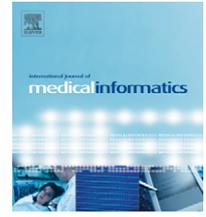




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Interruptions in a level one trauma center: A case study

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ABSTRACT

Background: The emergency department has been characterized as interrupt-driven. Government agencies and patient safety organizations recognize that interruptions contribute to medical errors. The purpose of this study was to observe, record, and contextualize activities and interruptions experienced by physicians and Registered Nurses (RNs) working in a Level One Trauma Center.

Methods: Design: A case study that relied on an ethnographic study design using the shadowing method.

Subjects: A convenience sample of physicians and RNs, each with at least 6 months of experience in the Emergency Department (ED), were asked to participate. In these kinds of detailed qualitative investigations, it is quite common to have a small sample size.

Ethical approval: Approval was obtained from institutional ethic committees prior to initiating the study. Community consent was obtained from the ED staff through in-service education.

Setting: All observations were made in the trauma section of the ED of a tertiary teaching hospital. The hospital is situated in a major medical center in the Gulf Coast region of the United States of America (USA).

Findings: Five attending ED physicians were observed for a total of 29 h, 31 min. Eight RNs were shadowed for a total of 40 h, 9 min. Interruptions and activities were categorized using the Hybrid Method to Categorize Interruptions and Activities (HyMClA). Registered Nurses received slightly more interruptions per hour than physicians. People, pagers, and telephones were identified as mediums through which interruptions were delivered. The physical environment was found to contribute to interruptions in workflow because of physical design and when supplies were not available. Physicians and RNs usually returned to the original, interrupted activity more often than leaving the activity unfinished.

Conclusion: This research provides an enhanced understanding of interruptions in workflow in the ED, the identification of work constraints, and the need to develop interventions to manage interruptions. It is crucial that interruptions be delivered in such a way that there is minimal negative impact on performance. The significance and importance of the

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interruption must always be weighed against the negative impact that it has on smooth, efficient workflow.

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1. Introduction

The Institute of Medicine (IOM) report, *To Err is Human* [1], brought attention to the fact that interruptions contribute to medical errors. Likewise, the Agency for Healthcare Research and Quality (AHRQ), the Joint Commission for the Accreditation Organizations (JCAHO) [2,3], and the United States Pharmacopeia (USP) agree that interruptions contribute to preventable medical errors. Furthermore, Morbidity and Mortality Weekly Review (MMWR) cites specific situations where interruptions contributed to medication errors in the Emergency Department (ED) [4,5]. However, only a limited number of research studies have specifically examined interruptions for physicians and Registered Nurses (RNs) working in the ED.

The ED is characterized as intense, life-critical, stressful, and interruption-laden, in large part due to a fluctuating workload of critically ill patients. Physicians who work in this environment simultaneously manage multiple patients and therefore are more likely to experience an increase in the number of interruptions than those who do not [6]. Furthermore, when comparing ambulatory care settings, physicians working in the ED have been observed to be interrupted three times more often than primary care physicians (PCPs) working in ambulatory care clinics [7]. Moreover, multi-tasking and the concurrent management of multiple patients have been observed to increase the number of interruptions experienced by physicians working in the ED. In one ED for example, physicians received approximately 30 interruptions per hour, which was positively correlated with the number of patients managed concurrently [6].

Many of the interruptions that physicians and RNs handle in the ED are due to synchronous communication events attributed face-to-face meetings, telephone calls, and paging. At least one-third of all communication events in the ED have been classified as interruptions [8-11]. Consequently, physicians and RNs are interrupted approximately 11 times per hour by communication events initiated by colleagues. Unequivocally, these findings provide evidence that synchronous communication among physicians, RNs, and other healthcare personnel results in an interrupt-driven environment.

Although observational studies provide evidence that the ED is interruption-laden, information is lacking about the types of tasks the physicians and RNs were performing when receiving an interruption, the nature of the interrupting activities, and the impact of interruptions on workflow, efficiency, and productivity. This indicates there is a need for more detailed study to observe, record, and contextualize activities and interruptions experienced by physicians and RNs working in the ED. The purpose of this research was to conduct a case study using an ethnographic research design to observe, record, and contextualize activities and interruptions experienced by physicians and RNs working in a Level One Trauma Center.

2. Methods

2.1. Study design

In this case study, the ethnographic technique of shadowing was used to collect data in a naturalistic setting. Shadowing is a qualitative technique that does not necessarily involve the use of statistical analysis of data. In shadowing, observers follow the subjects unobtrusively and take notes of what, how, and if it can be ascertained, why the subjects perform their routine activities in real-world settings.

2.2. Participants

A convenience sample of physicians and RNs, each with at least 6 months of experience in the ED, were asked to participate. Participation was voluntary and written consent was obtained prior to observation. Each session lasted a minimum of 2 h but did not exceed 12 h. The subjects had to be at least 21 years of age to participate.

2.3. Ethical approval

Approval was obtained from institutional ethic committees prior to initiating the study. Community consent was obtained from the ED staff through an in-service describing the study. Community consent is the terminology that refers to obtaining the community's permission or a leader's authorization for researchers to approach individuals in that group. Prior to beginning observation each participant signed informed written consent.

2.4. Setting

All observations were made in the trauma section of the ED of a large teaching hospital. The hospital is situated in a major urban medical center in the Gulf Coast region of the United States of America (USA). The organization is certified as a Level One Trauma Center. A Level One Trauma Center provides the most comprehensive emergency care to critically injured patients. This trauma center provides 24-h emergency and trauma care to approximately 52,000 patients a year. The ED occupies 51,000 square feet and contains major trauma and cardiac resuscitation rooms. Patients arrive at the ED via private car, ground and air ambulance. This study was conducted exclusively in the trauma portion of the ED.

2.5. Data collection

Observers typically worked in teams of two. Observer 1 is a Registered Nurse with 26 years of experience in healthcare and is competent in human factors. Observer 2 is a human factors expert with 6 years of experience. Two

observers were used to maximize the capture of interruptions in the fast-paced environment. Observer bias was addressed through self-reflection, participant validation, and review of observations with an expert in Emergency Medicine. Each observer received 30 min training using the data collection tool prior to beginning data collection. The ED staff also provided a 30 min orientation to acquaint the observers with the ED.

The observers recorded their observations using a semi-structured field note form implemented on Tablet PCs. Observers synchronized their stopwatches before the start of each session to assure accuracy in timing events. Subjects were shadowed for a minimum of 2 h but did not exceed 12 h. Recording observations began when the subject had completed the informed consent. Observations were recorded on a minute-by-minute basis.

It was determined that only two people would analyze the data to establish and maintain consistency in analysis. Each time-stamped observation was analyzed using line-by-line and constant comparison [12] to categorize activities and interruptions using NVivo® [13]. Two coders analyzed the data for agreement of activities and interruptions. A percent agreement score was calculated. The observational data were reanalyzed using MacSHAPA® [14].

2.6. Method to categorize activities and interruptions

The field notes were analyzed using the Hybrid Method to Categorize Interruptions and Activities (HyMCIA) [15]. HyMCIA was developed through the hybridization of a deductive *a priori* classification framework with the provision of adding new categories discovered inductively in the data using grounded theory [12].

3. Findings

3.1. Demographics

Five attending ED physicians were observed for a total of 29 h, 31 min. Eight RNs were shadowed for a total of 40 h, 9 min. Observations were made on either the 07:00–15:00 or the 15:00–23:00 shift. These shifts were selected because they were known to be periods of time characterized as high activity and recommended by a domain expert in Emergency Medicine.

3.2. Activities performed by physicians and RNs

An activity is defined as what a person does. Each activity observed was recorded and categorized using the HyMCIA method. A number of activities were categorized as role-specific for physicians; others were role-specific for RNs. Activities that were not-role specific were performed by both physicians and RNs. Physicians were found to perform slightly fewer activities per hour than RNs. This variance may be attributed to differing roles and responsibilities. Other factors, such as the number of patients in the ED, patient stability, and severity of the patient's injuries, could have possibly contributed to the differences.

3.3. Interruptions experienced by physicians and RNs working in the ED

3.3.1. A taxonomy of interruptions

Each recorded observation was analyzed for occurrences of interruptions. An interruption is defined as a break in the performance of a human activity initiated by a source internal or external to the recipient with occurrence situated within the context of a setting or location. This break results in the suspension of an initial task to perform an unplanned task with the assumption that the initial task will be resumed [16]. This definition supported the identification of the occurrence of an interruption. The following categories of interruptions emerged from the data to form a taxonomy of interruptions:

1. Intended recipient—the person to be interrupted.
2. Unintended recipient—not the intended recipient of an interruption; i.e., receiving a phone call that was incorrectly dialed.
3. Indirect recipient—the incidental recipient of an interruption; i.e., talking with another person and the subsequent conversation, thereby suspending the original activity.
4. Recipient blocked—the intended recipient does not accept the interruption.
5. Recipient delayed—the intended recipient postpones an interruption.
6. Self-interruption—an individual, independent of another person, suspends an activity to perform another activity; i.e., while walking stops abruptly and talks to another person.
7. Distraction—briefly disengaging from a task.
8. Interruption by Organizational Design—the physical layout of the workspace causes a disruption in workflow.
9. Artifact not Available—supplies and equipment that are not available in the workspace, thereby causing a disruption in workflow.
10. Initiator—a person who initiates an interruption.

As noted in the list above, the new categories of Interruption by *Organizational Design* and *Artifact not Available* were identified in the data. These new categories give a more precise description of interruptions in workflow experienced by physicians and RNs due to environmental factors.

The taxonomy of interruptions is a non-dynamic, hierarchical representation of the phenomena. A timeline provides a dynamic visualization of the occurrence and discontinuity introduced by an interruption within the context of activities. In Fig. 1 the time and duration of each activity the subject performed is shown across the top of the timeline. A list of activities is shown along the left margin of the timeline. The occurrence of interruptions is shown on a separate timeline directly beneath the activity timeline. Interruptions can be mapped back to concurrent activities performed on the upper timeline. Timelines are useful in visually showing an interrupt-driven environment such as is found in the ED.

The percent of activities interrupted was calculated for ED physicians. Analysis of the observations noted by Observer 1 in Iteration 1 found that overall, 12.43% of activities were interrupted. With continued scrutiny over nine iterations, analysis

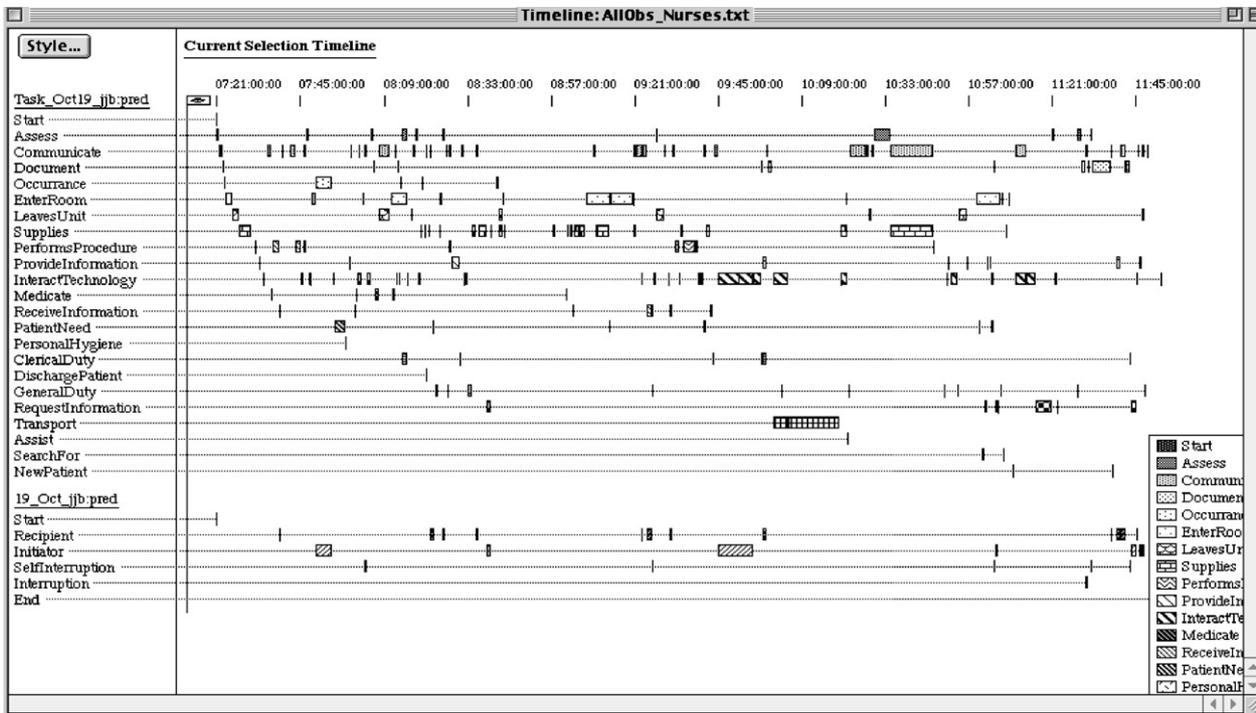


Fig. 1 – A sample timeline of activities and interruptions for an RN working in the ED.

of the physicians' data showed improvement in the identification of interruptions; also no new categories or instances of interruptions were recorded. Analysis of the data indicates an overall agreement of 99.48% for observations in which an event was identified as an interruption by Observer 1.

Analysis of field notes recorded for RNs followed the same protocol as for physicians. The percent of activities interrupted was also calculated for RNs. Initial analysis of the observations noted that Observer 1 found that overall, 4.11% activities were interrupted. The low number of interruptions identified in Iteration 1 was due to conservative categorizing of the data as there was concern about over-inflating the number of interruptions. At the end of Iteration 1, a percent agreement for categorizing interruptions was calculated. For RNs, analysis of the data indicates an agreement of 93.56% for observations for which Observer 1 identified an event as an interruption. It was determined that after nine iterations of categorizing the data, there was category saturation because no new categories of interruptions had been identified.

These findings provide additional insight into the frequency with which interruptions occurred. Iterative categorizing by those performing data analysis achieves a more comprehensive understanding of the observed phenomena. The results of repetitive analysis suggest that the coders became more sensitive to the subtleties in the presentation of interruptions as they continued their analysis and were able to refine their categorization of the data.

A more accurate understanding of the impact of interruptions was gained by determining the frequency of interruptions per hour. Fig. 2 shows the overall rate of interruptions for physicians and RNs.

The variations in the frequency of interruptions per hour could be attributed to a number of factors such as:

1. the number of pages received;
2. the number of telephone calls received;
3. the design of the ED;
4. the availability of supplies;
5. the unplanned and unexpected encounters with other staff members, patients, and families.

Although the roles and responsibilities are different for physicians and RNs, factors that contribute to interruptions may be similar for both groups. The two groups share a common workspace and workload in the ED even though the respective workflows are different.

3.3.2. Mediums to deliver an interruption

Although an individual may state that a telephone or pager interrupted them, the device is only a *medium* through which the interruption was delivered. In the ED, telephones and pagers were devices through which interruptions were delivered. As illustrated in Fig. 3, people, such as resi-



Fig. 2 – Interruptions per hour for physicians and RNs.

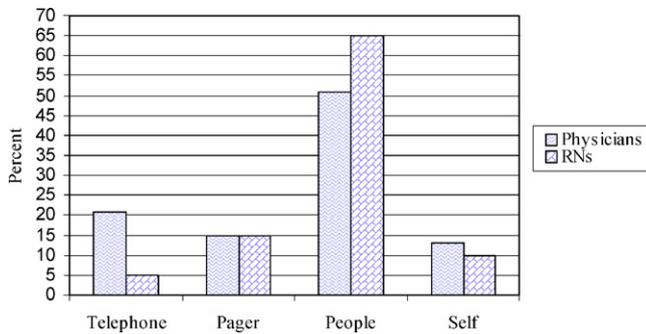


Fig. 3 – Mediums used to deliver an interruption in the ED for physicians and RNs.

dents, interrupted physicians and RNs more often than devices. Physicians received more telephone calls than RNs MDs. Physicians are known to interact with many hospital departments outside the ED. This may have contributed to the increased percentage of interruptions from telephone calls.

It was observed that physicians used both landline and mobile telephones. Physicians received 31.58% interrupting telephone calls through landline telephones. The other 68.42% came via mobile telephones. Physicians were observed to immediately answer mobile telephones. These particular mobile telephones are designed without a voice mail function. The absence of this feature forces the recipient of the telephone call to either answer it immediately or miss the call with hopes that the caller would phone at a later time. In contrast, the use of mobile telephones by RNs was limited to the charge nurse whose role was not part of this study.

Self-interruptions were observed when the study subject stopped performing the initial task and performed an interrupting activity without provocation from a source outside the subject. For instance, a physician was observed walking in the hallway. The physician chose to suddenly stop walking and start talking with another physician without prompting.

Although a large number of medical devices used in the ED are equipped with alarms, no observer recorded an interruption resulting from an alarm emitted from a medical device. It could be inferred that through regular and consistent monitoring of the ED patients, changes in conditions were detected before any alarms sounded.

3.3.3. Interruption by Organizational Design and Artifact not Available

Two new categories of interruptions were identified during data analysis, *Interruption by Organizational Design* and *Artifact not Available*. *Interruption by Organizational Design* represented 17.98% of all interruptions for physicians. *Artifact not Available* comprised 12.19% of interruptions for physicians. Similarly, 18% of interruptions for RNs were attributed to *Interruption by Organizational* while *Artifact not Available* accounted for 14.2%. Identification of such types of interruptions is another means to identify the environmental conditions that decreases efficiency, productivity, and increases the occurrence of medical errors.

3.3.4. Resumption of interruptions

Additional understanding of interruptions required the determination of whether the initial task was resumed or forgotten. Such information provides clarity regarding the possible effects of interruptions and how the subsequent delays can contribute to preventable medical errors. Data indicate that physicians and RNs, after being interrupted, resumed the original, suspended activity, only after they performed one to eight other activities.

The data show that in the majority of situations, physicians and RNs performed only one interrupting activity before returning to the interrupted activity. It could be inferred that the fewer interrupting tasks performed, the more likely the recipient of the interruption will return to the original task. However, returning to an interrupted activity does not eliminate the likelihood of an error occurring, possibly as a result of said interruption. Physicians resumed fewer interrupted activities than RNs. This may suggest that RNs used some memory aid or strategy to remember to return to the original activity. It was not observable as to what approach was used, or if any consistent method was taken advantage of, to remind the person they needed to resume the interrupted activity. It is also possible that the physicians and/or RNs knew someone else would cover the activity.

In this observational study, the actual consequences of the activities that were not resumed are not known. This would have required additional data collection, such as retrospective chart reviews, videotaping of the observation, debriefing of the subject, or some combination of strategies, which were not part of this study design.

Summarizing findings from this study:

- categories of interruptions have been identified resulting in a taxonomy of interruptions;
- two environmental conditions, *Interruption by Organizational Design* and *Artifact not Available*, were also found to contribute to interruptions;
- people were the most common medium through which an interruption was delivered;
- interruptions were observed to be resumed more often than not;
- it was not possible to determine if the activity was correctly resumed.

Additional study is needed to fully comprehend the extent to which interruptions contribute to medical errors. Further analysis of interruptions will improve understanding of the phenomena and will in turn contribute to the development of technologies and strategies to decrease or mitigate the negative consequences.

4. Discussion

The purpose of this case study was to use a qualitative approach to investigate activities and interruptions that physicians and RNs experienced within the context of a Level One Trauma Center. Interruptions were identified as the intrusion of a secondary, unplanned activity into an activity that was already in progress resulting in the suspension of the origi-

nal activity [16]. This definition clearly differentiated the serial performance of activities from those activities performed in parallel. Norman and Draper [17] suggest that people may engage in multiple activities in parallel but serialize them quickly by switching between them. Similarly, Mark, Gonzales, and Harris [18] found that knowledge workers preferred to serialize activities. Observations collected during this study reported that physicians and RNs, both knowledge workers, serialized activities. These observations were further verified when activities and interruptions were represented as serial events on timelines. This representation is important in understanding why some activities are interrupted more often than others and in determining the overall workflow in the ED.

The serial performance of an activity helped determine if an activity was resumed or left unfinished following an interruption. In this study physicians and RNs were observed to recommence an interrupted activity more often than leaving the activity unfinished. However, these findings were contrary to other studies of knowledge workers. O'Connell and Frochlich [19] found that interrupted office workers left 40% of the activities unfinished. In this observational study, when an activity was presumed to be abandoned or forgotten, it was based on the judgment of the observer. The physician or RN may have considered the activity completed or felt that it was not important to resume the activity, a fact that would not be apparent to the observer. The design of this study did not identify what memory aids physicians and RNs might have been using to help them remember to resume the primary activity. Helping physicians and RNs return to interrupted activities is a function that health informatic specialists should consider when designing products to be used in the clinical setting. The development of memory aids could prove useful in allowing them to more easily resume an interrupted activity. Currently, physicians and RNs have no technologies or strategies with which to manage interruptions but instead rely on physically delaying or blocking the interruptions. It is not possible to eliminate all interruptions but technologies should, and can, be developed and used to help physicians and RNs handle and manage interruptions.

Strategies developed to handle and manage interruptions must include mobile telephones as more hospitals extend communication systems to include mobile telephones. This study specifically reported that mobile telephones unquestionably interrupted physicians. Physicians were observed to promptly answer the mobile telephones because they did not have a voice mail function. The lack of this feature had the potential to cause interruptions because the call was rerouted to the hospital operators when not answered after a few rings. Failing to answer the telephone meant that the caller might not call back and the physician would miss important information. In a recent study by Soto, Chu, Goldman, Rampil, and Ruskin [20], mobile telephones were designated as a technology that reduced medical errors by reducing delays in communication. The study did not discuss how mobile telephones may have interrupted physicians. As with the introduction of other technologies into the clinical workspace, the use of mobile telephones must be evaluated as to what new interruptions are introduced, how they change workflow, and what errors that may occur as a result of an interruption due to mobile telephones.

Summary points

- Interruptions are acknowledged to contribute to medical errors.
- Few studies have examined interruptions in emergency medicine.
- This observational case study examined interruptions occurring in a Level One Trauma Center.
- Two environmental conditions, Interruption by Organizational Design and Artifact not Available also contribute to interruptions.
- Future studies of interruption should examine how new technologies introduce interruptions.

This study has provided an in-depth study of the interruptions that physicians and RNs experience while working in a Level One Trauma Center. However, several limitations have been identified. The sample size was small and was conducted in a sub-specialty of Emergency Medicine. Level One Trauma Centers are dedicated to the care of trauma victims. The specificity of the Trauma Center should be considered when generalizing findings from this study and applying it to other EDs. However, the occurrence of interruptions arises in all types of emergency departments as well as Intensive Care Units (ICUs) and in Operating Rooms (ORs). Future studies should examine not only specific clinical settings but how new technologies introduce interruptions so that strategies can be developed to manage them.

5. Conclusion

This study raises concern about how interruptions impact workflow in the ED. Of particular interest to health informatics specialists is the proliferation of new technologies, such as mobile devices, which makes the physician or RN continuously and instantaneously open to interruptions. They would do well to pay heed to the fact those physicians and RNs need techniques with which to manage interruptions. It is crucial that interruptions be delivered in such a way that there is minimal negative impact on performance. The significance and importance of the interruption must always be weighed against the negative impact that it has on smooth, efficient workflow. Consequently, the challenge that lies ahead for health informatic specialists is to develop strategies to mitigate the negative consequences of interruptions while enhancing the positive effects of delivering real-time clinical information.

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