COORDINATION PRACTICES FOR PATIENT SAFETY: KNOWLEDGE, CULTURAL, AND SUPPORTING ARTIFACT REQUIREMENTS

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Based on field studies in a trauma center, we synthesized a set of requirements on knowledge and cultures of an organization as well as on supporting artifacts for enhancing patient safety. Two different areas of trauma care were examined: fast paced initial resuscitation and management of operating rooms. The concepts of transactive responsibility systems and distributed cognition were used in deriving the requirements.

INTRODUCTION

Healthcare is a prime example of collaborative work. The care of a patient is coordinated among a number of workers over time and location, while at the same time these workers attend to the needs of other patients. A number of factors make coordination in healthcare extremely challenging. First of all much of work is ill-defined compared to other domains (Strauss et al, 1984), and thus reliable performance to ensure patient safety relies on adapting to specific circumstances and in bridging gaps among activities of different care providers (e.g. Cook et al, 2000). Secondly, despite of extensive planning and scheduling, demands and personnel resources change unexpectedly and rapidly. Thirdly, the stakes of both reliable and efficient operation are extremely high in healthcare. A recent published report by Institute of Medicine (Kohn, et al, 2000) projected 98,000 deaths every year in U.S. due to medical errors. Health care as a percent of the U.S.'s gross domestic product is projected to be 17% by 2010 (Heffner et al., 2002).

To understand how coordination occurs to achieve patient safety and operational efficiency, a number of studies have been carried out in a Level-I trauma center by our research group (Xiao et al, 2001; Xiao & Moss, 2001; Moss, Xiao, & Zubaidah, 2002). In this paper, we will synthesize the coordination practices of highly skilled teams in a high-velocity, high-stake environment: hospital care of trauma patients. We will focus on two areas of practices to examine knowledge, culture and supporting artifact requirements for safe, robust performance: building a complex, highly adaptive responsibility system and exploiting coordination artifacts to ensure a robust joint cognitive system of multiple team members and artifacts.

THE SETTING AND METHODS

Our study setting was a major urban Level-I trauma center. Patients who suffer trauma are brought to the center initially for evaluation, stabilization, and diagnosis. If needed, definitive treatment is carried out in other parts of the center, such as the operating room suite. We examined the initial resuscitation process and the management of the operating rooms.

Initial Resuscitation

Often the patient's injuries and conditions are unclear when the team first sees the patient. The patient's condition can change rapidly and unexpectedly. Occasionally there is great time pressure for the team to work rapidly. As part of a teaching hospital, the trauma center is staffed partially with physicians who are in training (residents and fellows) and who usually stay for one to several months in the trauma center. So the membership of a resuscitation team changes over time due to the turnover of training staff. The main challenges for teams included the uncertainty about incoming workload and the patient, highly fluctuating workload, time pressure, changing team membership, and potentially two competing goals of patient care and training. Interviews were conducted to address the questions of what strategies or practices were in use to ensure patient safety.

Management of Operating Rooms

The six operating room (OR) suite is part of the trauma center for emergency surgery for those patients who need immediate life-saving surgery within a short time of their admission to the trauma center. The majority of the OR surgeries are, however, non-emergency in nature. Non-emergency patients, either previously admitted to the trauma

center or referred through doctor's offices and clinics, are scheduled for surgery the day before. As with many other highly complex and dynamic work environments, uncertainty arises from various sources when changes are frequently introduced. In the study setting, change is constant and unpredictable. Examples of changes affecting the planned surgery schedule include cancelled surgeries, unexpected additional surgeries (which result from both newly admitted cases as well as deterioration of previous patient cases necessitating re-visits to the operating room), multi-patient trauma situations in which demand exceeds resource supply, and any external variables impacting OR operational status (unavailable or malfunctioning equipment, lack of supplies, and changes in staffing patterns). The challenges for the large number of people working in the OR suite include the uncertain and constant changing status associated with patients, availability of key personnel, reaching consensus among different stakeholders, keeping everyone informed, and above all, ensuring a safe environment for surgery. Data collection included observational studies on the use of a large dry erase magnetic white board (3.65x1.22 m or 12x4 feet) to address the question of how artifacts were used to support robust coordination.

TRANSACTIVE RESPONSIBILITY SYSTEM AND KNOWLEDGE AND CULTURAL REQUIREMENTS

Analysis of the interview data resulted in a set of practices describing how trauma teams maintain failure resistant performance. Detailed description of study findings can be found in Xiao & Moss (2001). To ensure reliability, teams are found to adhere to practices that reduce the likelihood of single errors causing performance failures. These practices include: learning and trusting each other's roles, sharing responsibility, cross monitoring and checking, ensuring team awareness. The teams in trauma resuscitation apparently are resilient to many failure-inducing factors, such as fatigue, noisy work environment, constantly shifting membership, high workload, multiple, concurrent threads of activities, and potentially conflicting goals between training on the job and performing.

Based on the findings, we postulated (Xiao et al, 2002) that in situations where work is highly distributed, time-pressured, and reliable performance a requisite, a transactive responsibility system is essential. We define a transactive responsibility system as the set of process and outcome responsibilities shared by members of a group coupled with knowledge of who is responsible for what. Individuals may not have the requisite expertise to intervene themselves but they know what needs to be done and who on the team is responsible or the most qualified to intervene.

In a multi-disciplinary team, expertise is distributed among different team members. However, distributing responsibility may make a team vulnerable to performance failures when unexpected situations arise. Analogous to how a "transactive memory" augments individual memory storage with pointers to the location of other knowledge (Wegner, 1991), we suggest that a team with a well-functioning transactive responsibility system may exploit the fact that everyone in the team shares the overall responsibility of reliable performance, and thus is adaptive to contingencies and vigilant to failures. In other words, the overall responsibility of reliable performance is fulfilled not by a single member of the team (e.g. the leader), but through transactive interaction among team members. The team could build into their interrelations transactive responsibilities such that one member would actively monitor or survey other members to ensure their tasks are fulfilled. Even though a task may be the responsibility of a particular team member who may possess special skills in accomplishing the task, other members of the team have enough knowledge of the skill to monitor the performance of that task and perceive a shared responsibility to see that the task is satisfactorily accomplished.

Several knowledge and cultural requirements can be derived from the postulated concept of transactive responsibility system. First a transactive responsibility system contains a transactive memory system for responsibilities: what role in the team is responsible for what. This transactive memory system for responsibility is important also because it allows members of a team to develop role expectations and then monitor the performance of others against that expectation. Second, as part of the transactive responsibility system, team members have the skill to monitor the performance of others, although they may not have the skills to "execute" a given task. In highly skilled domain, cross-training may not be possible. Thirdly, a transactive responsibility system accommodates cross monitoring or surveying among team members regardless of professional roles or ranks. Such cross monitoring demands a culture that encourages and supports communicating across hierarchical or professional boundaries.

DISTRIBUTED COGNITION AND SUPPORTING ARTIFACT REQUIREMENTS

In the field studies on management of operating rooms, our observation was focused on one artifact (Figure 1), although a number of other artifacts were found to be important for robust coordination against interruptions, memory failures, and communication obstacles. By exploiting the cognitive properties of the white board, such as storage and joint visual access, the teams improve the reliability of the joint cognitive system in terms of communication, memory, processing, and accessing. We proposed (Xiao et al, 2001) to model the role of artifacts under the framework of distributed cognition: an approach to collaborative work holding that a work unit is cognitive system in which cognitive activities are carried out jointly by workers with the use of tools. Through analyzing staff interactions with a large display board, we characterized the physical and perceptual properties of the board in terms of how these properties are exploited by the clinicians to support rapid paced, highly dynamic work.

Figure 1. An example of supporting artifacts: a large whiteboard used for management of operating rooms. The board is ferrous to afford the use of magnetic objects, such as strips on which notes can be written.

Public displays are common coordinative tools used in many settings. The users of the whiteboard in our study exploited the flexibility of the board to satisfy the need of distributed cognition: storing status and scheduling information, communicating tasks and updates, visualizing workload and staffing patterns, and referencing during face-to-face discussions. We were particularly intrigued by the clever use of magnetic strips and tags so that the representation of task activities and work schedules could be easily changed to match the frequent changes in the work environment.

In designing intelligent public displays, many of the previous attempts seem to focus on individual operations of objects on display. In the board we studied, the manipulation of the display objects was often accomplished jointly. In addition, the magnetic strips and tags “afford” direct manipulation by moving and placing both demand and supply elements. Our study also suggests that computerized public displays should consider the possibility of inventive use of coordinative artifacts. In complex organizations, changes over time such as the nature of workload and staffing, make it important to consider the possibility of adaptation, or “design enhancement,” by the users. It would be difficult to anticipate all possible uses of such boards. As another implication, the sheer physical sizes of public displays, like the one studied, change the nature of interaction. For example, we observed few access conflicts in front of the board, even when six or more people were observed accessing the board.

The supporting artifacts have direct implication to performance reliability of high-stakes organizations, such as patient safety in a hospital. In particular, visual access to supporting artifacts can improve reliability of human performance. By having external representation, humans can solve problems leveraging perceptual capabilities. Larkin (1989) noted several features of such "display-based" problem solving: (1) the process is easy, (2) it is largely error-free, (3) it is not degraded by interruption, (4) the steps are performed in a variety of orders, and (5) the process is easily modified. Zhang and Norman (1994) summarized how external representation helps problem solving: (1) external representations can provide memory aids and (2) external representations can provide directly perceivable information (such as constraints and options).

These and other studies on individual cognition with the support of the external environment point out the importance of examining in detail how artifacts are used, particularly in work settings. The board studied enhances the reliability of the joint human-board cognitive system (Larkin, 1989). The distributed cognition approach underscores the importance of supporting artifacts found in many collaborative environments. The intense task interdependency of many work settings calls for efficient and robust coordination mechanisms to counter uncertain, rapidly changing environments. Identifying and developing supporting artifacts should be an important part of establishing high

reliability organizations.

DISCUSSIONS

We synthesized two types of requirements for healthcare workers to ensure patient safety through the field studies conducted in the domain of trauma patient care. The first type of requirement is of knowledge and culture. In order to avoid single-point failure in a collaborative work context, cross-monitoring is essential. The ability (knowledge and skills) to perform cross-monitoring as well as the social environment (culture) to encourage cross-monitoring are two areas of requirements. The second type of requirement is of supporting artifacts. Collaborative work settings are full of supporting artifacts in various forms. Joint cognitive activities, such as monitoring, negotiation, information dissemination, scheduling, supporting co-worker's situation awareness, are often dependent on supporting artifacts.

The demand for safe operation in high risk industries has led researchers to study how to prevent accidents, why certain organizations have perceived good safety record, and what are the root causes of serious accidents (La Porte, 1996; Weick & Roberts, 1993). Understanding why certain organizations are resistant to failures is complementary to understanding why systems fail. Through field studies in a health care organization, we have uncovered some of the knowledge, cultural, and supporting artifact requirements. Further studies in this domain and others, in our opinion, will be necessary to inform the building of high reliable organizations.

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