Chapter 7
Characterizing the Nature of Work and Forces for Decision Making in Emergency Care

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Introduction

Healthcare as a complex system [1] is exemplified in emergency medicine [2, 3]. Emergency Departments (EDs) are dynamic, adaptive, and self-organizing. Additionally, ED providers are faced with inherent unpredictability regarding the number and severity of patients, concurrent management of multiple individuals requiring timely responses, and a need to cope with limited resources all within a life-critical, interruption-laden environment [4]. The layered complexity of such units includes the functions of the work, the implementation of technology, the people, the activities and workflows jointly performed by the people and the technology, as well as the social, physical, cultural, and organizational environment in which the ED is embedded. Managing the cognitive, physical, spatial, and temporal resources in such systems is crucial for patient safety and quality of care. Understanding the interaction of the complexity of this work and the environment, particularly as it relates to decision-making, is a first step in engineering solutions to support physician efforts.

Section 3 is adapted from Franklin et al's (2011) paper Opportunistic decision making and complexity in emergency care, *Journal of Biomedical Informatics.* 44, 469–476.

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V.L. Patel et al. (eds.), *Cognitive Informatics in Health and Biomedicine*,
Health Informatics, DOI 10.1007/978-1-4471-5490-7_7,

The purpose of this chapter is to consider the complexity of emergency care at two levels: (1) methods for describing the functions of the emergency care work domain and the associated complexity and (2) the impact of specific workflows and environments on those functions. The ultimate goal of our efforts is to create health information technology to support the Emergency Department. We begin by creating a Work Domain Ontology or description of work. Then narrowing the focus of ED efforts to task transitions, we next describe decision-making patterns as physicians shift between activities finding use of local rules to govern action. Looking at specific implementations of different workflows and different physical layouts, we detail the impact of these factors on decision making. Finally, we conclude with future directions for Health Information Technology (HIT) interventions in complex healthcare scenarios.

Understanding Complexity Using a Work Domain Ontology (WDO)

In order to better reveal Emergency Department complexity, we need an abstract description of the clinical and cognitive work performed by clinicians, independent of how the setting is implemented with specific technology, artifacts, and environmental variables. The work domain ontology is a framework for this purpose [5–10].

A Work Domain Ontology (WDO) outlines the basic structure of the work that the system together with its human users will perform [6, 8, 9]. It is an explicit, abstract, implementation-independent description of that work. It describes the essential requirements independent of any technology systems, strategies, or work procedures. It tells us the inherent complexity of work; it separates work context (physical, organizational, computational, etc.) from the nature or functions of the work itself.

A WDO is composed of goals, operations (or actions), objects and the constraints that capture the functions of work. As an example, let's imagine a *goal* of treating a patient. One *action* or *operation* in treatment might be to prescribe a medication. Now, a prescription can be "written" in a number of different ways. A doctor can enter the order into a computer, write out the prescription on a pad, or make a call to the pharmacy. The underlying work domain for generating the prescription is the same across all of these means of creating it. In each case the *operation or action* is "prescribing a medication"; the *objects or required components* for this operation include patient name, medication name, dosage, frequency, duration, route, etc.; the *constraints* include the dependency relations between operations and objects (e.g., operation "write a medication prescription" and the objects "Metformin" and "500 mg"), between objects (e.g., the object "glucose level" and the object "Metformin"), and between operations (e.g., the operation "write a prescription"

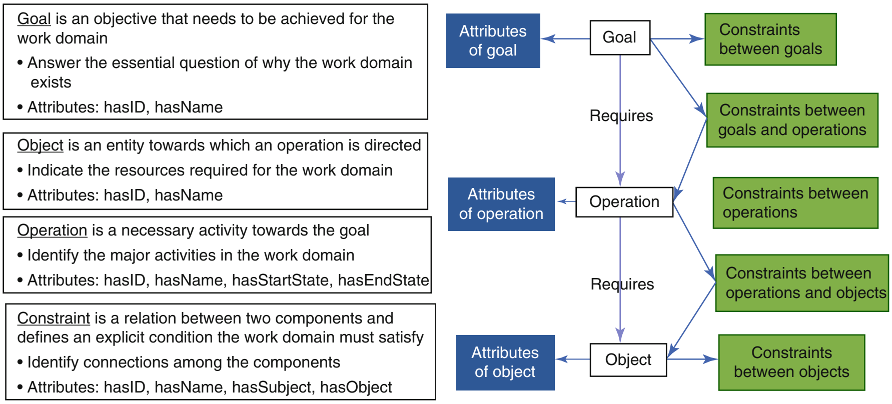

Fig. 7.1 Components of a work domain ontology

and the operation "modify allergy list"). The work domain is constant although the implementation varies if a computer or a prescription pad is used to generate the order.

Figure 7.1 shows the four components of WDO and their relations. The process of developing a WDO is similar to the process in ontology engineering, including defining the domain and the scope of the ontology, enumerating the goals, objects, operations, and constraints with various data collection methods (document analysis, observation, focus group, survey, etc.) and analysis methods (concept analysis, alignment, integration, etc.). The evaluation methods for ontology are also similar, including evaluation for different levels of granularity (e.g. lexical or concept level, semantic relations), fit for an application or with a context [10].

Partial Work Domain: A Single Perspective

We conducted a series of observations, interviews, and focus groups in order to develop a partial WDO for an emergency department. As this is a work in progress, we have completed the WDO from a single perspective of faculty physicians in a teaching hospital.

Faculty physicians at a teaching institution have at a minimum of three main and sometimes conflicting goals: (1) care of patients (individual patients and the totality of the unit), (2) management of resources and hospital administration, and (3) training and education of residents, fellows, and medical students. The tasks associated with each of these goals are a potentially many-to-many mapping (i.e. a single activity may answer any or all of the above goals). Our partial work domain includes only the faculty physicians' perspective. We anticipate many operations carry over to other perspectives or roles such as nurses, consultants, and trainees such as residents. The full work domain ontology will capture each of these perspectives in addition to the physician efforts.

Building Out the WDO

In order to create the Work Domain Ontology, we employed multiple methods to identify the goals, operations, objects of work and the constraints between these entities. Below we detail how we captured one aspect – the operations of work through observation.

Identifying Operations

Data were collected in a Level 1 Trauma Center in an Emergency Department of a large teaching hospital located in the Gulf Coast Region of the United States. This Emergency Department is separated into pediatric, medicine, and trauma units, with the trauma unit as the center of our study. We collected 55 hours of observation of attending physicians (three clinicians across two observations each) using pen and paper field recordings. The activities recorded included both ongoing activities (e.g. asking questions as part of medical history) as well as passive activities (e.g. observing a resident conducting a procedure). Think aloud data, for example "I am reviewing this chart", when provided by clinicians, created a pool of mental tasks. A total of 3,769 discrete activities were observed. Using the descriptive language from the field notes and grounded theory [11] to develop themes, these activities were distilled down to 125 individual tasks. These tasks such as *advising* (offering suggestions about the best course of action) and activities of direct patient care such as *performing procedures* were then implemented into our WDO as operations. The screenshot in Fig. 7.2 shows a sample 35 operations [12].

Refinement and Linking to UMLS

In addition to identifying the concepts observed during physician work, we also linked the activities (concepts) to the controlled vocabulary provided by the Unified Medical Language System (UMLS). Merging the UMLS concepts with our Emergency Department WDO required us to clearly identify our concepts and refine our understanding to match the contents of the UMLS meta-thesaurus. The intent of this integration was to clarify our WDO to a common terminology. Our method was to enter our initial terms for our ontology in the UMLS search query. When disparities were located, terms were either (1) reconciled by semantic type or (2) the search was split into several searches to create a combination of UMLS codes that incorporated our class properties.

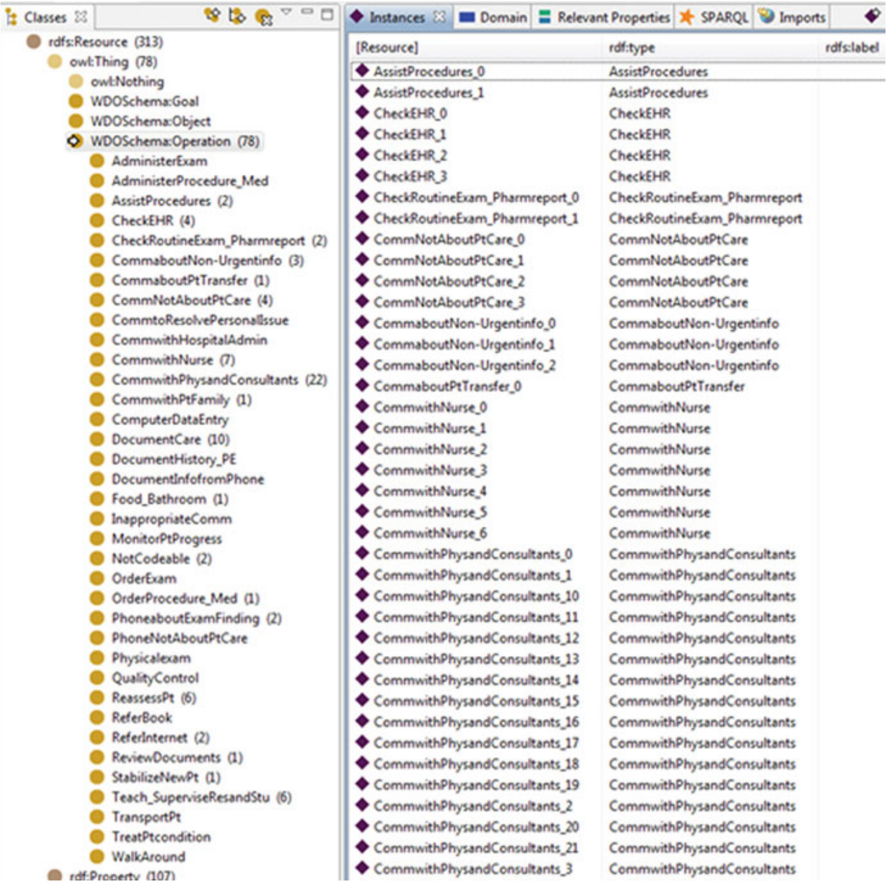

Fig. 7.2 A partial WDO of ED based on observed operations

Adding in Objects

In addition to the activities or operations, objects needed to be refined for specific emergency department work domain ontology. Objects can be broadly separated into (1) information and (2) resources, where (1) is any kind of information in the ED collected, starting with vital signs, as well as lab values and initial results of patients. Resources are personnel, workstations, and other artifacts in the ED. For example, a task such as communicating about a patient transfer requires not only the information regarding the patient (name, medical record number, current location) but also information regarding the receiving unit (new bed location, new physician name) as well as details regarding time and availability of position (e.g. whether transport has been ordered, whether the bed is currently available or pending). When possible, our objects were fit to the UMLS existing categories, however, additions were preserved.

Codifying Constraints

The work domain is more than the activities that occur and their necessary objects. Constraints must also be coded into the WDO, mainly the competing need for resources and the state of an object as available or not. Resources are typically limited to some extent in the ED. There are fewer workstations than personnel and access to devices such as CT machines are some examples. The degree of constraint may be viewed as subjective or highly bound by context. For example, the constraint of a single CT machine is felt more strongly when multiple critical patients must be triaged for access. In other circumstances, this competing need for this resource is not observed.

With the creation of this work domain ontology, we are better able to understand the complexity of clinical care, management of multiple goals, and the constraints in work such as dependencies on collaborative tasks (e.g. consult reports, compliance of patients). The WDO helps to articulate the interaction of components across efforts and provides a bigger picture as to the scope of operations, objects, and constraints. Additionally, the merging of our ED ontology with concepts from the UMLS terminology shows promise in making components of our WDO reusable for the purpose of modeling other environments.

Task Transitions: Narrowing the Focus to Decision Making

While the WDO identifies the components of Emergency Department work, it does not fully capture all efforts. One significant gap is the articulation of how operations are selected, how constraints limit choice, and how decisions are made. To further explore the complexity of emergency care, we now turn to decision making.

Looking at patterns of how physicians select their activities and how their behavior is governed by local rules are two aspects of complexity that emerge in such a non-deterministic environments.

Our approach to decision making is based on distributed cognition, which considers the ED as a system composed of individuals and technology situated in a complex physical, social, organizational environment that extends across space and time. Combining our method of categorizing physicians' behaviors with a cognitive, ecologically based Naturalistic Decision Making (NDM) [12] paradigm, we created a classification system that highlights the variability of the decisions made in this environment including across-task decisions that are not covered by existing models of medical decision making.

Decision Making

Current theories of decision making from classical models of risk and utility to contextual models of Naturalistic Decision Making (NDM) all emphasize the inherent factors of uncertainty and complexity in the medical decision process [13–15].

Task complexity, including that created by uncertainty and non-linearity, affects the efficiency of decision-making, as more complex tasks require more cognitive effort [16, 17]. However, much of the research on decision making and support systems has focused on the choices made during the care and treatment of a single patient. That is, these models revolve around a within-task choice often decisions in treatment or diagnostic reasoning. While this is a rich area for potential support with technology and a point in care with significant risk for error, physicians, particularly those in critical care environments such as Emergency Departments (EDs), also make many decisions *across* tasks (e.g. the selection of what to do next from multiple alternatives following a task). We extend the decision making model to consider selecting between potential activities.

Task Transition Decisions

From our previous work including the observations used to build the work domain ontology [18, 19], we began our exploration of decision making by reviewing canonical activities in the Emergency Department. Common tasks include patient assessment, observation, and communication. We analyzed these activities for the overarching goal for which each activity is conducted (e.g. care of patients, student teaching, etc.), the events surrounding each activity (e.g. patient arrival, x-rays complete), and the situational factors at that moment. Using these methods we determined that there are a number of task shifts in which a physician must select what their next action will be. The most clear cut selection of next task is the decision of *what to do following the completion of a goal*. However, the complexity of the ED rarely allows a physician to see a task (such as caring for a single patient) through from beginning to end without intervening activities. Therefore, the selection of between – task actions is a common occurrence that moves physicians from one activity to the next. Movement between the care of multiple patients is one example of a task transition decision.

Methodology

In our study of task transition decisions, the same faculty physicians from the Work Domain observations were again followed across multiple shifts. Data was collected for seven sessions across five physicians including two new additional doctors. The forty plus hours of observation provided rich data for the analysis of workflow processes and decision making. During the shadowing sessions, environmental elements in the ED were recorded, including the locations of the activities by physicians, the time, the participants engaged in the task (e.g. the other parties the physician might be speaking with, caring for, or interacting with), all observable antecedent events (e.g. being asked to attend to a patient, answer a call, responding to an alarm), and other ongoing activity in the ED (e.g. arrival of new patients, consulting physicians from other departments appearing in the ED, number of beds filled, etc.). In addition to shadowed observation, our methods included a 'think aloud' narration of the physician's activities in which the physicians were asked when possible to articulate their immediate goals [20]. However, given the demands of the ED, should a physician fail to provide this narrative no attempts were made to ask for clarification of the actions observed. Our observers did not interrupt or engage the physicians to prevent any potential harm or alteration in the functioning of the ED. Additionally, at patients' requests, observers waited outside treatment rooms limiting data collection for infrequent spans of time.

Categorizing the Decision Types

Decisions in the ED can be described at many levels of granularity. For example, there is the abstract level of patient care, viewing an image, generating a diagnosis, and levels all the way to a fine grain selection of picking an imaging technique (see Rosch [21], Smith and Medin [22] for discussions on categorization). Therefore, it is necessary to specify at what level of detail efforts should be concentrated and analysis should occur. Using the multi-stage iterative method described in the Hybrid Method to Classify Interruptions and Activities (HyMCIA) developed by Brixey and colleagues [19], we compared data collected across multiple observation sessions to clarify emerging categorizations and to redefine our protocols. From these activities, we adopted a flexible framework that allowed for categories to emerge both in data collection and analysis.

Categories of behavior emerged from our data such as a deciding on the next goal, moving between patients, switching between roles (physician as care giver versus physician as teacher), and coping with environmentally forced breaks in task (interruptions, delays, necessary communication). All of the aforementioned decisions are considered to be between task transition decisions (or choices in goal selection). Using this decision space, we then consider what types of decisions are made in these moments.

Results

Three main types of decisions emerged from our analyses. Physicians made planned decisions by following the logical progression of action such as moving into the next step in a protocol. For example in the care of a patient, planned decisions would include documentation following a patient exam. However, sequential activities along a planned course are often disrupted. While intervening activities may occur, a return to a plan is quite common. However, serial progression through a protocol is not required for a decision to be deemed planned. That is, although the

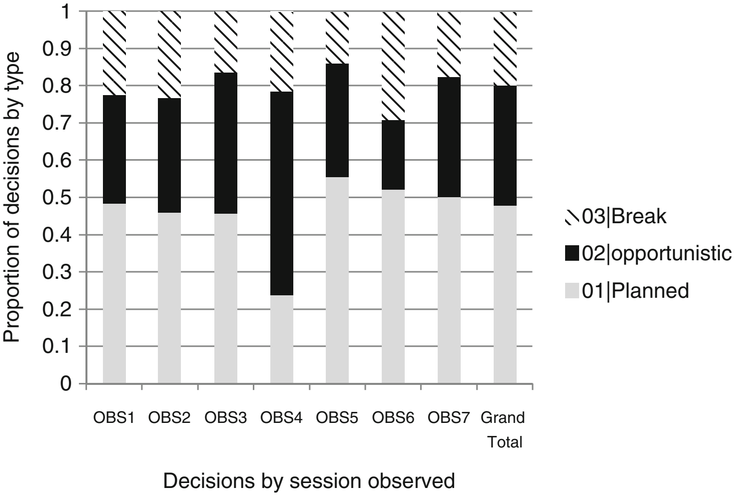

Fig. 7.3 Decision types observed

attending physician may have seen other patients since the initial exam of the patient, after reviewing the patient's x-rays the decision to then chart is considered a planned choice (or logical progression) in treating this patient.

A second type of decision that emerged from the data are opportunistic decisions. These decisions are a choice in action created through unanticipated circumstances such as proximity to another individual. For example, passing by a patient sitting in the hall is an opportunity to interact with that individual. It is through the unanticipated chance, the physician decided to interact with that patient rather than moving to the CT room (the intention articulated during his think aloud).

Breaks in task, our third decision type, are unanticipated choices forced upon a physician via an interruption, disruption or impediment to a task. The decision in these moments is to disrupt current activity to attend to a new requirement or demand. Breaks can be momentary such as the disruption of a pager going off (followed by a quick return to the previous activity) or may result in a complete change in task.

When we consider how often each type of decision is made in the course of a day's efforts, we find that on average 45 % (sd .14) of the physicians' decisions were planned, 34 % (sd .15) were opportunistic, and 21 % (sd .6) were produced by a break in task. The decision types for the seven sessions are displayed below in Fig. 7.3.

Through the exploration of task transition decisions, we can see that the choices made in the ER are most often (55 % opportunistic + break) created by the environment, rather than by conscious selection of the physician. While we might have anticipated a stronger adherence to protocol, response to local rules (e.g. responding to immediate needs rather than a global plan) is in line with our expectations of the Emergency Department as a complex system. Task transition decisions are not in most cases guided by protocol but are instead the result of situational factors. Further, as these decisions are not based on choices in diagnostic reasoning, treatment options or other well-established guidelines, this research highlights the need for new research on cognitive support at this level of decision making.

Dashboard displays systems showing the current status of all the patients in the emergency room may help physicians to better select the next patient to care for based on patient need (rather than the physician's memory of who needed assessment or proximity). Similar clinical dashboards have been developed for patient management in ICU care [23] and broader areas of resource allocation and project management. Our results suggest that work on the effect of opportunistic decision-making on workflow is also needed.

Here, we developed a new methodology for the study of decision making based on the distributed cognition framework that considers people and technology as an integrated system in complex physical, social, and organizational context. We identified three major types of decisions during task transitions and this taxonomy is important in understanding how physicians make decisions in the ED making. Next we look at the environmental factors influencing these choices.

Environmental Factors in Task-Transition Decisions

Beyond identifying decisions types based on the intent of the physician (next step in protocol = planned, respond to a break in task = disruption or interruption, or take advantage of an unexpected chance = opportunistic decision), we also must consider the role of the environmental or contextual factors that influence these decisions. Exploring the antecedents of task transitions decisions allows us to broaden each decision type. Next, we identified the contextual influences involved in physician choices.

Planned Decisions

Planned decisions follow the clinical pathway of treatment or the logical progression of care. Planned decisions can be influenced by the directions of a colleague (e.g. care plans handover over during shift change), determined by a set protocol (e.g. protocol for caring for a stroke patient), or may be routines determined by the preference of an individual (e.g. seeking out an ED wide update following the completion of documentation for each patient). We therefore broadly define planned decisions include the sources of influence:

Protocol/Logical Plan – next step in action series following common protocol or logical progression (e.g. following assessment there is creation of a treatment plan)

Preference – individual selection of next activity when no other outside forces influence the selection of the decision. This is a habitual choice or routine (e.g. completing walk around the unit to update situational awareness prior to charting)

External Forces – response to acknowledged/anticipated external forces that shape the selection of activity (e.g. being given patient priority during signout across shifts, following administrative policy etc.)

Break in Task

The catalyst for a break in task also comes from multiple sources. Physicians are often interrupted or disrupted during a task by needs of others including nurses, students, and patients. Interestingly enough, we have observed on a number of occasions, physicians interrupting themselves. Artifacts such as communication devices including phones, pagers, or alarms are also immediate sources of breaks in task. We classified breaks in task as having three main sources:

By organizational design – the physical layout of the workspace causes a disruption in work flow (e.g. chairs/beds/people impediment to ongoing activity)

Self – physician suspends an activity to perform another activity triggered by their own thought process (e.g. changing destination while walking down the hall) and captured through think aloud protocols

People or Artifacts – outside entity requires the suspension of current effort to perform task (e.g. needing to respond to an interruption for information, disruption caused by pager)

Opportunistic Decisions

Finally, opportunistic decisions arise from the conflation of several unforeseen events. This includes a doctor being in the right place to complete an unexpected act, someone having additional resources available to them (such as personnel) or having a bit of free time when blocked from completing a task. **Opportunistic Decisions** are choices in action created through unanticipated circumstances.

The three main sources of opportunity are proximity, time and resources. It is possible to have the right person, the right time, and the right resources simultaneously to allow for a decision/activity that otherwise would not have occurred.

In general, opportunities arise from:

Proximity – use of physical location in decision-making. Nearness makes desirable this course of action. Proximity is an opportunistic decision but not all opportunistic decisions require proximity. For example, a physician might select their next patient based on their proximity, but may also locate a piece of needed equipment when it is found unexpectedly on their way to complete a different task.

Time – often generated by artifact absence, lulls in workload or during necessary delays (e.g. time during an x-ray). For instance, in caring for a patient, a physician must step away from the bedside while x-rays are being taken. If the

Fig. 7.4 Relationship between factors and decision types

Environmental factor	Planned	Opportunistic	Break
Human	✦	✦✦	✦✦
Physical	✦	✦	✦
System	✦✦	✦	
Time	✦	✦	
Human • ✦ physical		✦	

✦✦ Single factor according for at least 70% of that decision type

physician uses these few minutes to check on the patient in the adjoining bed, this decision is considered an opportunity of time.

Resources – staff, materials, and other resources influencing decisions (e.g. additional attending physicians whose appearance alters the distribution of demands – Since you are here, I can now do another task.)

The Impact of the Environment on Decision Making

With multiple environmental factors are at play in each type of decision, we next considered the frequency of occurrence for each sub-type of task transition decision [24]. To do this, we created a matrix of the decision types and our categories of environmental influences. Using this grid, we determined the most frequent environmental factor(s) for each decision type (e.g. medical devices as related to breaks in task.) We then determined the most frequent type(s) of decision for each factor (e.g. opportunistic decisions relationship with factors such as time.) The next step was to survey the grid created by the factors and decisions and to isolate those cells that contained both the most frequent factors and the most frequent types accounting here for at least 70 % of the data. (If a single factor did not account for 70 % of the data, the next most common factor was included. This allows for multiple decision types/multiple factors to be considered the predominant influence). From this we determined that certain factors co-occur consistently with particular types of decisions. In Fig. 7.4 below, we illustrate this by indicating which factors were found for each decision type. The larger ◆ shape indicates the most prevalent environmental factor for each decision type.

As can be seen in the table, some decision types were affected by more than one category of environmental factors. Breaks in task are influenced by other individuals in the ED (e.g. residents, nurses, patients) and physical factors such as medical devices. However, for opportunistic decisions, there is also a combination of factors that robustly co-occur. Opportunistic decisions are influenced by time, proximity and by other individuals in the environment, and a combination of location and personnel is also common. That is, opportunities arise when the right person is located in a place that engenders an unexpected interaction. For example, as an attending physician is walking towards an exam room to care for a patient, he sees a resident looking at images at a PACS station. Stopping to talk with this resident about the images for another patient takes advantage of the opportunity presented by both the presence of the resident and proximity to the PACS station. It is the combination of these two factors that creates the opportunity. Therefore we have created a combined factor that incorporates both aspects.

Understanding the role of environment on each kind of decision has implications for the interventions created. If the goal is to increase adherence to protocol through a decrease in interruptions, it is necessary to understand the source of these interruptions. Similarly, to capitalize on opportunistic decisions, we much explore the impact of proximity on decision making.

Implementation Effects

The WDO created for the emergency department is implementation independent, meaning the tasks, objects and constraints are not influenced by the current installation of the EHR system or the staff working on a particular day. Task-transition decisions, on the other hand, are shaped by situational factors. Looking at a different implementation of work in our original hospital site allows us to tease apart how physical and workflow changes impact decision-making.

In a natural experiment, the same Trauma 1 hospital from the initial studies elected to implement a significant workflow change moving to a model that is known as “split-flow”. The goal of split flow is to alter wait times and improve process flow by separating out the very ill and less acute patients at a different point in care (i.e., triage). This model splits the flow of patients into two categories: (1) those needing expedited treatment that proceeds in a typical fashion and (2) less serious patients are tested, treated and monitored in a results pending space. These less acute patients progress directly from the triage space to the results pending waiting room without being treated in the main section of the emergency department. This reduces the overall patient through put in the back unit, reduces wait to treatment for those patients and alters the physical space. Figure 7.5 below indicates this new physical layout.

When this change was implemented in the department under study, a dedicated triage physician was not assigned. Rather doctors, including residents, working in the ED cared for and now monitored patients across a larger space. This space includes no line of sight between spaces (i.e. you cannot see between the units of the ED into the results pending room.) This change in workflow moves the physicians through a different series of room disrupting previous behavior patterns.

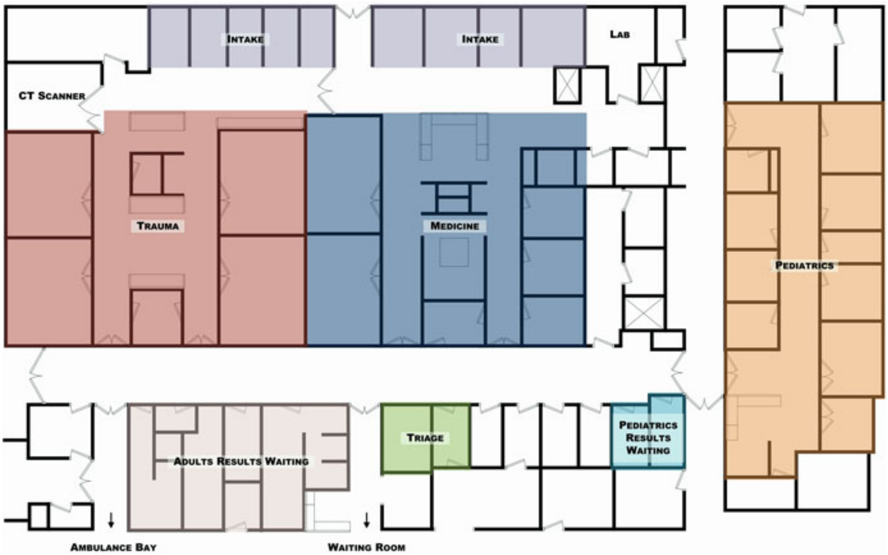

Fig. 7.5 Split flow layout of the hospital

While the change in workflow is significant, it is not expected to alter the WDO created for the Emergency Department. The patients in this flow receive the same treatment, have the same constraints, and the same care is required as in the previous sample – only the implementation has changed. Looking at task transition decisions we can now begin to explore the impact of implementation on complexity.

Decreasing Opportunities

Opportunistic decisions in the original study were determined by factors such as proximity. We predicted that such opportunities would decrease with the workflow change. Both the alteration to work and the change to the physical layout were hypothesized to negatively impact the ability of faculty physicians to make such choices by decreasing line of sight (e.g. could see the potential opportunities) and altering movement patterns as predictable routines were hypothesized to support opportunistic task transitions.

Methods

The same five attending physicians from the above study were shadowed. We compared 20 hours of their behavior in the initial workflow studies to 20 hours of post "split-flow" efforts. Paired T-tests were used compare performance across these points.

Results

While we had anticipated a decrease in the circumstances leading to opportunistic decisions (e.g. proximity), such decisions increased in each session after the layout change with 16 % growth on average ($p<.02$). We believe that this may have occurred as the new physical layout required the physicians to move through larger ED spaces. Such movement may have resulted in more opportunities taken. Further, the split-flow may have increased communication needs (e.g. monitoring of unseen patients) that may have driven additional opportunistic choices of catching conversations when possible. The limitations of our study, including small rates of think aloud data, do not allow us to conclusively determine what in fact caused this shift. However, these results do indicate a change in previously seen patterns with a different implementation of workflow and physical layout.

To further continue the study of the impact of implementation on decision making, we conducted another study following our group of clinicians – this time in a different hospital system.

Implementation 2

At our second site, many factors have changed. While still located at a teaching institution in the same major metropolitan area, the second hospital is a county hospital servicing a different clientele (e.g., fewer trauma cases, etc.). Additionally, a different EHR is implemented at this site, the physical layout is different and the work flow includes smaller pods within a unit limiting overall patients per provider. So the question is how well does the WDO generalize and how well will our task transition decisions hold up at a new site?

Replication Methods

In this iteration of the study, seven faculty physicians were shadowed at the second hospital site for a total of twelve four hour sessions observations (48 hours total). As with the previous study, the physicians were observed as they went about their daily work. Attention to task transitions was again the focus of the efforts.

Although this site differed in terms of physical layouts, EHR system and to some degree the severity of patients presenting (e.g. fewer trauma patients), we see a similar pattern to previous findings. As shown in Fig. 7.6, task transition patterns (depicted with averages across physicians observed more than once) are roughly equivalent to previous findings. Opportunistic decisions are 28 % (sd .026) of the task transitions made at this new site. Planned decisions account for 48 % (sd .0356) of choices and breaks in task influence 23 % (sd .0347) of the decisions made.

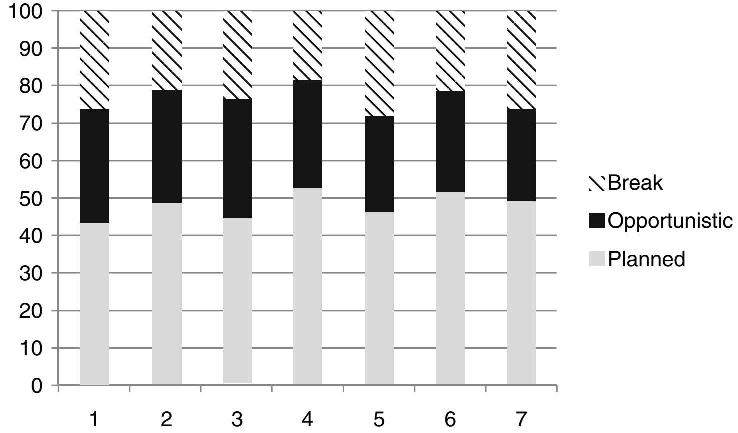

Fig. 7.6 Decision making at second site implementation 2

So while we see some variation, such as a decrease in opportunistic decisions from 90 to 28 %, this it is not significant change in performance. Contrary to our previous findings within a single site, the impact of workflow and physical layout (i.e., split-flow) had a greater effect in the first hospital site than in this different hospital site.

The potential reasons for this are many. Perhaps the change within a single department with set expectations is different than the set of expectations that play out in another hospital. Perhaps a mix of more acute (trauma cases) in conjunction with less severe (results pending) patients leads to different mental and physical work. What these results show us is that the work of emergency care and the decisions required to complete this care result from the interplay of the functions of work and the ways in which that work is expressed.

Summary

Our studies show that approximately half of the times ED physicians follow plans or protocols to make their decisions on task transitions and the rest of the times they make the decisions based on situational factors. This finding is observed at two separate hospitals with different physical layouts and different EHR systems.

This finding is based on the observations of operations and actions which are guided and coded by the Work Domain Ontology. A Work Domain Ontology, even in a partial state, proved vital in understanding the work and the complexity of the work in this domain from the influence introduced by the implementation of workflows within the system. Topics for future studies include detailed analyses of workflow dynamics and how information technology affect the dynamics in terms of care quality, patient safety, and efficiency of care delivery.

Health Information Technology Solutions

ED clinicians perform life-critical tasks that require acquisition, processing, transmission, distribution, integration, search, and archiving of significant amount of data in a distributed team environment in a timely manner. Monitoring the constantly changing information environment, responding to unpredictably occurring issues, collaborating and communicating with other people in the system as issues arise are all tasks required as part of patient care. Rather than focusing on a single task at a time, ED clinicians are forced to switch between multiple tasks and usually multiple patients. And many of these switching decisions are based on unplanned, unorganized, and unpredictable environmental factors. ED clinicians are constantly under information overload, multitasking, time pressure, and information requests.

Information visualization, if designed properly with human-centered principles, can make use of people's powerful visual system to efficiently process information that otherwise requires a lot more cognitive effort. The human visual system is powerful because it can process information in parallel, automatically, and unconsciously, and it can bypass the bottleneck of human working memory that is limited in capacity. Visualization is an important tool for healthcare due to the vast amount of data that have to be processed by the clinicians.

Information dashboards have become important business intelligence tools for many industries. However, the tracking board and other dashboard type of displays designed for the ED in EHR systems have significant challenge. The electronic ED whiteboard developed by Aronsky and colleagues [25] is an important step towards good visualization for the ED, which is an advanced version of the physical whiteboards with carefully selected advanced functionality. HIT solutions such as dashboards, information push systems and even smart phone technology are all potential means of supporting decision making through greater situation awareness. Managing the complexity of the ED environment through HIT supports aims to achieve better individual performance, better team communication, and better clinical outcome important to patient safety and care quality.

Discussion Questions

1. Given the impact of environmental factors on performance, prior to changes in workflow or physical layout in a hospital system what kind of potential impact studies might you recommend?
2. Emergency Room clinicians are faced with high information demands in an ever-changing environment. What are some training considerations with the implementation of health information technology (HIT) solutions?

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