

Chapter 16

Summary

The findings of this exploratory research effort include substantive evidence that trauma patient resuscitation and anesthesia are high stress domains. A dynamic evaluation of perceived stress obtained by analysis of videotapes for a single task (tracheal intubation) showed increased stress ratings when the task became urgent and, the ratings showed nearly parallel increases and decreases in temporal profiles with different task urgencies. Personal involvement increased the emphasis on workload compared to ratings by non-involved neutral raters'. Principal component analysis of 7 measured subjective ratings of stress showed a high commonality among items. The first two principal components account for more than 75% of the variance suggesting stress was rated on a single dimension, although methodological limitations may have confounded these data.

The domain of trauma patient resuscitation was found to have a higher than normal and under-reported rate of non-optimal performance. Video analysis revealed decision-making errors, a sentinel critical event, and team communication and coordination failures undetected by self-reporting systems. Results of our analysis for causes of non-optimal performance include failures to follow standard operating procedures, poor communication among team members, and system failures which hindered performance and promoted errors. An algorithm that includes both a task sequence and a communication protocol was recommended to overcome non-optimal performances. A simple change in the configuration and placement of equipment in the patient resuscitation area rectified the system failures and has prevented a repeat of the sentinel event during the last 4 years.

Analysis of videotaping of high stress tasks highlighted the dynamic and uncertain nature of such a complex work domain. Fixation errors occurred as a result of unreliable signals from patient monitoring devices and delays in feedback of information. In complex, uncertain domains multiple confirmatory signals are used. Fixation errors occur when redundant information substitutes for unreliable signals creating a false sense of system stability.

Team performance under stress was examined by evaluating team coordination and determining when coordination breakdowns occurred. A study was conducted to contrast the same high stress emergency medical procedure (tracheal intubation) under two circumstances differentiated by task urgency. The findings revealed that, tasks performed in high urgency situations were carried out with less information on patients whose

condition was more critical than occurred with tasks performed in low urgency situations. The task of tracheal intubation was more difficult in high task urgency situations, but was completed at a faster pace. Components of task complexity occurring in high urgency situations included multiple concurrent tasks, uncertainty, changing plans, compressed procedures, and high workload. Procedures carried out sequentially in low urgency situations may have to be performed concurrently when task urgency is high.

Team coordination breakdowns occurred in four types of situations: 1) when there was pressure to seek alternative solutions or there were conflicting plans, 2) when an unexpected non-routine procedure was initiated or there was inadequate support in crisis situations, 3) when there was diffusion of responsibility and a lack of task delegation, and 4) when there was inadequate verbalization of problems. Team coordination occurs in most situations with minimum explicit verbal communications. When team coordination broke down, there was often a lack of explicit communication. Several forms of non-communication task coordination activities were noted including: following protocols, following the leader, anticipation, and activity monitoring.

Four strategies may improve team coordination in complex environments including use of established work procedures; second, extensive on-job training with anticipatory helping of others on the team without explicit communication. Thirdly, caregivers should have continuous visual and auditory contact. Fourthly, workspace design can promote team coordination by reducing the impact of task complexity.

The products of this exploratory project include:

- A turn-key operated audio-video data acquisition system (VASNET) network to gather human factors and ergonomic data in a dynamic high stress real workplace.
- A video analysis tool (VINA) that integrates multiple data sources in a relational database with audio video material by means of a machine-readable time code. Coding of video was simplified and changed from a time-consuming 200 or more: 1 ratio (coding time: video run time) to 20:1 or less. In some instances where a specific structure for analysis was pre-determined, trained graduate students could perform on-line coding of events (1:1).
- A framework for coding and analysis of verbal communications.
- A model for predicting stress from stressors
- A method to measure dynamic stress was validated during this research.
- A library of video tapes was collected that include a spectrum of different levels of stress task urgency and outcome. Supporting documentation includes subjective stress ratings, audio commentary by participant and non-participant care providers, case discharge summaries, anesthetic and surgical records, laboratory data, and in about 35 cases, communication analyses. In addition, a 32-item questionnaire was completed by the care providers immediately after the videotaped management was completed.
- A data extraction framework, performance metrics, a task analysis and a task communication algorithm for tracheal intubation were developed.
- A process to re-engineer the workplace was developed using video data, link analyses, workspace appropriateness, and item importance.
- A systematic analysis of auditory alarms in the workplace was conducted.
- An analysis framework of team coordination and its breakdowns was described.

- A decision error analysis methodology which identifies system errors was developed.

The data collected are under ongoing and future analysis in various aspects of decisionmaking under stress and performance in real environments.

16.1 Implication for Future Research on Team Performance and Stress

Training The findings from the current studies suggest three strategies for training: (1) Increasing team coordination (2) Standardizing verbal communication protocols (3) Development of clinical pathways and protocols.

Although implicit coordination is used in the overwhelming majority of situations, under stress when plans and routine are disrupted by a truly unexpected event, team dyscoordination occurs because explicit coordination is then required.

Dynamic stress The current project showed that it is feasible to measure stress using both subjective as well as physiological measures in real work environments. The data collected demonstrates that subjective measures can reflect the dynamic changes during the course of performing a stressful task. For future applications of stress measurement, the following implications are suggested here.

First, there is a tendency for subjective measurement of stress to follow one dimension. Although this findings needs to be verified, two possible actions are recommended. Either one should separately measure one dimension at a time (instead of measuring multiple at the same time), or simplify the measurement scale and focus on one single dimension. Secondly, physiological measures during the performance of tasks have to be fine-grained in terms of temporal resolution. Changes in stress level, as demonstrated in the current project, are high enough so that minute-to-minute measures of subjects' physiological measures (such as heart rates or blood pressures) are necessary to reflect changes in stress.

Performance and stress The current project established general correlations between performance and stress, although, as previous studies have shown, the relationship between performance and stress is not clear. An inverted-U curve is still a prevailing working hypothesis between performance and stress (Yerkes & Dodson, 1908; Janis & Mann, 1977).

16.2 Future application of the results and products of this research

The library of videotapes and supporting interpretation is a valuable resource that can be used as a control population for a variety of human factors and medical research projects.

The videotapes will be used to investigate what information a remote medical decision-maker requires to supervise management of emergencies. The audio-videotapes will also be used to examine the added value of video over audio (a commentary will be provided without images), and the benefit to decision-making of continuous vital signs data compared to intermittent verbalizations.

Furthermore, the audio videotapes will be used as stimulus material to examine how effective remote decision-makers are at identifying appropriate and timely diagnoses and interventions. Lastly, the audio videotapes will be used to test how different types of medical subject matter experts (surgeons, anesthesiologists, and nurses) function as independent remote decision-makers. The audio videotape library may be used to test whether decision-making aids can improve performance of remote decision-makers. Training techniques may be developed as a result of the task analyses that develop established work procedures. Primary underlying team coordination breakdowns may be used to identify team training strategies. Standardized verbal communication protocols developed from communication analysis may improve individual and remote decision-making performance.

16.3 Conclusions

The report characterizes the nature of errors using the task model of tracheal intubation - a high stress task. Using a framework established by task analysis, the report shows how communication failures, omission of standard operating procedures, and systems failures contributed to errors.

Performance of the care providers was quantitated by temporal measurement, conformity to a expert developed process model, and inclusion of high priority tasks in urgent and stressful situations. Subjective stress scores show that dynamic ratings can be used to identify differences in task urgency, and perceived stress appears to be uni-dimensional in character.

Explicit communications occurred less frequently than anticipated, but were found to be omitted in several cases in which non-optimal care or errors occurred. Analysis of team coordination strategies identified non-verbal techniques used in dynamic stressful domains such as trauma patient resuscitation.

Several cognitive and decision-making models were hypothesized and described in this report. Recommendations that may be used in training programs were described, including task/communication protocols and techniques to avoid team coordination failures.