

# “Who’s Scribing?” Documenting Patient Encounter during Trauma Resuscitation

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## ABSTRACT

With healthcare moving towards electronic health records, it is important to understand existing work practices to design effective systems. We conducted an observational study in a Level I trauma center to examine the documentation process and the role of the nurse recorder in trauma resuscitation. We identified several difficulties with current recording practices, including the late arrival of the nurse recorder, parallel activities of the trauma team, and multitasking by the recorder. Our observations showed that the recorder’s role extends beyond archival responsibilities. The recorder, with the help of a paper record, manages the resuscitation process, rather than passively documenting it. Our findings highlighted the complexity of the recorder’s role and the need to consider documentation in the broader context of trauma teamwork. We proposed a set of design challenges that emphasize important aspects of trauma care to be considered when designing technologies to support the documentation process.

## Author Keywords

Medical records, trauma resuscitation, documentation methods, collocated teams.

## ACM Classification Keywords

H.0 [Information Systems]: General; K.4.3 [Organizational Impacts]: Computer-supported collaborative work.

## General Terms

Design, Human Factors

## INTRODUCTION

Developing more accurate medical records and effective documentation methods are essential aspects of improving healthcare. The information captured in medical records is important for clinical decision-making, for the coordination of care among providers, and as a source of research data.

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These functions, however, are limited by current systems that use handwritten records or rely on manual entry into electronic records. Trauma resuscitation—the critical, fast-paced, initial evaluation and treatment of trauma patients in the emergency room—is a setting where these limitations are even more evident. The events in trauma resuscitations are currently documented in the medical record using contemporaneous recording by a dedicated nurse recorder and retrospective summaries by physicians. The accuracy of these documents is limited by the need to observe simultaneous tasks by individuals in a confined space, a reliance on manual data entry for recording and time-stamping events, and a reliance on physicians’ retrospective recall. The written records that are produced often contain both inaccurate data (e.g., incorrect values for vital signs) and missing data (e.g., dosage and timing of medication administration) [9]. The manual paper-based documentation and delayed physician summaries make the system inefficient and limit accessibility to patient data.

Attempts to computerize the documentation process in trauma resuscitation began two decades ago [12] and have not yet yielded a feasible solution. As the move towards computerization in medical setting continues, it is important to understand challenges to transforming current documentation practices into digital ones.

This paper reports on an observational study of the documentation process and the roles of the nurse recorder during trauma resuscitation. The research describes the limitations of the current, paper-based recording system and the various roles a nurse recorder can have while documenting patient encounter in an emergency situation. The goal of this research is to determine the social, organizational and informational factors that affect the documentation process in the trauma bay and whether this process can be enhanced by computer-based data entry. Our findings revealed several problematic aspects of the current recording process and highlighted important roles of the nurse recorder that go beyond simple documenting of trauma resuscitation. The nurse recorder is a highly skilled professional within the trauma team, meaning that it is unlikely that this role can be replaced with a computer-based system. Based on these findings, we identify a set of challenges that computerized data entry must address to

support the work of the nurse recorder and to ensure that the patient encounter is recorded efficiently and accurately.

In the next section, we provide a brief overview of trauma resuscitation and summarize prior studies relevant to our work. We then describe our study, research site, and methods. Next, we present our findings, first detailing the limitations of the current recording system and then describing the roles of the nurse recorder. We conclude with requirements for technology design.

## BACKGROUND AND RELATED WORK

### Trauma Resuscitation and Data Recording

Trauma resuscitation is complex and critically important for the outcome of injured patients. During resuscitation, potentially life-threatening injuries are identified and treated, and plans for hospitalization are developed. The purpose of the medical record in this setting is to archive critical data and events, mainly to facilitate subsequent medical care, evaluate team performance and perform research. Accurate documentation is required to capture a range of patient conditions and medical team activities, including vital signs, physical examination, test results, and treatments given. Because of fluctuating patient status and the large number of evaluation and treatment steps required during trauma resuscitation, a nurse is usually dedicated for documentation to ensure that the entire event is recorded. Data about patient status and the work of the trauma team become available in a short time period (<30 minutes) and in a continuous data flow from sources both inside and outside the hospital. In most trauma centers, this information is conveyed verbally and is recorded using a paper-based trauma flowsheet.

There are important differences between the trauma bay and other clinical settings with respect to the creation of medical records. First, the brief encounter with a trauma patient prevents creating elaborate notes. The multiple-page trauma flowsheet used at most trauma centers has designated areas for information such as demographics, mechanism of injury, physician response times, vital signs, location of injuries, diagnostic and therapeutic procedures, medications given, and final disposition. Second, the nurse recorder rarely interacts with the patient during resuscitation. Thus, there are no free-form observational notes on the trauma flowsheet. The primary role of the nurse recorder resembles that of a court stenographer, producing a record for assessment of on-going care and post-event review. Because other clinical settings rely on documentation created during trauma resuscitation, the work of the nurse recorder must be efficient and error-free.

### Related Work

Current practices of recording clinical data in the emergency department are time-consuming and yield data of variable accuracy. While documentation in other clinical settings can simultaneously follow the patient encounter,

emergency physicians and nurses often multitask and are frequently interrupted in their workflow [7].

Interruptions and multitasking in hospital environments have been extensively documented within HCI and CSCW literature [e.g., 4, 6, 16, 19, 23]. These studies have shown that multitasking, interruptions, ad hoc conversations, and workarounds are essential components of medical work and affect the ways in which medical information is produced and used. The present study extends this line of research by looking at how interruptions and multitasking shape the documentation process in a critical care medical setting.

Despite their potential, electronic health records (EHRs) do not always result in improved accuracy or efficiency [3, 15]. EHRs are unlikely to decrease documentation time because they still require manual data entry [17]. Computerized order-entry systems may reduce some types of errors but increase the risks of others [18]. Zhou et al. [24] found that computerization of the nursing data in inpatient care affected nurse workflow because the system did not support entering informal patient information into the medical record. Studies within CSCW have found that computer systems often mischaracterize the use of paper-based medical records [14] and ignore the “invisible work” embedded in the activities of nurses and other medical staff [21]. In our study, we examine the workflow of trauma teams to avoid such negative effects of computerization.

Of particular interest to our work are studies that examined how paper-based systems are currently embedded in the practice of healthcare. Fitzpatrick [11] challenged common conceptualizations of the health record as a passive information repository and suggested that there is no such entity as “*the* health record” [emphasis in the original]. Healthcare professionals instead construct, integrate, interpret and communicate information through an evolving set of inter-related forms, papers, and documents that are embedded in the social, spatial and organizational milieu of the hospital. Similarly, Berg and Bowker [5] described the medical record as an integral part of the medical work, rather than just “an innocuous storage device.”

Motivated by this prior research, we examined whether the documentation practices observed in other healthcare environments also occur in trauma resuscitation. Because trauma resuscitation is a highly dynamic and very short event, some of those practices may occur only partially or in modified forms. Our earlier study [20] found that the trauma flowsheet is seldom used to look up information needed for decision-making. While extreme time-pressure may prevent use of the flowsheet record in direct patient care, the flowsheet may support the work of trauma teams in more subtle ways. The above studies have argued that technology design in socio-technical settings must account for social, informational, and organizational aspects of the medical work. We therefore focused this study on the work of the nurse recorder and the use of the trauma flowsheet to better inform technology design in trauma resuscitation.

**CURRENT STUDY**

We conducted an observational study in the trauma bay, a designated room for trauma resuscitation, to understand the process of documenting patient encounter and to characterize the role of the recorder. Trauma resuscitation is a valuable domain for studying the documentation process for several reasons, including the frequent occurrence of incomplete and inaccurate data, the structured format of patient evaluation, and performance in a single site in the emergency department, where task demands change rapidly and vary in nature, predictability, and difficulty.

**Research Setting**

Our research site was a Level 1 (highest-level) regional trauma center located in an urban, teaching hospital. Level 1 trauma centers are preferred sites for the initial triage of seriously injured patients and are major referral centers for injured patients initially treated at other hospitals. On average, this center receives 1200 trauma patients per year. It uses the same staffing and procedures as other high-level trauma centers in the US. Size and composition of trauma teams varied based on the extent of the patient's injury and anticipated need. Most often, teams consisted of the attending surgeon, surgical residents, an anesthesiologist, an orthopedic surgeon, nurses, a respiratory therapist, a pharmacist, clinical care technicians and an x-ray technician. All major trauma centers use a standard protocol [2] that has been developed to guide the initial evaluation and management of critically injured patients.

**Method**

Data were collected through observations, videotaping of trauma resuscitation events, and focus groups. In the past two years, we have observed the treatment of 60 different patients, of which 18 were videotaped, transcribed, and analyzed. Privacy issues with human subjects have been carefully addressed through the Institutional Review Board (IRB). To maintain confidentiality, video recordings were transcribed and reviewed within 96 hours and then erased. Video recordings and transcripts were reviewed and discussed with a trauma surgeon and nurse on our research team to assure data quality and accuracy. Due to privacy issues, we had access to trauma flowsheets from simulated resuscitations, but not to actual patient records.

Observational activities included note-taking and informal discussions with trauma team members during idle hours. A focus group was conducted with three nurses who participate regularly in trauma resuscitations and routinely assume the role of the nurse recorder. The focus group discussion concentrated on the problems that nurses experience while documenting patient encounter.

Field notes, transcripts of videotaped events, and focus group discussions were analyzed using constant comparison method [22], whereby each new observation is compared to previously coded observations for fit. We paid particular attention to the nurse recorder's tasks and the use of the

flowsheet, as well as to the interactions and information exchange between the recorder and trauma team members.

We next present our results, first identifying limitations of the current documentation process and then examining the role of the recorder in supporting the work of trauma teams.

**LIMITATIONS OF THE CURRENT RECORDING SYSTEM**

We identified five common challenges to the manual documentation process during trauma resuscitation: the late arrival of the nurse recorder, parallel activities (and reporting) of trauma team members, incomplete or missing reports about examination findings, multitasking by the recorder, and the recorder's outlying position relative to the main resuscitation area. Here we describe these in detail.

**Late Arrival of the Nurse Recorder**

Trauma nurses are drawn from a larger pool of emergency department nurses. Upon receiving alert about an incoming trauma patient, a charge nurse assigns the primary nurse and the nurse recorder for that particular trauma resuscitation. Because of their close proximity to the trauma bay, nurse assignment usually occurs without problems and can quickly adjust to the needs of the trauma team. The nurse recorder, however, arrived late in 30 percent of the events that we observed. We learned that the nurse recorder may be late when held up by other duties or when the patient arrives unexpectedly and no recorder is assigned in time. Although this problem is organizational in nature and is primarily caused by understaffing, it negatively affects the documentation of trauma resuscitation.

In the following example, the nurse recorder arrived late to the trauma bay and missed the initial, verbal report that was given by the emergency medical services (EMS) crew who transported the patient. The recorder's delay made it difficult to record the pre-arrival information as well as initial patient-evaluation findings.

*As the EMS crew brings in the patient, the orthopedic resident asks if anyone is scribing. "No" is heard from the back of the room. One of the paramedics starts reporting pre-arrival patient information. The orthopedist repeats his question about the recorder but receives no answer. The attending physician quickly scribbles a few things on the trauma flowsheet and rushes to the patient side. The patient is transferred to trauma bay stretcher and the team leader starts patient evaluation. The paramedic continues his report about patient injuries and treatments en route, while the team leader starts reporting initial evaluation findings. The orthopedic resident asks for the third time, "Are we scribing anything?" and several team members answer at once, "No one is scribing!" One minute later, the nurse recorder arrives and starts writing down information. The paramedic approaches the nurse recorder and repeats the pre-arrival information. The nurse recorder toggles between the flowsheet pages trying to capture information given simultaneously by the paramedic and the trauma team as they evaluate the patient and report their findings.*

This example points to several problems caused by the late arrival of the nurse recorder. First, notice that critical information about the patient is usually reported in the first five minutes of the patient encounter. This information includes EMS report from the field, initial vital signs, and initial patient-evaluation findings. It provides baseline information for both trauma teams and clinicians involved in subsequent patient care. Accurate documentation of this information is therefore crucial. Second, absence of the recorder created visible concern among team members. The orthopedic resident inquired several times about the nurse recorder, distracting him from his tasks. Finally, upon arrival, the nurse recorder faced difficulties in catching up with the ongoing evaluation and capturing information she missed. Some information was “pushed,” e.g., from an EMS crewmember who approached her table and repeated his report. Information about initial evaluation, on the other hand, needed to be “pulled” and the recorder had to inquire about evaluation findings directly from team members who were involved in patient care. The recorder’s catching up interfered with the ongoing care, requiring the team leader to repeat his past findings while acquiring new ones.

It is worth noting that the paper-based trauma flowsheet supported the nurse recorder while she struggled to recover information that had been reported previously. The multiple-page flowsheet was spread over the recorder’s table, which made it easy to navigate and look for appropriate fields to fill-in missing information. Also, the structure of the flowsheet follows the steps of evaluation protocol, which supported rapid data entry.

### Parallel Activities and Reporting

The second limitation of the current documentation system is parallel activities in the trauma teamwork. The work done by trauma teams involves significant parallelism. This observation is not surprising because of urgency to detect and treat life-threatening injuries. For example, while the team leader is examining the patient’s airway, chest and lung sounds, the junior resident and orthopedist may start observing pulses and evaluating for fractures. Because of these simultaneous activities, findings by different team members often get reported at the same time. The following statement given by a nurse during our focus group discussion illustrates this problem:

*“... [Sometimes] it’s just too much input. There needs to be an organized sequence in which the information is given, because there is one person who’s the scribe for the trauma, and there are five or six team members ... who potentially are giving information, whether it’s patient assessment information, the technician reporting the vital signs, the nurse saying where they just established an IV. So, there is one person who’s trying to write everything and there is five people giving that person information at the same time, and if it’s not given in an orderly fashion sort of... it’s like you are all over the page...”*

To work around this problem, the nurse recorder often asked for information to be repeated. Sometimes, the recorder left the recording table to collect data themselves, moving more closely to the patient, or even leaving the room to consult with a team member.

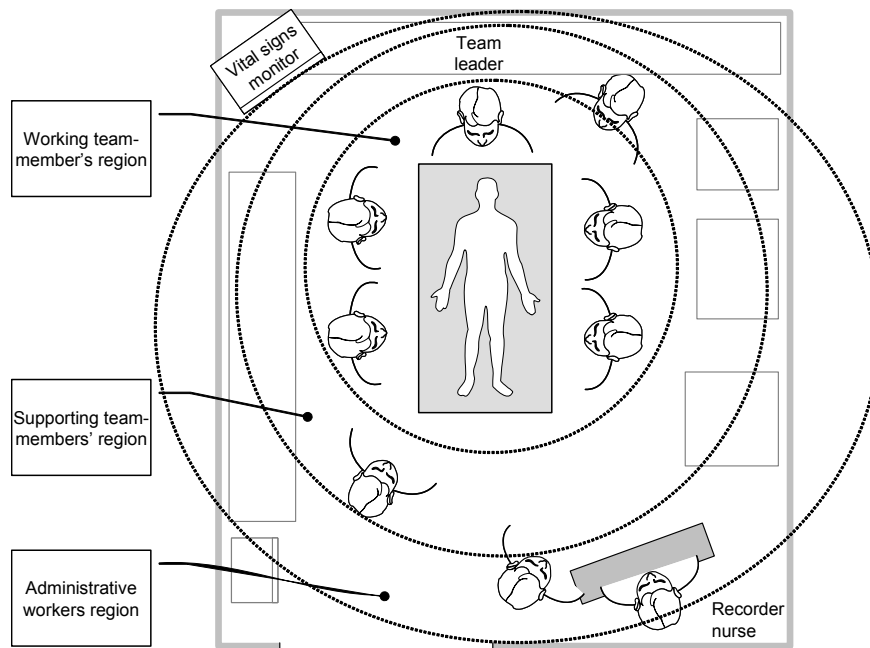
The difficulty of capturing parallel reports was exacerbated when EMS crewmembers approached the nurse recorder after handing over the patient and briefing the entire team. In these cases, EMS provided additional data to the recorder. This reporting overlapped with the reports given by team members who had already started evaluating the patient. While there are benefits of additional reporting by EMS crewmembers, their extended report interferes with the recording task because the recorder has difficulties capturing information from multiple sources at once.

### Incomplete and Missing Reports

Trauma team members are required to report aloud the status of their activities, such as completion of a specific task or an evaluation finding. Reporting also helps the team maintain situation awareness about current activities in the trauma bay. Team members who are actively involved in patient care sometimes fail to report evaluation findings. As we learned from a discussion with trauma surgeons, physicians on the team may decide not to report findings that contribute no new information or are obvious to those standing nearby. Report failures pose a problem for the nurse recorder who is not part of the working team. As an outlying observer (Figure 1), the recorder mostly relies on verbal reports to document the resuscitation event. When these reports are partial or missing, the recorder performs workarounds similar to those in dealing with parallel reporting. The recorder asks for clarifications, requests a repeat of information, or directly inquires about the event. For example, in one case, a clinical care technician reported the size of an intravenous (IV) catheter to the nurse recorder but did not specify location. The recorder clarified by asking, “*Is the IV in the right or the left?*” Sometimes, instead of clarifying verbally, the recorder approached to check the size and location of the IV access themselves. Despite the relatively short distance, coming to the patient was often challenging because team members were crowded around the stretcher and the recorder struggled to approach the patient for obtaining needed information.

The following example shows a case in which the nurse recorder dealt with a missing report:

*EMS crew attempted patient intubation on their way to the trauma center and administered a dose of a paralytic drug commonly used before intubation. Upon the patient’s arrival, the team leader asks the anesthesiologist to reattempt intubation. The anesthesiologist administers a new dose of the same medication without informing the team about her activities. The nurse recorder notices pharmacist near the anesthesiologist and inquires: “You guys medicate anything other right now?” The pharmacist turns to the recorder, nods and reports the name and*



**Figure 1. Physical distribution of trauma team members in the trauma bay.**

dosage of the medication. The recorder acknowledges this information and writes it down.

It is important to note that the recorder detected an event that needed documentation by observing team members' activities. The recorder recognized that administration of a medication was in progress by seeing the pharmacist talking to the anesthesiologist, as well as by using her domain knowledge and knowledge of the roles and tasks performed by trauma team members.

### Multitasking of the Nurse Recorder

Although primarily dedicated to documenting trauma resuscitation, the nurse recorder may sometimes assist with patient care. The recorder may help the primary nurse with establishing intravenous access or drawing blood, or may temporarily leave the trauma bay to deliver blood samples for lab work. While the primary nurse appreciated the recorder's multitasking, it introduced interruptions in the recording process and caused information loss. Consider the following excerpt from our field notes:

*The trauma team is about to start with the patient log roll, to assess for back injuries. The nurse recorder is at her table, busy with labeling blood samples that she has just received from the primary nurse. The team leader and junior resident start examining the patient's back and, at the same time, report the findings. The recorder is switching between labeling blood samples and writing down the reported information. The log roll is completed and the team prepares for taking x-rays. The recorder finishes the paperwork and announces to the team that she is taking the blood samples to the lab. After taking x-rays, the team leader and attending physician start with the ultrasound examination to check for abdominal bleeding. A*

*minute later, they report findings, but no one records this information. The team continues assessing for other external injuries. Two minutes later, the primary nurse approaches the recorder's table, starts writing down the reported information and acting as the recorder.*

Interruptions similar to this example were common and were mostly caused by the recorder's multitasking. When the recorder temporarily left the trauma bay, another team member had to step in and continue with the recording. This role switching resulted in additional workload for team members who had taken on the new role. On the other hand, the paper-based trauma flowsheet facilitated exchanging roles. Because the form is open for access and does not require special training to use, it allowed the primary nurse to effortlessly assume the recording role.

### Outlying Position of the Nurse Recorder

The physical layout of the trauma bay and distribution of the team members also affect the documentation process. Based on physical distribution of trauma team members and their roles, we can divide the space of the trauma bay into three concentric regions (Figure 1), such as working, supporting, and administrative regions. Team members in the region surrounding the patient belong to the working part of the team because of their direct involvement in patient care. Outside of this region are team members standing ready to help with fetching equipment or with specialized patient care. They have supporting roles and include attending physicians, additional nurses, EMS crewmembers, and medical students. The third region accommodates administrative part of the team and includes the nurse recorder, unit clerk, security and others. Depending on the team dynamics and the needs of the patient, team members often move across the regions. For

example, the recording table is positioned in the third region, but the recorder occasionally crosses into the second or even first region, when switching from an observer role into a worker role, as seen in the multitasking example.

The nurse recorder is positioned in the lower right corner of the room, diagonally from the vital signs monitor and the team leader (Figure 1). This position keeps the recorder out of the way while still providing an overview of the activities in the trauma bay. We observed, however, that the recorder's outlying position often prevented the recorder from hearing reports about examination findings or observing activities in the trauma bay. To resolve this problem, the recorders sometimes moved their table closer to the patient area, or repeatedly inquired until obtaining needed information. The following example from our field notes illustrates the recorder's use of a workaround to overcome this limitation:

*Two EMS paramedics bring in a trauma patient. Core members of the trauma team are already in the room and include the team leader, junior resident, primary nurse, two technicians, the nurse recorder and an orthopedic resident. As paramedics bring in the patient, the team leader inquires, "What's the story?" One of the paramedics starts report, but talks quietly. The recorder moves his table closer to the patient area to hear the report better.*

Workarounds can have a cascading effect, triggering a series of further workarounds before the system is back to a stable state [16]. We often observed this phenomenon when recorders moved their table closer to the patient area. For example, the space of the trauma bay is crowded (there may be more than 15 people present at a time), densely used, and filled to capacity with equipment and various instruments. Trauma team members have developed certain ways of moving around the trauma bay to respond to this physical organization. Moving the recorder's table closer to the patient made some team members use alternate routes to reach equipment because the recorder was now in their way. Other team members also move across the regions, but those who bring large equipment, including the recording table, cause greater inconvenience.

### THE SECONDARY ROLES OF THE NURSE RECORDER

While the primary, recording function of the nurse recorder could benefit from technological aids to improve the documentation process, we also found that the recorder had additional roles that went beyond archival duties.

First, we found that the nurse recorder played a key role in reminding team members about skipped tasks. For example, a technician is charged with periodically reading out and reporting the patient's vital signs. If the vitals were not reported for an extended period, the recorder prompted the team to check on them. The recorder also reminded the team about skipped evaluation steps. In the example below, the team leader assessed the patient's airway (step A), breathing (step B) and circulation (step C) and moved on to

examination of the patient's back injuries (log roll, step E). By seeing the missing fields in the flowsheet, the recorder realized that the team leader skipped the neurological exam (step D) and asked for any findings about pupils.

*The team leader and chief resident discuss findings from the patient's log roll and medications given so far. The chief resident orders a dose of morphine and the pharmacist starts preparing it. At this point, the nurse recorder glances at the trauma flowsheet and turns to the team leader: "How about the pupils or anything? Belly? Belly soft?" The team leader first confirms that the patient's abdomen is soft and then reaches for the penlight to assess the patient's pupils.*

Second, the recorder "regulated" the environment. For example, the recorder asked people to leave the room if it was too crowded, as there were often onlookers without a specific role. Or, when the room was noisy and people were not able to hear each other, the recorder requested silence. The following excerpt from the field notes illustrates this secondary role of the nurse recorder:

*The attending physician arrives at about 11 minutes into the patient's admission to the trauma bay. The patient has sustained four stab wounds and the team leader is considering inserting a chest tube. The attending physician starts discussing the patient's condition with the team leader. There are 13 people currently in the room, five of whom are involved in direct patient care. Those that are not involved in the patient care are dispersed around the room, observing what is going on. The recorder has problems hearing the technician who is reporting vital signs. She asks for vital signs to be repeated. Soon after, the recorder reports the results from a blood test, but the team leader cannot hear her. The recorder then speaks loudly: "If you guys don't need to be in here, please step outside!" After hearing the recorder, six people start leaving the room. The recorder acknowledges this by saying: "Thank you!"*

Third, the recorder acted as a point of contact between the trauma team and remote specialists and hospital units. We often observed the recorder paging other providers who were needed in the trauma bay, or arranging for follow-up testing, such as CT scans. In one case, the team treated a patient who sustained internal bleeding from a severe pelvic fracture. The orthopedic resident was needed to perform pelvic examination but was late. After the attending requested that someone find the orthopedist, the recorder picked up the phone and paged the orthopedic resident.

The recorder also acted as an interface between the trauma team and the unit clerk, channeling patient information needed for administrative paperwork. This usually happened at the beginning of resuscitation, while the EMS crewmembers presented their report from the field. A unit clerk approached the recorder's table and asked for patient personal information, such as name or address. The recorder provided this information if it was obtained earlier from EMS report.



Figure 2. Recorder's corner.

Finally, we observed that the “recorder’s corner” (Figure 2) played an important function in supporting the conduct of trauma resuscitation by serving as an information hub. The recorder’s corner is equipped with basic office supplies and a telephone for calling other hospital units. The printer is available for making stickers for labeling patient records and blood specimens. The recorder’s table is portable and has documentation forms prepared on it at all times (e.g., trauma flowsheet, blood-work sheet, intubation checklist). Trays on the wall contain additional flowsheets and other supporting documents. Throughout the resuscitation events we observed, trauma team members came to the recorder’s table to sign in upon their arrival, take patient stickers, complete forms, ask questions, or clarify patient information. After completing initial report for the trauma team, paramedics often approached the recorder’s table and provided additional details to the recorder. Towards the end of the resuscitations, the physicians came to the recorder’s table to copy patient information from the flowsheet to their notes or ask the recorder directly about patient information.

### Discussion of the Trauma Flowsheet

The secondary roles of the nurse recorder revealed important features of the paper-based trauma flowsheet and its limited but important support for the complexity of the trauma teamwork. Our findings show that the role of the nurse recorder goes beyond archival duties and the role of the record is more than just an archive. These observations resonate with findings from other studies [5, 11], but with a key difference. The record is a *living* document that is being used by the recorder to help *manage* the resuscitation. It not only supports the work of trauma teams, but also enhances their performance in subtle ways. The meaning and use of the multiple-page trauma flowsheet has evolved to aid the tasks and goals of the resuscitation team. There is a symbiosis between the document and the activities taking

place in the room. For example, the document is spread over the recorder’s table and allows for simple navigation and quick data recording. This is an important feature because it supports the nurse recorder when catching up with previously reported information or simultaneous reports. Next, the format of the flowsheet follows the order of evaluation procedures. This feature enables rapid data entry, especially when trauma teams adhere to the evaluation protocol. As various team members report findings about the patient’s airway, breathing or circulation, the recorder captures this information by simply filling in appropriate fields. However, as our observations have shown, trauma teams often deviate from evaluation protocol due to the urgency to attend to life-threatening injuries. Even then, the flowsheet plays an important role because it allows for quick detection of missing information. Missing items often imply tasks or evaluation steps that were skipped. This feature of the flowsheet prompts the recorder to request information, which in turn steers the team to comply with the resuscitation protocol. The document also shows members of the trauma team currently present in the room, which may prompt the recorder to summon those who are missing. Even regulating the environment can be related to the flowsheet. Someone who is trying to document the patient encounter may be most aware of the number of people in the room and be able to act when the number is excessive. Furthermore, the flowsheet provides information necessary for administrative purposes and the recorder uses it to channel patient information to the unit clerk. At the end of the resuscitation, the physicians are using the document to build their archival records. It is important to retain the above features of the flowsheet when designing new approaches to support the documentation process in trauma resuscitation domain.



## DISCUSSION OF SYSTEM REQUIREMENTS

In summary, we have found that recording clinical data during trauma resuscitation is demanding and poses several difficulties for the nurse recorder: 1) late arrival of the recorder, resulting in information loss and interference with ongoing care; 2) simultaneous tasks and parallel reports, which make it difficult to hear and record information; 3) partial or missing reports, which necessitate workarounds; 4) multitasking by the recorder, resulting in role-switching and higher workload for a team member who temporarily substitutes the recorder; and 5) outlying position of the nurse recorder. These difficulties were exacerbated by the recorder's need to engage in secondary tasks, such as reminding the team of steps that were missed, regulating the environment, and operating an information desk.

Based on these findings, we have identified several challenges that computerized support must meet to support efficient and accurate documentation of the patient encounter during trauma resuscitation. It is premature to propose specific design solutions and new technologies at this point in our research. Therefore, we frame our discussion by drawing from the literature on ubiquitous computing and existing technologies. We refer to these technologies to help describe the requirements for effective support of the documentation process and to better illustrate the challenges that new technologies must meet.

### Supporting Recorder's Primary Role

*Documentation methods must be adaptable to the recorder's occasional absence.* An important challenge for technology design is to start the documentation process immediately upon the patient arrival. Our findings showed that the late arrival of the nurse recorder jeopardized documentation and impaired the resuscitation process. By arriving late, the recorder not only misses critical information, but also interferes with the ongoing care by trying to catch up and requesting information that had been reported previously. The effort for recording the data in these situations is high, and there is a challenge of capturing missed information. We found that the heaviest reporting occurred in the first five minutes of the patient encounter (i.e., during patient handover and primary survey). After this period, activities usually declined as the trauma team went through the secondary survey. Current technological solutions for automated capture and access work well in some scenarios [1] but may not be ready yet for the noisy and dynamic environment of the trauma bay. Nonetheless, some ubiquitous computing technologies could assist in information capture in the absence of the nurse recorder. For example, using the concept of selective archiving, Hayes et al. [13] developed a tool to support information capture in a disruptive environment of a classroom setting for the purposes of functional behavioral assessment. Through a set of capture services embedded in an environment, selective archiving enables capturing activities and experiences that are otherwise hard to capture manually. Similarly, initial reports and evaluation findings

during critical moments of the patient encounter could be preserved by automatic videotaping until the nurse recorder arrives. This would enable the recorder to retrieve and document segments of missed information at a later time.

*Documentation methods must support capturing of multiple and simultaneous data streams.* Another challenge is the need to document parallel reporting. As described earlier, trauma team members are required to report evaluation findings and the status of their activities. Timely reporting is important for teamwork as well as for documentation. Data about patient status and the work of the trauma team become available through several modalities, such as auditory (speech), visual (observations of patient status and team tasks) and electronic sources (vital sign monitors and data from hospital-based information systems). Reports about patient status and team tasks often happen simultaneously as several team members may be evaluating the patient at the same time. A team member, usually the critical care technician is assigned to read out the vital signs monitor periodically and call out the readings for others in the team. Because most emergency departments do not have electronic monitors integrated with the medical record, the recorder mostly relies on technicians' verbal reports.

The nurse recorder plays an important role in disambiguating and serializing these, often simultaneous, information streams. Our observations, however, showed that the recorder had difficulties keeping up. Difficulties were also observed in keeping pace with several data streams when the recorder was multitasking. While humans have difficulty with filtering out multiple voices and listening to parallel conversations, computers are even less successful at this task. Partially automated capturing of some data streams might improve this substantially. Data that originates from electronic devices, such as the vital signs monitor, is already in digital form and can be easily captured. Automatic localization and tracking of artifacts using radio-frequency-identification (RFID) tags and other technologies for localization and tracking could automatically capture information about medications and instruments used during resuscitations, thus reducing the recorder's task load. A previous study [8] used computerized barcode data entry during simulated trauma resuscitations and found that this reduced the number of errors compared to handwritten data entry. Partial automation of clerical data entry has a potential to give the nurse recorder more time for complex activities that cannot be easily automated, such as multitasking and disambiguating simultaneous reports. However, partial computerization of the trauma flowsheet introduces the challenge of merging two parts of the flowsheet record—one created automatically and the other created manually.

*Documentation methods must be sensitive to implicit clues associated with reporting.* As seen in examples of the recorder's dealing with missing or partial reports, documenting patient encounter during trauma resuscitation requires attention to team members' interactions and



activities taking place in the trauma bay. While the recorders mostly rely on explicit verbal reports, they also use knowledge of domain and roles of team members to interpret their actions and anticipate the tasks they are performing. Understanding people's activities and gestures, and what these could imply, is therefore an important aspect of improving the documentation process. Thus, the challenge is to rely not only on explicit recording, but also to continuously monitor team members' actions and apply domain knowledge to interpret those actions. With up to 20 people in the room, people may occlude each other and no single viewpoint will suffice. Our discussion of the recorder's outlying position highlighted this problem. A solution is therefore needed that will improve observability of the trauma bay.

*Documentation methods must allow quick and open access, and be flexible in supporting interruptions and multitasking.* Open access to the trauma flowsheet proved to be an important feature when the recorder left the trauma room and another team member had to take over the recording. The flowsheet also supported quick data entry when the recorder struggled to recover missing information or while multitasking, e.g., labeling blood specimens or assisting with patient care. A computerized system may require user authentication or special training for use, which would hinder its use by other team members. This may have negative impact on the recording process, even while helping with some aspects of documentation.

A recent study [10] provided the nurse recorder with computerized data entry with the goal of improving clinical decision-making, rather than improving documentation methods. The authors do not report what effects this computerization had on the documentation process, but they mention that the system helped reduce error rate by 10 percent. Improving clinical decision-making is more challenging than improving the documentation process. Improvement of the documentation process can help decision-making, but has other applications as well, such as improving information transfer to subsequent hospital units, enabling post-event review of team performance, use in medical research, and possibly improving the resuscitation process as a result of improving its documentation. Our findings highlight the complexity of the recorder's task and the need to consider documentation in the broader context of trauma teamwork. The relative merits of paper-based versus electronic trauma flowsheet should be considered in the context of recorder's multiple roles, as well as the goals of trauma resuscitation. It is important to retain affordances of paper-based trauma flowsheet when designing approaches that support the documentation process.

### **Supporting Recorder's Secondary Roles**

The secondary roles of the nurse recorder are important to trauma teamwork and need to be considered in a solution that improves the documentation process. Our observations showed that there are benefits of having a member of the team who performs these secondary roles. We believe that

technology should assist nurse recorders, rather than entirely replace them. Because of the complexity of recorder's tasks, current technology will not be able to handle them reliably, suggesting that there is a need for continued human interaction. The nurse recorder may be freed from some manual data entry but should still be available to manage special situations, disambiguate difficult cases, and help prevent the team from making errors. The recorder is best suited for these functions because other team members are busy with patient care.

Finally, a broader system might be designed to support the whole trauma team rather than the recorder alone. This system might offer direct services to other team members, which are currently offered by the recorder's secondary roles, such as information seeking, finding patient stickers, making phone calls to other hospital units, or interfacing between administrative and medical staff.

### **Study Limitations**

Our study has several limitations. First, the ethical issues involved in medical care restrict the kinds of studies that can be done. We did not have access to actual patient records (including the trauma flowsheet) and mostly relied on observations and input from trauma team members.

Second, both informal and focus group discussions with trauma team members centered on current practices and problems during the resuscitation process. We did not solicit their suggestions on technology needs and potential design at this time. This is part of our future work.

Third, we used one site only. It could be questioned whether what we have reported generalizes to other trauma centers. However, because most US trauma centers use the same staffing and procedures and follow the same resuscitation protocol, we believe that our results are at least generalizable to sites within the US. Additionally, it may be difficult to generalize from trauma resuscitation to generic medical care, and from medical care to other disciplines. Even so, trauma resuscitation alone is an important domain.

### **CONCLUSION AND FUTURE WORK**

We conducted an observational study in a regional trauma center to examine the documentation process during trauma resuscitation and the role of the nurse recorder. We identified problems that make the documentation of trauma resuscitations demanding, and described the various roles of the nurse recorder in documenting and supporting the work of trauma teams. We proposed a set of design challenges which emphasize important aspects of trauma care that must be taken into account when designing technologies to support the documentation process.

The study presented in this paper is part of a larger research agenda. To date, we have focused on uncovering limitations of the present, paper-based documentation system. We are currently planning a set of participatory workshops with trauma team members to discuss technology requirements

and propose a set of solutions to be evaluated in a simulation setting.

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