are crafted with an orientation towards expectations of future events. For instance, resident's rounds are an example of orienting towards future work. When the residents come to work, they know that morning rounds start at 8 am and they will be expected to have all the pertinent information about their patients at that time. So, residents' rounds consist of checking on the patient and gathering all the necessary information they will need for the morning rounds; tests should be ordered well enough in advance that they can be available when needed, etc. Although these rhythms are a feature of the daily work in the unit, they are not "set in stone." That is the rhythms are affected by unexpected occurrences. For instance, a trauma case that suddenly comes into the hospital requiring immediate SICU admission can disrupt rounds, bed management decisions, and the flow of patients. However, as we analyzed the data, the rhythms in the unit became more apparent to us as a guiding feature of the work in SICU and especially of using and providing information. Some common patterns illustrate the role that rhythms play.

Decoupling Seeking and Providing Information
Researchers often view the seeking and providing of information as closely coupled. In traditional models of information seeking, when an individual needs information, she will usually *immediately* attempt to find the needed information. However, thinking about information seeking in the context of work rhythms provides us with a slightly different view of both seeking and providing information. Individuals want information when it will be the most beneficial to them in their work – not necessarily sooner and definitely not later. The rhythms of their work guide their need for information. For instance, a resident might order a routine lab early in the morning but not need the results before other lab results are also available because that lab result will only make sense in relationship to the other results. Taking rhythms into consideration changes our notion of information seeking. An individual might request (seek) information at a particular point in the day but not need (i.e. be provided with) the information until later in the day. Therefore, the seeking of information can often be *decoupled* in time from the providing of the information.

Rhythms as Information
Individuals oriented toward the working rhythms of the unit can anticipate the availability of information. For instance, one of the attending physicians stated that when he sends an emergency lab, he knows approximately when it should be ready and is checking his computer around that time to see if the lab result is available. Rhythms also provide the workers in the unit information about each other. Nurses know that the physicians will be in the unit examining all the patients during a certain time in the day (i.e. morning rounds). This knowledge allows them to plan their information seeking activities accordingly. For instance, if at 7:50 am a nurse realizes she needs some physician information, she might wait until 8 am when rounds start to ask her question. However, in the evening, if a nurse needs information, she will page a physician because she knows that the team will not round again until the next morning. People even explicitly ask about each other's work rhythms. For instance, a nurse unfamiliar with the schedule of the radiology department might ask when the radiologist is free to examine the patient. If the nurse was working in the radiology department, he might already know the radiologist's daily rhythm and not need to ask about it.

The work rhythms themselves provide *information* to the information seeker. Individuals use the information that rhythms provide to help them accomplish their work and guide them in their future activities.

Challenges of Multiple Rhythms

As we have described earlier, the SICU has multiple large-scale and small-scale rhythms. Although the multiple rhythms help the SICU staff in their work activities, they can also pose a challenge to the various groups attempting to coordinate their work activities.

Different work rhythms can conflict with each other. The nursing work rhythms are different than the physician rhythms so nurses and physicians sometimes have different expectations about the availability of information. In one instance, a resident asked a patient's nurse at the beginning of her shift what various consultants had said about the patient's condition. Exasperated, the nurse replied, "Give me a break. I only came on at 7 am. Anything I know I'll tell you." The resident, having been there earlier in the day, assumed that the nurse would already have the information. However, the nurse, having just started her shift, had not yet found out about the consultants' views. The resident was new and had not yet learned the rhythms of the unit. The different work rhythms of the resident and the nurse created different orientations to availability of information

The different work rhythms of the nurses and physicians also can cause problems in coordinating the work activities of the two groups.

> *During morning rounds, a nurse approached one of the residents and asked him to write a discharge summary for a patient who was leaving the SICU. The discharge summary is quite extensive and can take as long as an hour to complete. The resident was irritated because he had seen the patient at 7 am and asked if there was anything that he needed to do before the patient left. However, at that time the nurses were in the middle of a shift change and did not pay much attention to what he was asking and told him that they could not think of anything that he had to do. Now, the nurses tell him that the patient is already to go except for the summary and they would need the bed soon for a new patient. He said that he couldn't write the summary now because he was busy with rounds. As a work-around to writing a full summary, the resident wrote "D/C [discharged] to Spain with a full summary to follow" in the orders.*

Coordinating particular work activities among groups that maintain different rhythms of work is a non-trivial task. As Zerubavel [32] states, "Many [rhythms] run independently of one another, and since there is not any attempt to coordinate them, conflicts arise." In this case, the resident was available at 7 am to do the necessary administrative work (i.e. writing the discharge summary) for discharging the patient. However, at that time the nurses were involved in their own work and were not able to tell the resident what he needed to do. When they were oriented to the administrative work that needed to be done for the patient, the resident had moved on to another work activity, rounds, which he was not willing to interrupt to complete the administrative work for the patient. The nurses and the residents were in different phases of their work and when the phases did not overlap, problems arose.

Despite the occasional problems caused by diverse rhythms, the SICU staff, for the most part, was able to successfully reconcile the various, multiple rhythms in their daily work.

TRAJECTORIES AND RHYTHMS

Studies of work in medical settings inevitably invite comparisons to the classic studies conducted by Anselm Strauss and colleagues [26]. In addition, one of Strauss' analytic devices, the concept of trajectory, is sufficiently related to our use of rhythms that the relationship bears elaboration. The major differences between the concepts lie in their scope and orientation. Trajectories are centered on patients and other features of the setting; rhythms are repeated over time and concern temporal arrangements.

Both trajectories and rhythms speak to the importance of understanding the work that both surrounds and includes the patient. Strauss use illness trajectories to refer to:

> *Not only the physiological unfolding of a patient's disease but to the total organization of work done over that course, plus the impact on those involved with that work and its organization. (8)*

In comparison with the notion of disease progress, trajectories provided a general analytic view of understanding the broad patterns in the way that people work together. The analytic power of trajectories lies in the ability that it provides us to examine the activities related to taking care of a patient, and the peoples and technologies with which the patient will come into contact with during the course of his treatment. As the illness unfolds, the work of managing that illness also unfolds. Trajectories present us a way of examining this management from a number of different perspectives: the patient, nurses, physicians, family, and other health-care providers. Although activities and events re-occur during the course of an illness trajectory, the focus is on the work over time for a given patient rather than the re-occurrence per se.

In contrast, rhythms provide a method for us to think about events and activities iterating over time. Trajectories draw our attention to common elements of different occasions of work; the concept of rhythms is concerned more with the relationship between different occurrences and with the temporal coordination of actions. Zerubavel [32] notes that:

> *Not only do these cycles introduce a rhythmic structure into hospital life by forcing routine and nonroutine activities and events into regular temporal patterns, they also interrupt its continuous flow. (xxii)*

Rhythms play a powerful role in helping us understand the work of an organization by foregrounding the *intrinsically temporal and cyclic nature* of the work. For instance, people often change their work practices to fit the new work setting. In the SICU, a nurse closely monitors the patient's vitals (blood pressure, temperature, heart rate, etc.) taking readings at least every hour but more often if necessary. However, if the nurse was transferred to the "floor" where the patients require less monitoring, she might take all the vitals only once every couple of hours. Both units had similar activities but the difference in the importance of the information dictated their frequency of occurrence.

So, trajectories are largely patient-centered; different patients can have different trajectories. Rhythms are independent of a given patient and describe generic patterns of coordination and action.

RHYTHMS BEYOND THE SICU
Although our study examined rhythms in the particular organizational setting of the SICU, rhythms exist in all organizational environments and manifest themselves in many different ways. Egger and Wagner [11] describe the difficulties of creating "time schedules" for operations in a surgical clinic. Although they do not explicitly discuss rhythms, their study highlights the challenges that different people's working routines (e.g. surgeons, nurses, anesthesiologists) pose in creating a single time schedule for daily operations. Beyond the medical domain, other studies have examined the concept of rhythms in different organizations and for different purposes. Hudson et al. [17] examined interruptions in the daily work of managers at a research lab. They found that the managers expected and even welcomed interruptions during certain times of the day and discouraged interruptions at other times of the day. Other staff members learned these rhythms and attempted to tailor their interruptions to match the managers' expectations. In a study in another research organization, Begole et al. [6] present rhythms as an awareness mechanism for contacting colleagues. They were particularly interested in examining how to provide information to geographically separate members of a work team about the availability of other members. By monitoring computer activity, they attempted to build up patterns of interaction that could reveal regularities in working patterns. They showed that individuals had regular rhythms that were not represented in their on-line schedules.

More broadly, Zerubavel's [33, 34] discussion of schedules and cultural calendars presents an intriguing picture of how rhythms are socially created in our everyday life. Rhythms manifest themselves in various ways in our lives. They are just not a phenomenon of work but are a facet of our everyday lives. It is this pervasiveness that makes them a compelling focus for developing information tools.

CONCLUSIONS
In our investigation in the SICU, we found that medical practitioners must continually balance and integrate medical and organizational information in decision-making; that the processes of seeking and providing information are seamlessly interwoven with other working activities; and that they are coordinated in part through the set of working rhythms that provide a resource to interpret and manage work. The notion of rhythms providing members a resource for interpreting and coordinating work is supported by other research investigations [6, 17, 32]. This integration of work and information stands in contrast to traditional models of information retrieval, and to traditional approaches to information support. We can characterize this traditional approach as a "database query" model of information seeking. The "database query" model conceives of a single user issuing a well-formulated query against an understood data repository in order to retrieve identifiable results. Our observations suggest that real information work is much less well-defined and is inseparable from other ongoing activities.

These observations have two conjoined consequences for the way we think about designing information systems to support these sorts of activities. We need to conceive of information repositories (such as patient record systems) not merely as places where information is stored and retrieved, but rather as places where work is done; and, conversely, we need to see how work systems provide people with solutions to information needs and problems. In other words, these two activities go hand-in-hand and the technologies to support them must also be intertwined.

In CSCW, awareness technologies have often been used to integrate information spaces and representations of activity. The intertwining of information work with other work activities that we have highlighted here provides further support for this integration. However, our work also points towards a new approach. In particular, it highlights the opportunities for incorporating cyclic and temporal information – to show not only current activities, but patterns of former actions, and expectations about future activities. In other words, not only do we want to use awareness approaches to "populate" information spaces, but also to give a sense of how current activities are related to the past and to the future. The information that Begole et al. [6] generate describing regularly occurring work rhythms can support information displays that exploit the temporal patterns of activity that surround information. Some researchers, such as Hill et al. [16] have suggested visualizations that can extend beyond the purely synchronous, and social navigation approaches [20] have created information spaces enriched by the temporal aggregation of activities. However, the specifically cyclical nature of many working activities opens up new areas in the design space that can provide for more detailed coordination. The cycle of work helps to render information meaningful because of its very connection to past events and future expectations.

CSCW has long had an interest in the sequential organization of activity; our experiences in the SICU have drawn our attention to its cyclical organization. We believe that this approach can provide a valuable enrichment of information spaces, and especially to support the interweaving of information use with other forms of work.

REFERENCES

1. Allen, T.J. 1977. *Managing the Flow of Technology*. Cambridge: MIT Press.

2. Baeza-Yates, R. and B. Ribeiro-Neto. eds. 1999. *Modern Information Retrieval*. Menlo Park: Addison-Wesley.

3. Bardram, J.E. 1997. "I Love the System - I just don't use it". In *Proc. ACM Conf. on Group Work (GROUP'97)*. 251-260. New York: ACM.

4. Bardram, J.E. 2000. Temporal Coordination: On Time and Coordination of Collaborative Activities at a Surgical Department. *Computer Supported Cooperative Work*. **9**: 157-187.

5. Bates, M.J. 1999. The Invisible Substrate of Information Science. *Journal of the American Society for Information Science*. **50**(12): 1043-150.

6. Begole, J., J.C. Tang, R.B. Smith, and N.Y. Yankelovich. 2002. Exploring work rhythm awareness: Coordinating contact among colleagues. In *Human-Computer Interaction Consortium Winter Workshop*.

7. Cicourel, A.V. 1990. The Integration of Distributed Knowledge in Collaborative Medical Diagnosis. In *Intellectual Teamwork*, J. Galegher, R.E. Kraut, and C. Egido, Editors. 221 - 242. Hillsdale, NJ: Lawrence Erlbaum Associates.

8. Dervin, B. 1999. On studying information seeking methodologically: The implications of connecting metatheory to method. *Information Processing and Management*. **35**: 727-750.

9. Ducheneaut, N. and V. Bellotti. 2001. E-mail as habitat: an exploration of embedded personal information management. *Interactions*. **8**(5): 30-38.

10. Duncan, R. and M. Shabot. 2000. An enterprise web viewing system for clinical and administrative data. In *Proc. of the American Medical Informatics Association Symposium*. 1116.

11. Egger, E. and I. Wagner. 1992. Time Management: A case for CSCW. In *Proc. ACM Conf. Computer Supported Cooperative Work (CSCW'92)*. 249-256. New York: ACM Press.

12. Fidel, R., H. Bruce, A. Pejtersen, S. Dumais, J. Grudin, and S. Poltrock. 2000. Collaborative Information Retrieval. In *Information Seeking in Context 2000: The Third International Conference on Information Needs, Seeking, and Use in Different Contexts*. London: Taylor Graham.

13. Forsythe, D.E., B.G. Buchanan, J.A. Osheroff, and R.A. Miller. 1992. Expanding the concept of medical information: An observational study of physicians' information needs. *Computers and Biomedical Research*. **25**(2): 181-200.

14. Gorman, P.N. 1995. Information Needs of Physicians. *Journal of the American Society for Information Science*. **46**(10): 729-736.

15. Gorman, P.N., J. Ash, M. Lavelle, J. Lyman, L. Delcambre, D. Maier, M. Weaver, and S. Bowers. 2000. Bundles in the Wild: Managing Information to Solve Problems and Maintain Situation Awareness. *Library Trends*. **49**(2).

16. Hill, W.C., J.D. Hollan, D. Wroblewski, and T. McCandless. 1992. Edit Wear and Read Wear. In *Proc. ACM Conf. Human Factors in Computing Systems (CHI'92)*. 3-9. New York: ACM.

17. Hudson, J.M., J. Christensen, W.A. Kellogg, and T. Erickson. 2002. "I'd be overwhelmed, but it's just one more thing to do:" Availability and interruption in research management. In *Proc. ACM Conf. Human Factors in Computing Systems (CHI'02)*. New York: ACM.

18. Johnson-Lenz, P. and T. Johnson-Lenz. 1991. Post-Mechanistic Groupware Primitives: Rhythms, Boundaries, and Containers. *The International Journal of Man Machine Studies*. **34**: 395-417.

19. McDonald, D.W. and M.S. Ackerman. 1998. Just Talk to Me: A Field Study of Expertise Location. In *Proc. ACM Conf. Computer Supported Cooperative Work (CSCW'98)*. 315-324. New York: ACM.

20. Munro, A., K. Höök, and D. Benyon. eds. 1999. *Social Navigation of Information Space*. London: Springer.

21. Nygren, E., M. Lind, M. Johnson, and B. Sandblad. 1992. The Art of the Obvious. In *Proc. ACM Conf. Human Factors in Computing Systems (CHI '92)*. 235-239. New York: ACM.

22. Paepcke, A. 1996. Information Needs in Technical Work Settings and Their Implications for the Design of Computer Tools. *Computer Supported Cooperative Work*. **5**: 63 - 92.

23. Reddy, M., P. Dourish, and W. Pratt. 2001. Coordinating Heterogeneous Work: Information and Representation in Medical Care. In *Proc. of the European Conference on Computer Supported Cooperative Work (ECSCW'01)*. 239-258. Dordrecht: Kluwer Academic Publishers.

24. Sonnenwald, D.H. and L.G. Pierce. 2000. Information behavior in dynamic group work contexts: interwoven situational awareness, dense social networks and contested collaboration in command and control. *Information Processing and Management*. **36**: 461-479.

25. Stein, A. and E. Maier. 1994. Structuring Collaborative Information-Seeking Dialogues. *Knowledge-Based Systems*. **8**(2-3): 82-93.

26. Strauss, A., S. Fagerhaugh, B. Suczek, and C. Wiener. 1985. *Social Organization of Medical Work*. Chicago: University of Chicago.

27. Symon, G., K. Long, and J. Ellis. 1996. The Coordination of Work Activities: Cooperation and Conflict in a Hospital Context. *Computer Supported Cooperative Work*. **5**(1): 1-31.

28. Twidale, M. and D.M. Nichols. 1998. Designing Interfaces to Support Collaboration in Information Retrieval. *Interacting with Computers*. **10**(2): 177-193.

29. Twidale, M., D.M. Nichols, and C.D. Paice. 1997. Browsing is a Collaborative Activity. *Information Processing and Management*. **33**(6): 761-783.

30. Wilson, T.D. 1996. Information Behaviour: An Interdisciplinary Perspective. *Information Processing and Management*. **33**(4): 551-572.

31. Xiao, Y., C. Lasome, J. Moss, C.F. Mackenzie, and S. Faraj. 2001. Cognitive properties of a whiteboard: A case study in a trauma center. In *Proc. of the European Conference on Computer-Supported Cooperative Work (ECSCW'01)*. 259-278. Dordrecht: Kluwer Academic Publishers.

32. Zerubavel, E. 1979. *Patterns of time in hospital life: a sociological perspective*. Chicago: University of Chicago Press.

33. Zerubavel, E. 1985. *Hidden rhythms: schedules and calendars in social life*. Berkeley: University of California Press.

34. Zerubavel, E. 1989. *The seven day circle: the history and meaning of the week*. Chicago: University of Chicago Press.