A Pilot Project to Understand Medical Rounds:

Implications for Information Technology

By Amy Kerfoot

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CERTIFICATE OF APPROVAL

This is to certify that the Master's Capstone Project of

Amy L. Kerfoot

"*Understanding Medical Rounds: Implications for Information Technology*"

Has been approved

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Capstone Advisor

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Abstract

This pilot research project examined the many purposes and activities of medical rounds. Crucial for teaching and patient care in an academic medical center, rounds were categorized against the framework of distributed cognition, a theory of cognition grounded in cognitive anthropology. Through a series of observations of interdisciplinary rounds in academic medical intensive care settings, supplemented by interviews with participants, the multiple purposes and perspectives of rounds were organized into a categorical list to aid future work on the topic, especially as they apply to technology development and the field of medical informatics. The theory of distributed cognition focuses on the idea of an activity system composed of a common body of knowledge that organizes the interactions of many actors and their tools around a common purpose. Applied first in educational and social settings, the theory is being applied to the healthcare arena.

This work explores the application of such diffuse knowledge in an intensive care setting. The results of this pilot observation and interview study is a tentative taxonomy of types of medical rounds, as well as their characteristics and key facilitators. By first creating a clear conception of the types of rounds themselves, the path is cleared for future work on how distributed cognition can improve understanding of cognitive performance in the intensive care setting. This can allow the biomedical informatics community to incorporate aspects of this model into future information tool

design, as well as improved teaching and patient safety. Careful attention should be given to the diverse needs represented in different types of rounds, and a modular approach employed to address them

Introduction:

Have you ever watched the terse, codified exchanges taking place between doctors and nurses in an operating room during surgery? Or have you marveled at the rapid delivery of information between providers in a medical emergency? Have you looked at the cryptic, nearly unintelligible notes contained in the pocket of a physician's lab coat or the back pocket of a nurse's scrubs? In stressful, highly complex medical situations, there never exists a single individual who has "all the information". The interdisciplinary nature of the healthcare team demands that multiple players exchange crucial information and expertise for the well-being of the patient. As such, these sequences of information exchange are loaded with the opportunity for interruption and errors. They must also be facilitated by physical artifacts serving as cues in the group knowledge base. Long an area of interest to social and organizational researchers, information exchange has been examined under multiple frameworks. One highly applicable to the field of medicine is the theory of distributed cognition.

The distributed cognition framework, developed by Edward Hutchins and others in the mid-1980's[i], draws from the disciplines of cognitive science, sociology, and psychology. The theory asserts that cognition (thinking, learning, and understanding) occurs at the level of the "activity system," composed of multiple actors, their tools and cognitive artifacts, and a shared

knowledge about goal oriented action. Knowledge, in other words, does not reside within a single individual, but rather is represented across tools, objects, and individuals in a setting. In the field of aviation, the cockpit, complete with its gauges and communication devices (radios, visual cues, air-traffic control mandates) is representative of a sphere of knowledge. Environmental cues act in a complementary manner to enhance the work of the pilot. A pilot, no matter how experienced, is not capable of comprehending or responding to every aspect of his flight and its interaction with other traffic. Rather, it takes the work of many individuals and technologies in a coordinated fashion to produce a safely executed flight. In medicine, recent literature suggests that potential applications of distributed cognition as a means to better understand and improve clinical communication, education, and patient safety are numerous. This distributed cognition theory is a logical framework for organizing the cognitive resources and medical information exchange within the field of medical informatics, specifically in the context of understanding rounds.

Rounds are a multi-faceted aspect of medical education and clinical practice that takes many forms: there is not a single definition, a single purpose, or a single type of rounds. Rather, "rounds" may take the form of didactic lectures for education (known as ‘grand rounds’), as well as a physical “parade” of one or many physicians around the hospital to visit various patients or locations for interaction with staff or technologies. In academic medical centers, these morning rituals are frequently led by senior faculty

(attending physicians), and may include residents (medical school graduates training for specialty careers), medical students, nurses, mid-level clinical staff (physician assistants, nurse practitioners), and clinical pharmacists. Depending on who provides the perspective, the primary purpose may be education, patient care, evaluation of team members, or other purposes. While "grand rounds" involve very little audience feedback, observed feedback encounters involving a senior physician supervising one or several residents, are based heavily on feedback and behavioral learning. Few laypersons know what constitutes the definition of rounds, and physicians of various levels of experience often provide diverse answers. Despite their varied nature, rounds are historically important as a tool for education and patient care.[ii] Rather than a single activity, rounds can be viewed as an activity system, complete with cognitive artifacts and meaningful environmental cues for use by the human actors, clinical staff. Thus, the distributed cognition framework is a logical choice for characterization and explanation of rounds. From the perspective of distributed cognition, the medical informatics field can design better information tools to account for multiple inputs and the need for meaningful environmental cues.

While the application of distributed cognition in the healthcare setting has attracted the attention of some noted researchers in biomedical informatics, the work is still in its infancy. As a candidate for a Master's degree in Biomedical Informatics, I have conducted this pilot project to characterize the types, goals, and resources of medical rounds. The work is informed by

the theory of distributed cognition. The work's importance is derived from the assumption that this categorical understanding allows rounds, including tools and best practice guidelines, to be improved. Dr. Paul Gorman of Oregon Health & Science University supervised this work, with the intention of applying the initial knowledge of rounds to research into effective rounds leadership. The results of my work consist of categorical explorations of medical ICU rounds, with supportive evidence from qualitative data (interviews and observations). Ultimately, this knowledge may be used to support research improving the effectiveness of rounds for teaching and patient care.

Methods

Design:

This work consisted of a qualitative observational study, with no intervention. The purpose was to construct a set of operational definitions and a tentative taxonomy of medical rounds in the adult critical care setting. Through the combination of a literature review, naturalistic observation of multi-disciplinary medical intensive care unit rounds, and five to eight semi-structured interviews with clinical staff, themes for the various types of rounds were created.

Setting:

Oregon Health and Sciences University (OHSU) is a 509-bed academic medical center serving the greater Portland (Oregon) metropolitan area. It

employs 239 resident physicians. It is affiliated with the OHSU School of Medicine

Subjects:

Clinical staff members are comprised of the following: attending physicians, critical care fellows (medical school and residency graduates training to be medical intensivists), residents (medical school graduates training for internal medicine careers on a rotation in the intensive care unit), medical students, nurses (RN's), respiratory therapists (RT's), occupational therapists (OT's), pharmacists, and registered dieticians (RD's).

Sampling:

A convenience sample of subjects was chosen based on scheduled work availability in the cardiac/medical ICU unit at the time of data collection. Special attention was given to interviewing clinicians of various disciplines, in order to gain a balanced perspective. All participants gave verbal consent to participate in interviews. Consent to conduct such qualitative human subjects research was given under OHSU IRB #00002534

Data Collection/Measurement:

The literature review consisted of electronic search of the MEDLINE database, as well as the Cochrane Database of Systematic Reviews and Google Scholar. Terms searched included "medical rounds" AND "categories"

or “types”. The services of a reference librarian were utilized in order to conduct a more robust search of the medical literature, as no Medical Subject Headings exist to directly identify such categorization of rounds. As an adjunct to literature review qualitative research consisted of personal interviews with medical ICU staff, combined with naturalistic observation. Field notes and interview statements were analyzed for themes on the various names and goals of rounds. As a naïve, non-physician observer in the ICU, I took special care to notice explicitly stated goals, as well as less overt sources of motivation for activity.

Data Analysis and Validation:

Data analysis in this project was based in a Grounded Theory approach. Grounded theory, a social science qualitative research methodology, emphasizes the construction of a theory in the midst of data collection, guided by the information learned early in a project.[iii] Prior to data collection, a literature review of distributed cognitive theory was conducted, in addition to relevant classifications of rounds found in the medical literature. Through naturalistic observation, supplemented by interview data, points of agreement and saturation were reached on the classification of rounds: the names used, the purposes, and the actors in each activity system. This framework then guided a construction of a taxonomy of rounds.

Limitations:

The study is limited in scope to one institution's medical ICU, with data being collected over several weeks in the spring of 2009. While efforts were made to ensure that subjects had clinical experience in a variety of settings and institutions, the results contained herein may not be representative of settings external to this department. Notable differences exist between various institutions, and between community and academic settings. While the results obtained herein may not accurately describe rounds in other institutions, the activity system processes by which the ICU provides informed patient care and enlightened learning opportunities do merit examination in other settings.

Interview Subjects:

1. Physician (MD, Critical Care Fellow)

2. Physician (DO, Critical Care Fellow)

3. Physician (MD, MS, Critical Care Fellow)

4. Attending Physician (MB, BS, PhD. Intensivist)

5. Respiratory Therapist

6. Patient Care Nurse (BS, BA, MS, RN)

7. Charge Nurse (BSN, RN, CCRN)

Observation Sessions:

Session 1) 2.5 hours. Early rounds (1.5 hours), Teaching Rounds (45 min).

Session 2) 3 hours. X-ray rounds (1 hour), formal rounds (2 hours)

Session 3) 2.5 hours. 1 hour interviews, X-ray rounds (30 min), formal rounds (1 hour)

Results

"**Pre- Rounds"**:

Every interview quickly drove home a point: while rounds are a busy daily activity in themselves, they require preparation. Specifically, each patient's information is presented to the attending physician during rounds. Clearly, this data must be gathered beforehand, in this instance, by the residents. The early-morning activity known as "pre-rounds" or "early rounds" is a crucial part of the rounding process. It generally begins at about 6 am, and may last up to two hours. It is the primary means of data gathering, and takes place before the arrival of attending physicians. Because it is conducted by students and residents, without the supervision of the attending physician, it presents a learning opportunity while functioning autonomously. Each patient is examined, and changes from the previous day's rounds are carefully noted. The patient's electronic record is examined, and the previous day's plan of activity analyzed. In this context, the resident and student formulate a

summary of the patient's condition to the extent that their knowledge allows, along with a plan for the day's treatment recommendations. The patient is at the center of this process, as the purpose is to gather data for imminent presentation to the attending during morning rounds. No other clinical disciplines are represented in pre-rounds, possibly because the residents, as future attending physicians, are gaining experience in analyzing examination data, presenting it in an organized manner, and making the appropriate treatment plan from those observations. One critical care fellow interviewed noted that early rounds represent "'baby steps'. This is one of the first shots students have at presenting the patient in a logical manner. As a resident, they're expected to do it better." (paraphrase) Early rounds are implicitly time-sensitive. Residents must arrive early enough to see all patients before the scheduled beginning of more formal morning rounds. However, because the plan is to be presented to the attending physician, nursing staff, critical care fellow, and clinical pharmacist, it must be accurate and as comprehensive as possible. The presentation by medical students and residents is an opportunity for evaluation by attending physicians (and thus impacts future career opportunities).

While the primary goal of pre-rounds is to gather data on the patient's condition in order to formulate a rudimentary treatment plan during round, the primary cognitive resources in use are the students/residents' basic pathophysiology knowledge, the visual and laboratory result cues from the patient, direct patient feedback (although many ICU patients are unable to

provide such feedback), and the input of other young physicians in the room. In concert, these resources help the residents to formulate a “best-effort” plan pertaining to each patient’s most pressing medical issues. A fellow noted that evaluation of a student’s or resident’s learning is based on these plans:

“If they (a resident) can’t present a coherent assessment and plan, you start to wonder. Nobody says out loud that this is an evaluation, but everyone knows that it is.”

Teaching Rounds: (“chalk talk”):

Because OHSU is an academic medical center, charged with the dual mission of patient care and teaching of medical students, residents, and fellows, an educational time is formally built in to daily activities on the floor. A 15-30 minute “teaching rounds” session is typically conducted at the conclusion of pre-rounds, and prior to the start of X-ray rounds. The attending physician and the residents on service in the unit (five to seven in most instances) gather into a room with a whiteboard and have an interactive didactic session pertaining to a medical condition. The condition of choice is usually related to either common ailments in the ICU, or an unusual case that is currently being presented by a patient in the unit. The educational format is conversational, but clearly being led by the attending physician, with a traditional, pedagogic teaching focus. Teaching topics ranged from tuberculosis-related aspergillus in the airway to pericardial effusion, to

abnormal calcium levels and cardiac calcification related to long-term dialysis for kidney failure. As one critical care fellow stated:

> "The ICU setting really drives home the teaching points. It's a lot more relevant to see a patient down the hall with a condition than just hearing it in a lecture. Everything makes more sense this way, so a lot of information is packed into those short sessions."

With the attending physician as the facilitator of this educational lecture, his or her experiential knowledge is a primary resource during this activity. Residents and students ask questions, but the format is driven largely by the attending physician's agenda for the day. On some occasions, the critical care fellow delivered the instruction. These instances were less formal than those led by the attending physician, but were clearly an opportunity for the fellow to use his or her growing knowledge base to teach important clinical care processes. This grooms the fellow for a potential academic medicine career, or simply for greater proficiency and autonomy as a provider. The residents (and students, if present) are forced to integrate medical school knowledge on demand, in a context most appropriate to the day's agenda.

"**X-ray rounds":**

The medical intensive care is full of complicated patients whose conditions may change rapidly. Formal rounding occurs only once per day. However, the previous day's order set often contains requests for x-rays,

blood tests, or other diagnostic testing to occur. After early rounds, and prior to formal morning rounds, the physician team (attending, fellows, residents, students) review x-rays and test results. This approximately 30-minute session takes place at a hallway computer (since Picture Archiving Communication System (PACS) capabilities within the Epic Electronic Medical Record) permit x-rays and test results to be viewed within the record), with the team gathered around the monitor. It is led by the attending physician, but all members are actively asking and answering questions. In some instances, complicated x-rays are reviewed in the radiology department (on another floor on the hospital) with the help of a diagnostic radiologist. In these instances, a phone call is made to schedule an on-demand appointment with a radiologist. The entire care team then relocates to radiology to review the x-ray and interpret the results. The information about a patient's condition gleaned during x-ray rounds is then used during formal rounds to create a comprehensive care plan.

During X-ray rounds, the main goal is to integrate various imaging and diagnostic modalities, which often present a dramatically different picture than physical exam or emergency department diagnoses. The expert opinion of a radiologist is often sought, as it provides interpretation of computerized axial tomography (CT) scans, X-ray pictures, or magnetic resonance imaging (MRI) scans most commonly used in the hospital. Information resources in use include not only the diagnostic images themselves, but also the combined experience of critical care intensivists, medicine residents, and radiologists.

Formal Rounds:

Regular rounds in the medical ICU begin around 9 am, after the conclusion of pre-rounds, teaching rounds, and X-ray rounds. At this time, the attending physician, fellow, residents, and students assemble in the hallway outside a patient room, working their way down the hall patient by patient. A minimum of two or three wireless Computers on Wheels (COW's) usually accompany the team. The carts are rather large, and present an obstruction in the hallway, meaning the resident using the computer is usually sandwiched tightly against a wall. The attending physician leads the conversation, frequently asking questions of the residents. The questions are answered with information gained during pre-rounds. In most cases, one resident is responsible for presenting the patient and treatment plan. If he/she does not know the answers, the other residents are asked to assist. In almost all instances, the attending physician calls attention to issues not considered by the house staff, and portions of the treatment plan are modified before being entered as notes or orders to the patient record. Depending on the complexity of the patient's case, the stability of other patients on the floor (frequently, emergency codes are called, forcing everyone to temporarily abandon rounds in order to stabilize a crashing patient), the patient census, and interruption from nurses, nursing assistants, or colleagues from other departments providing consultation, rounds take anywhere from two to four hours.

When questioned, staff members repeatedly stated that there was an implicit goal of finishing rounds by 11 am, so that daily treatment activities could begin. However, depending on the mix of patients, the particular attending physician on duty, and the ability of the treatment team to form a comprehensive plan efficiently make for wild variation in the duration of rounding activities. On one observed occasion, they lasted until nearly 3 pm, resulting in foul moods on the treatment team. From the perspective of all clinicians in the unit, long rounds are sub-optimal because they prevent the staff from involvement in direct patient care activities. A nurse summed up the time sensitivity by noting:

> "They have to get done with rounds by around 11 if people are going to get anything done. After rounds, the orders go in (through physician order entry) and the real work begins for the day. If we have a lot of patients (in the ICU), our lives are impossible if they spend the entire day rounding."

Rounds culminate in a detailed treatment plan for each patient, but many aspects of the plan cannot be carried out until residents are free to begin their work and convey information to the nursing staff or respiratory therapy. Thus, with a heavy patient census, teaching conversations are often curtailed for the sake of brevity and efficiency.

Although rounds primarily result in a daily plan for a patient, there exists a longer-term strategy to both get the patient well enough to leave the intensive care unit, and to appropriately manage the limited resources

(number of beds, limited number of respiratory therapists) on the floor. In order to get patients out of the ICU, and to do so in an organized manner that always allows for fluctuation in patient load and unexpected admissions, these goals must be built into the daily treatment plans, creating a triad of goals. The nursing leadership on the floor plays a significant role in the administrative aspect inherent in managing ICU resources. Nurses are involved to a much greater extent than physicians in daily patient care activities, often functioning as advocates for the patient in conflicts over treatment options. While nurses were not observed on rounds for extended stretches of time, they would frequently join the conversation on a particular patient, often adding useful information about the patient's condition overnight. In many instances, a clinical pharmacist was present on rounds. This individual's duty was to examine the extensive medication list of each patient, to advise the treatment team on the best choice of any new medication, and to take the patient off as many medications as possible. By doing so, the pharmacist seeks to avoid potentially dangerous drug interactions, and to ensure the efficacy of each medication the patient truly needs.

In addition to creating a daily treatment plan, incorporating long-term planning, effectively managing limited resources, and keeping rounds to an acceptable duration, there exists another implicit goal: self-preservation. The intensive care unit is, by nature, a stressful place. Patients are in dire medical straits and unresponsive, families are distraught, emergencies are unpredictable but frequent, and staff (especially house staff) are sleep-

deprived. The heavy workload also allows an individual's personal life to suffer. This creates an emotionally charged atmosphere. There exist strong bonds among residents and nurses. Fellows seemed to identify closely with the residents, but have additional responsibilities for teaching and patient care that create a closer alliance with the attending physician. The attending physician was frequently observed to push residents to learn as far as that day's emotional load allowed. On the occasions such challenges were too great, a resident ended up in tears. Other residents appeared to contain emotions outwardly, but when frustrated, appeared to shut down and withdraw from the conversations. For all members of a treatment team, fatigue, stress, and human emotions play a significant role in the progression and intensity of rounds. On occasions where the emotional load becomes too great, all members of the team incorporate a limited degree of sensitivity, while still pushing for professionalism, learning, and doing what needs to be done for the patient. When rounds were observed to progress more quickly than usual on days when the ICU was full of complicated patients, there appeared to be a self-preservation goal driving the activity. Sometimes, team members did what they needed to do as quickly as possible in order to go home for some much needed sleep, or simply a change of scenery. A critical care fellow summed this up:

> "I'd like if they were a 'no crying in the ICU' rule, but it's not realistic. People are stressed and sleep-deprived. If you're having problems, it's OK

to take that space for yourself, but unfortunately, it comes to work a lot of the time. It's part of the dynamic in there, and you learn to deal with it."

Truly "multi-disciplinary" rounds occurred in this particular ICU only once per week. These occasions involved a nurse, a social worker, a pharmacist, and usually a resident. This represented the only observable occasion that families were directly addressed. Although patient's families did not join the rounds, the discussion of each patient frequently involved formulating updates or plans for families to address other aspects of the patient's life. These discussions were frank and practical, covering topics such as a patient's life expectancy, ability to return to work, or function normally after discharge. The information and cognitive resources at work included a patient's electronic record and medication list, but was expanded to include social issues surrounding the patient's life. These sessions were recorded by the social worker, who brought information back to the patient's family for ongoing discussion and consideration. In a healthcare climate where multi-disciplinary care is receiving increased attention, such focus was relatively minimal in this particular ICU. Possible cause for this is likely the additional teaching mission, which involves time and resources that might otherwise be used for the consideration of multiple clinical perspectives.

Taxonomy of Rounds in a Medical ICU

	Pre-rounds	Teaching Rounds	X-ray Rounds	Regular Rounds
Who facilitates	Resident	Attending, fellow	Attending	Attending
Who participates	Residents, Medical students	Attending, residents	Attending, residents, fellows	Attending, residents, fellows, nurses, pharmacists, respiratory therapists.
Patients participate?	Yes	No	No	No
Plan of care documented how:	Handwritten notes, limited data entry to EMR	Handwritten notes for study	No documentation. Results are incorporated into treatment plan during rounds	Resident or attending enters orders at COW in patient record as treatment plan is formulated.
Information/Cognitive Resources Utilized	Basic science/ disease state knowledge, patient feedback/visual cues	Attending knowledge/experience, patient illnesses.	X-rays, CT scans, MRI, attending/radiologist perspective	Attending knowledge, resident discussions, patient EMR, Micromedex, handwritten notes from pre-rounds nursing and pharmacy perspective.
Goals	Determine patient's status over last 24 hours, create a	Deliver didactic lecture on a condition or topic related to	Review and interpret test results to aid treatment plan	Evaluate residents and medical students. Assimilate information from nursing, pharmacy

	plan to present during morning rounds	critical care medicine.	formulation	

[iv] (adaptation) **Table 1**

Discussion

In an activity system, the cognitive processes may be distributed across various members of a group, across both internal representations and environmental structures, and across temporal boundaries (i.e. earlier events may influence the nature of later ones). Sometimes, physical artifacts serve as concrete representations of a situation's knowledge base. These concrete representations of social constructs hold importance beyond explicit communication. Yan Xiao of the University of Maryland notes the critical impact that information tools can have on the spatial and communicative relationships that are so central to cognitive processes in the healthcare setting.[v] His article states that, "paper-based forms perform functions more than simply conveying information. Ignoring other functions may have detrimental effects when paper forms are replaced with computerized forms."[vivii]

The concepts of activity systems, cognitive artifacts, and "groupthink" may seem far removed from the realm of medicine. However, the University of Maryland Medical Center, famous for its shock trauma center, is a pioneer in applying distributed cognition principles to the logistical and team aspects of

its inpatient critical care setting. Dr. R Adams Cowley, MD, founder of the shock trauma center in Baltimore defined the very essence of modern emergency medicine when he noted, "There is a golden hour between life and death. If you are critically injured you have less than 60 minutes to survive. You might not die right then; it may be three days or two weeks later -- but something has happened in your body that is irreparable."[viii] In such life or death situations, it is not surprising that a shared physical artifact, such as a whiteboard, takes on central importance as a mediator of knowledge among the many providers. Similarly, the trauma unit can effect dramatic differences in patient outcome with careful attention to rounding practice and well-facilitated inter-provider communication.[ix]

Work performed by Dr. Colin McKenzie and his colleagues at University of Maryland explores in detail how a surgery scheduling whiteboard facilitates distributed cognition in the midst of routine emergencies. Its prominent location and canvas-like appearance makes it an effective tool for communication and collaboration in a highly dynamic environment.[x] In a similar vein, Hazlehurst, et al. have used distributed cognition to examine the communication process in cardiac surgery, concluding that vital situational awareness is borne of knowledge dispersed among physicians and cognitive artifacts.[xi]

While the trauma center served as an early foray into understanding medical care processes from the perspective of distributed cognition, the

theory's potential applications are widespread in medicine. As mentioned previously, medical rounds are replete with many goals, purposes, and participants. By using distributed cognition to better understand the nature and representation of knowledge they contain, researchers in medical informatics can begin designing clinical information applications to appropriately fill the trauma room whiteboard niche for rounding clinicians. At the same time, new tools can capture the benefits of physical artifacts while also exploiting the ubiquity of digital information. Like the trauma center, rounds have their own culture and unique needs. Any physical manifestations of data must be highly portable (as they will be carried around the hospital), must allow for data input from multiple users, and must represent the information in a highly meaningful, dynamic fashion. Design should account for the fact that rounds have multiple purposes, and so too should their tools. Depending on the user (attending physician, resident, or other clinician), the primary goal may be quite different. A medical student is present for the sake of learning. A resident must consider his or her educational goals while treating a large volume of patients. The attending physician is concerned with providing high-quality teaching, and at the same time evaluating the residents on his or her service. Nurses, on the other hand, may be primarily concerned with the well-being of the patient. Pharmacists bring knowledge and concern of the medications given to the patient, along with potential drug interactions and maximal therapeutic efficacy. Rounds represent all of the above opportunities to all these individuals; they present the means of bringing various actors together in

space and time for multiple purposes. Distributed cognition represents the framework by which to organize the goals, inputs, and players. After doing so, the information tools modeled after physical cognitive artifacts will best meet the many demands of the interdisciplinary healthcare setting.

The great importance of getting information tools right is patient safety and error avoidance. The Institute of Medicine (IOM) has led the way over the last decade with a frank and unsettling glimpse of the culture of safety (or lack thereof) and tract record of the American medical system. Preventable errors are said to be responsible for as many as 98,000 Americans per year.[xii] The skill of dedicated clinicians may be negated by miscommunication. Varpio and colleagues presented a review article examining interprofessional communication in medicine. They concluded that communication is often oversimplified, with expensive, even fatal errors as a result. The proposed solution is not simply to "try harder", but to re-frame the context. In other words, the traditional understanding of medical teamwork, primarily focused on one person or discipline at a time, has poorly captured the flow of knowledge and responsibility, ultimately resulted in errors and poor safety. Instead, re-distributing the center of knowledge to the environment by looking at the medical arena as an activity system permits a type of understanding that can be used to design workflow leading to better outcomes.[xiii] Only with a more sophisticated understanding of how errors currently happen so often can they be avoided in the future. Distributed cognition shows promise in allowing

researchers to understand the patient care setting in different, more comprehensive way.

Formal rounds involved the greatest number of cognitive resources: electronic patient charts, hospital formulary and drug information (online), handwritten notes, laboratory and imaging results, clinical expertise from pharmacy and radiology, the patient advocacy role of the nursing staff, and the experienced role of the attending physician. Stated goals from interviewees included teaching, incorporating ancillary data, learning (formulating treatment plans from patient data and presenting in a coherent manner), evaluation of students' and residents' performance, long-term and administrative planning, and the maintenance of time and emotional limit considerations. Medical students, residents, fellows, attending physicians, nurses, pharmacists, respiratory therapists, radiologists, internal medicine sub-specialists (such as cardiologists and hematologists), and social workers all contributed to various rounding processes. Information was pooled from a wide variety of sources, including the patient's electronic medical record, bedside records from other hospitals, ancillary lab and diagnostic data, online medical and pharmaceutical resources, the collective knowledge pool and perspectives of multiple clinical practitioners, and the conditions of patients that drove teaching topics.

As rounds took place, the use of such numerous and diverse information and cognitive resources created a complex activity system. Rarely were all players in the same place at the same time, and if they were, they

were not doing the same things. A main patient care/teaching-oriented conversation was usually happening within rounds, but side conversations were frequently observed, and residents often engrossed with electronic order entry, review of the MicroMedex formulary, review of handwritten or electronic chart notes on a patient. A summary of various cognitive resources is presented below:

Cognitive Resources

Item	Type of Cognitive Resource	Where Used
Teaching topics	Formal medical knowledge	Teaching rounds
Expert opinion (diagnostics)	Human Expertise	X-ray rounds
Patient electronic chart (some information duplicated on paper)	Digital resource (backup paper copy at bedside)	Early rounds, rounds, X-ray rounds
Handwritten notes (informal)	Informal notes, adaptation of formal medical knowledge	Early rounds, rounds
MicroMedex (online formulary, drug information)	Online resource	Rounds, possibly after early rounds.
Reference materials (e.g. medical dictionary pocket guide, UpToDate)	formal medical knowledge, online resources	Early rounds, teaching rounds (supports learning processes), X-ray rounds
Conversations	Human Experts	Rounds (to assist evaluation of residents), to facilitate all rounding processes (sharing information on patient conditions that may not be contained elsewhere).

Table 2

With two to three COWs present during the conversations, the physical dynamics of rounds were impacted. The carts were awkward to move up and down the hallways, and required the entire team to re-position itself more formally outside each patient room than would have otherwise been required. The tall monitors blocked individuals from fully viewing each other's body language. The one-to-one interaction between a resident and the computer effectively removed that individual from the conversation for periods of time. Each computer functioned independently of the others, meaning the residents were unable to see what was being entered or viewed by their colleagues. The COWs also changed the organizational responsibilities of the residents. Prior to EMR implementation in the ICU, a resident had to spend a great deal of time preparing chart notes on each patient, and preparing copies for the attending and other team members. While time consuming, it provided a measure of assurance that each person was viewing the same information. Papers presented less of a physical obstruction than wireless computer carts, and permitted greater agility. A resident explained,

> "It used to be a lot more work to get all the paperwork organized each morning (before rounds). EPIC changed the workflow a lot. It's good in a lot of ways, but now it's harder to make sure we're all on the same page… literally."

Papers did involve greater labor with order entry, and the possibility of clerical errors was greater. Ultimately, an electronic setup that permits greater

mobility, physical interaction, and cross-disciplinary collaborative processes is desirable. Distributed cognition could be well-applied as a theoretical framework to construct mobile information representations that permit greater collaboration, and foster more synchronous communication.

Conclusion

Rounds as they currently exist involve discrete blocks of time devoted to different types of activities. The taxonomy contained in this discussion summarizes the types, goals, and participants in various types of rounds. Each type involves its own goals and cognitive resources. The intensive care unit really “knows” its patients through a somewhat scattershot approach of teaching, data review, utilizing various clinical perspectives, and treatment planning. The electronic record serves as a central repository for notes and orders, but it does not tell the whole story. Its real-time maintenance during rounds also presents a distraction that removes the resident from the conversation taking place.

This pilot work describing the types and characteristics of inpatient rounds is designed to enable a theoretical approach to information technology design that calls upon distributed cognition. As referenced in distributed cognition literature, the ICU represents a complex “activity system”, where information about the patient is not contained in any one place. As healthcare information technology evolves, clinicians and designers must collaborate on how to best support the multi-faceted healthcare environment. For an inpatient

medical service, rounds represent a significant and crucial means to “keep tabs” on each patient. Treatment planning, teaching, and evaluation are all firmly routed in daily rounding activities.

This project illustrates that there is still much to learn. However, there exist some immediate implications. With the variety of information needs, goals, and perspectives contained within hospital rounds, designers of future electronic medical records and/or information tools designed to be used during the clinician’s workday would be wise to consider a “modular” approach. As evidenced by the descriptions and observations contained herein, each “type” of rounds has a very different goal, or multiple goals wrapped into one. The use of diverse cognitive resources to create this complex environment makes it highly unlikely that a single interface for information needs will be adequate. Rather, a system capable of accepting multiple users’ input simultaneously, providing different modules (or “tabs”) for various types of rounds, and representing this information in real time, may represent greater finesse in creating situational awareness for each participant.

By thoroughly understanding types, goals, participants, and cognitive resources inherent in rounds, information technology may best utilize distributed cognitive theory to help create a virtual “environment” that contain the cognitive artifacts necessary to embodying knowledge in an activity system. Due to the enormous heterogeneity of rounds in different institutions and disciplines, this represents a significant undertaking. It is evident that

further research is necessary to identify the similarities and differences in other medical settings, as well as at other institutions. However, the careful application of distributed cognition theory to the setting at hand can permit the methodical construction of a meaningful information environment. A taxonomy of rounds is a first step in using theory to better represent the information contained in a setting, and to assist its participants in using such information to the fullest.

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