1. TITLE PAGE

Title: Developing and Training Interruption Management Strategies for Emergency Physicians

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2. ABSTRACT

Purpose: To develop an understanding of the type and source of task interruptions impacting emergency medicine physicians and to understand the strategies physicians use to handle interruptions.

Scope: Interruptions have been recognized as a significant burden to physician performance resulting in increased stress and frustration as well as increased likelihood of error, which can have patient safety implications.

Methods: Eighteen different emergency physicians were observed in 2-hour blocks for a total of 36 hours of observations. During each observation each task and interruption the physician engaged in was documented on a second-by-second basis using a web-based application.

Results: Physicians were interrupted 12.7 times per hour and the most frequent source of interruptions was from nurses and other attending physicians or residents. The most common physician task that was interrupted was computer-based tasks. Physicians rarely used strategies to delay or reject interruptions; these strategies were documented as being used less than 3% of the time. A newly developed interruption decision framework is presented that looks at the priority of the primary task and the interrupting task to guide how physicians might respond to interruptions. Specific cognitive strategies for handling interruptions were also developed and are described.

Key words: interruption, patient safety, workflow

3. PURPOSE

The objectives of this study were to (1) quantify the types of interruptions faced by emergency physicians, (2) identify trainable cognitive strategies to address the most common types of interruptions, and (3) develop a preliminary understanding of how the cognitive strategies can be trained in existing simulation environments.

4. SCOPE

Background. An AHRQ report published nearly 10 years ago described several working conditions that affect patient safety.[1] The report highlighted task interruption in the context of physician's working conditions, in particular, the cognitive factors associated with managing task interruptions. In addition, the report suggested that there are serious medical errors and adverse patient outcomes that are the result of healthcare workers being interrupted. Emergency physicians, in particular, work in an environment that is bombarded by frequent task interruption.[2–4] Studies by our team and others have described clinicians in the ED as "interruption-driven" with attending physicians being interrupted as frequently as every 7 minutes.[2,3] These interruptions place a serious cognitive burden on the physician and force physicians to carefully manage multiple tasks and correctly remember information at the right time and in the proper context. Numerous studies have since confirmed the assertions in the AHRQ report; interruptions are not simply an annoyance and burden. Interruptions can lead to an increase in information loss, dropped tasks, error rates, and the amount of time to deliver care, which presents a real threat to patient safety.[5–10]

Context. Though there have been several studies that have quantified the number of interruptions faced by emergency physicians, there have been few studies that have documented the source

of these interruptions with a focus on developing cognitive strategies to mitigate the disruptiveness of interruptions. Our study focused on the source of interruptions so that effective cognitive strategies can be designed and eventually implemented in existing simulation training.

Setting. The MedStar Health System is a 10-hospital system serving the Baltimore and Washington, DC, region that represents a microcosm of the American healthcare system, having a broad spectrum of hospital types, demographics, and patient populations. The 10 hospitals include large tertiary care/academic medical centers, small community hospitals, and a university hospital; inner city, suburban, and rural hospitals; teaching hospitals, and hospitals staffed only by private attending physicians. MedStar Health has a total of 478,000 annual ED visits, 713,000 annual inpatient admissions, and 1.6 million annual outpatient visits.

Emergency physicians were observed in three different MedStar Hospitals: MedStar Georgetown University Hospital (MGUH), MedStar Union Memorial Hospital (MUMH), and MedStar Washington Hospital Center (MWHC). Each of these hospitals provided a different volume of patients in different settings (Table 1).

Hospital Setting	ED Visits per Year
MedStar Georgetown University, Washington, DC	36,000
MedStar Union Memorial Hospital, Baltimore, MD	58,000
MedStar Washington Hospital Center, Washington, DC	91,000

Table 1. MedStar data collection site characteristics.

MedStar Georgetown University Hospital is a tertiary care academic medical center hospital with 350 beds, approximately 36,000 ED visits per year, 20% of which are admitted to the hospital. All EM residents and many EM faculty members provide patient care at both the MGUH and the MWHC.

MedStar Union Memorial Hospital is a top specialty hospital in the city of Baltimore with a 150-year history. The hospital has 289 licensed beds, and the ED has an annual patient volume of 58,000. There are 19,500 inpatient admissions per year, and 115,000 outpatient visits per year, 2,500 employees, and 558 affiliated physicians.

MedStar Washington Hospital Center is a large, inner-city ED and Level I trauma center and is the busiest emergency department, most active trauma center, and largest cardiac service in Washington, DC. MWHC is a 926-bed urban teaching hospital where the emergency department accounts for 55% of all hospital admissions. On average there are about 7,500 patient visits with about 5,600 discharges each month from the ED. The ED is staffed with 30 board-certified emergency physicians and has 48 treatment rooms. It is also home to a nationally ranked EM residency program as well as fellowship programs in ultrasound and critical care medicine.

Participants. Eighteen different attending physicians were observed during this study. Attending emergency physicians also served as subject matter experts to inform the development of cognitive strategies that may mitigate the disruptiveness of interruptions and to inform how these strategies might be integrated with existing simulation training.

S5. METHODS

Study Design. This study was a time and motion observational study. The 18 participants were each observed individually for 2-hour blocks of time, resulting in a total of 36 hours (2,160 minutes) of observational data. Six physicians were observed from three different hospitals: MedStar Georgetown University Hospital, MedStar Union Memorial Hospital, and MedStar Washington Hospital Center. The observation blocks were structured such that all hours of operation in the ED were fairly represented, including night shifts. From each hospital site, two physicians were observed between 7am and 3pm; two physicians, between 3pm and 11pm; and two physicians, between 11pm and 7am. The observer stood a few feet behind the physician and did not enter patient rooms in order to limit observer interference with normal clinical practice.

Data Collection. A web-based application was developed to document the tasks physicians were engaged in on a second-by-second basis and to document the when interruptions occurred. The following data related to task interruptions was collected:

- The length of the interruption measured in seconds.
- The source of the interruption was documented as a physician/resident, nurse, student, assistant/technician, phone, device, patient, or other.
- The type of primary task that was being interrupted, which was documented as a computer task, paper task, direct patient care, phone, device, or an in person conversation with a nurse, student, assistant/technician, or physician/resident.
- Whether the primary task was immediately returned to following the interruption was documented.
- Whether the interruption was immediately responded to, delayed, or denied - or whether the physician engaged in multitasking behavior to handle the interruption - was documented. If specific strategies were observed, those strategies were described in the notes section of the application.
- The location of where the interruption occurred was recorded as being at the workstation, in the hallway or transition area of the emergency department, or immediately outside of the patient room.

Figure 1 shows the web-based application that was used for data collection. The application keeps a time log of each task, and the data can be downloaded for analysis.

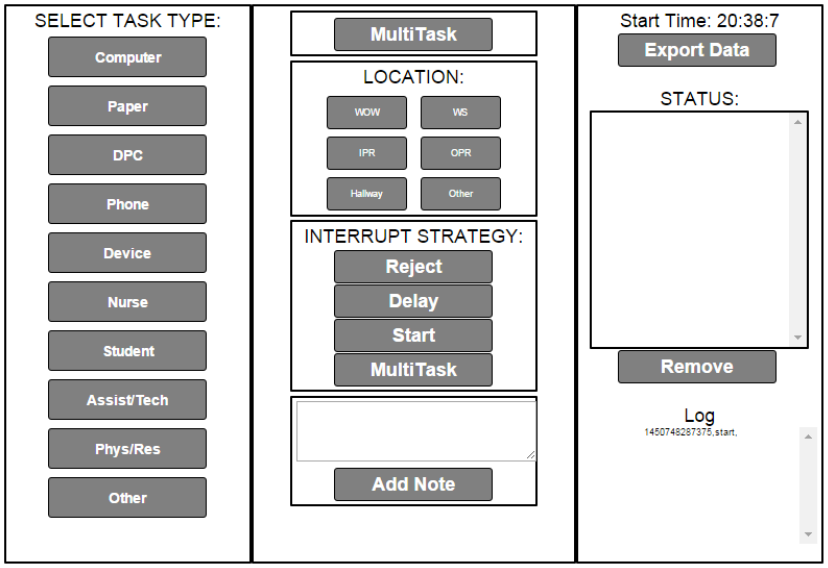

Figure 1. The interface of the data collection tool.

Measures. A rate of interruptions was calculated per hour of observation and the average length of interruption was calculated. The average number of interruptions was examined per category. In addition, the number of interruptions that were part of each observed strategy was also examined. Two observers conducted all of the observations in this study. The two observers dually coded one 2-hour session in order to determine inter-rater reliability. Over the course of the 2-hour session there was 86% agreement between the observers.

Limitations. Observers did not enter patient rooms in order to protect patient's privacy. Consequently, we could not observe any interruptions that occurred in patient rooms. In addition, the observer could not document when a physician returned to an interrupted primary task after several other tasks were completed due to difficulties in maintaining awareness of these tasks.

6. RESULTS

Principal Findings:

Time and Motion Study

There were a total of 457 interruptions documented across all of the observation periods. The interruption rate was 12.7 interruptions per hour. The average length of each interruption was 31.7 seconds. The most frequent interruptions were in-person conversations from other physicians or residents (n = 193) or nurses (n = 144). Figure 2, below shows the breakdown of the source of interruptions.

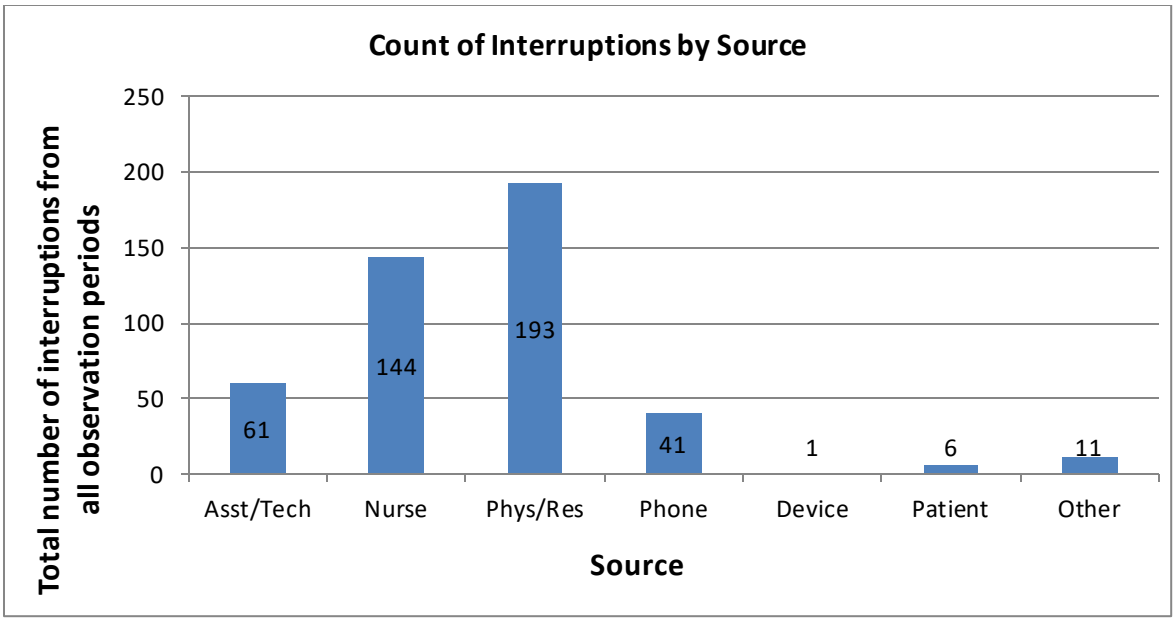

Figure 2. Count of interruptions by source.

In addition to examining the source of the interruptions we examined the primary task that was being performed by the physician when the physician was interrupted. Computer tasks were overwhelmingly the most frequent task interrupted, with 209 of the interruptions occurring while the physician was working at the computer. Figure 3, below, shows a breakdown of the primary tasks that were interrupted.

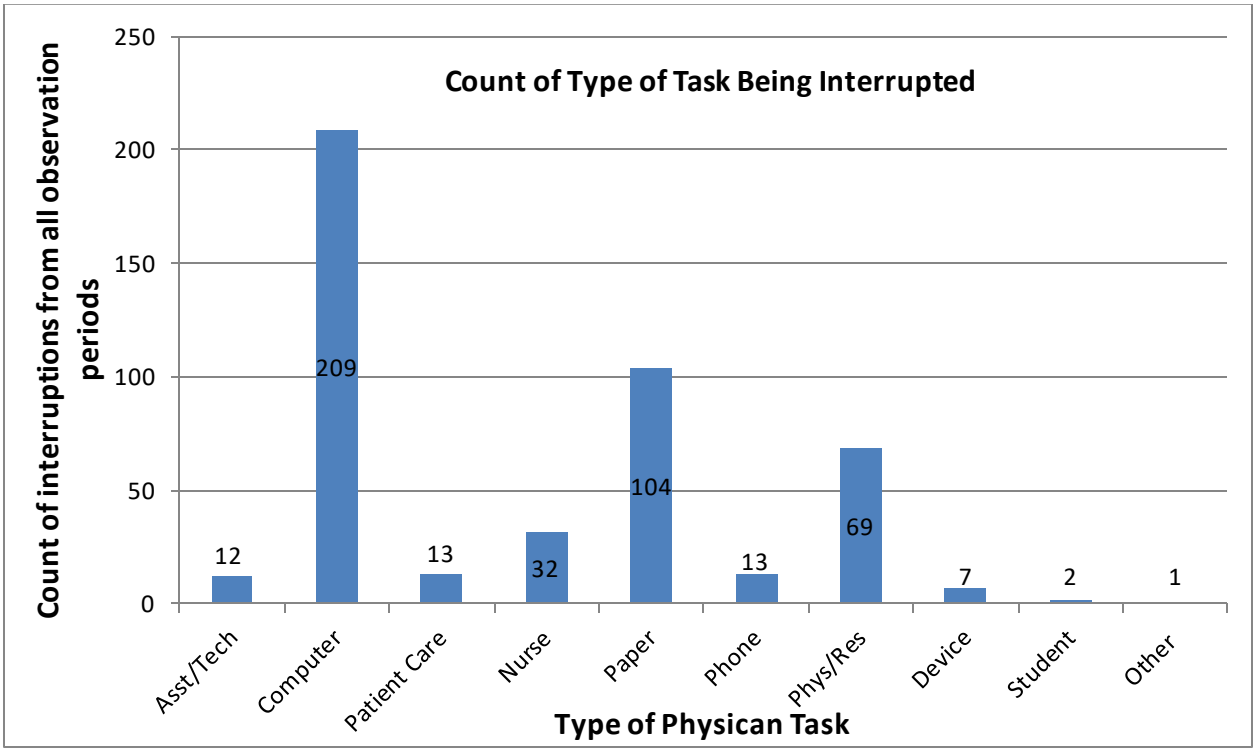

Figure 3. Count of the type of task being interrupted.

The descriptive analysis of the type of interruption strategies used by physicians was surprising. The majority of the time, the physician immediately accepted the interrupting task. Of the 457 total interruptions, only .8% (n = 4 occurrences) of the time did a physician delay the interruption by asking the interrupter to wait until the physician completed their current task or subgoal. Rejecting interruptions occurred only 1.3% of the time (n = 6 occurrences).

Development of Cognitive Strategies

The research team developed a general framework for expressing the cognitive strategies that emergency physicians should consider given the specific context in which they are working. The framework takes into consideration the priority and safety risk of the primary task that the physician is currently engaged in and the priority of the interrupting task that the physician is being asked to perform. Table 2 shows the interruption decision framework that was developed. These general criteria serve as a framework for physicians to guide them in their decision-making to delay, reject, or accept an interrupting task given their rapid assessment of the primary and interrupting tasks.

	Primary Task	
Interrupting Task	*High Priority/Risk*	*Low Priority/Risk*
High Priority	Select one of the tasks based on immediate priority needs and ask the care team to help with the other pressing task.	Pause performance on the primary task and engage the interrupting task
Low Priority	Reject the interrupting task; maintain focus on primary task	Serially perform tasks based on efficiency or possible multitasking opportunity

Table 2. Framework for determining whether interrupting tasks should be performed.

In addition to this high-level framework, specific strategies were developed for when physicians do engage the interrupting task. The strategies are focused on facilitating resumption of the primary task to reduce the likelihood of error on the primary task and to expedite the time to resume work on the primary task. The specific strategies are detailed in Table 3.

Strategy Description	**Example from Clinical Practice**
Actively use environmental cues to indicate where to resume in the primary task	When placing a medication order and interrupted the physician can actively place the mouse cursor on the last step in the medication order process to serve as an environmental indicator as to where to resume.
Complete the current subgoal of the primary task that is being completed before transitioning to the primary task	When placing a medication order and being interrupted the physician can complete the subgoal of selecting the patient name and address the interruption before starting the subgoal of selecting the medication name.
Occasionally direct attention over to the primary task while performing the interrupting task if one is able to do so	If interrupted by a resident with a question in the middle of placing a medication order the physician can occasionally glance at the medication ordering screen while talking to the resident in order to keep the primary task goal in memory if it is safe to do this.

Strategy Description	Example from Clinical Practice
Attempt to address the interrupting task as quickly as possible and return to the primary task without delay or engaging in another interrupting task	The physician was discharging a patient and was interrupted by a resident with a medication question. While talking to the resident, a nurse asked a question. The physician asked the nurse to wait, finished the conversation with the resident, returned to finish the discharge, and then talked to the nurse.
Before engaging in high-risk tasks anticipate sources of interruptions and proactively address those needs	The physician knew she had several high-risk medication orders to place, so she checked in with the nurse staff to see if they needed anything before placing the orders.

Table 3. Specific strategies for mitigating the disruptiveness of interruptions.

Integration with Simulation Modules

The research team sought to determine how the interruption decision framework represented in Table 2 could be integrated with existing simulation training modules. The goal was to develop some very preliminary simulation scenarios to encourage development of strategies for handling interruptions. Simulation events were retrieved from the Society for Academic Emergency Medicine (SAEM) simulation case library. The research team selected four different simulations that mapped to the interruption decision framework that is presented in Table 2. The four descriptions are presented below.

1. High-Priority Primary Task/High-Priority Interrupting Task: A 45-year-old man is brought in by EMS for being unconscious. During the physical exam, a nurse interrupts the physician to alert the physician that patient in room 2 is in cardiac arrest. The physician must determine how to respond to the interruption from the nurse. This scenario is based on the methadone overdose simulation scenario from Richard Stair, MD.

2. High-Priority Primary Task/Low-Priority Interrupting Task: A patient that arrived with shortness of breath who attempted suicide with aspirin and alcohol just took a turn for the worse and the patient is now unresponsive. During the transition to the unresponsive state, a patient interrupts, asking when the patient can be discharged, because the patient was told over 2 hours ago that he was going to be discharged. The physician must determine how to respond. The original simulation scenario was developed by Patty Manhire and Dave Betten.

3. Low-Priority Primary Task/High-Priority Interrupting Task: The physician is talking to a nurse about where to find the special instructions in the electronic health record for medication orders. Another physician interrupts, asking for help with an intubation that he has been struggling with for the past 10 minutes. The interrupted physician must determine how to respond.

4. Low-Priority Primary Task/Low-Priority Interrupting Task: The physician is reviewing the medication history in the electronic health record for a patient who presented to the ED with minor bruises from a fall. The nurse interrupts the physician to ask about dietary restrictions for another patient that has the stomach flu. The physician must determine how to respond to the interrupting nurse given the current primary task.

Discussion: The majority of the interruptions that emergency physicians faced were from either nurses or other physicians and residents. The observed physicians were primarily interrupted when they were working on computer-based tasks. With an understanding of the source of the interruptions and the primary tasks that were being performed when the interruptions occurred, this research will provide a foundation for developing strategies to mitigate the disruptiveness of interruptions. In addition, the infrequent use of strategies to delay or reject interruptions was surprising and may require further investigation in future research. Because the majority of interruptions stemmed from other caregivers, the clinical care team can be introduced to methods for better initiating interruptions so that the team is cognizant of when and how to best deliver interruptions.

Conclusions: Our results demonstrate that emergency physicians are interrupted frequently and that these interruptions typically occur when physicians are working on critical computer-based tasks, such as ordering medications, procedures, and diagnostic tests. The lack of use of cognitive strategies to delay or reject interruptions suggests that there is an opportunity to optimize physician response to interruptions.

Significance: The significance of this research is that it demonstrates a high rate of interruptions to emergency physician workflow, primarily driven by nurses and other physicians and residents. Interruptions have been associated with increased rates of error and, given that many of the interruptions occurred while the physician was working at the computer, which is the primary method for ordering medications, labs, and diagnostic tests, there is risk for error on these critical tasks.

Implications: There is an opportunity to modify health information technology systems to better support emergency physicians who are frequently interrupted. Physicians can be better informed about different high-level and low-level strategies for handling interruptions. Finally, there is an opportunity to integrate interruption training into existing simulation modules.

6. LIST OF PUBLICATIONS AND PRODUCTS

Currently, there are two journal publications in preparation based on the supported study. During the project period, two conference papers were published based on this study.

Fong, A., Meadors, M., Batta, N., Nitzberg, M. Hettinger, A., & Ratwani, R. (2014). Identifying Interruption Clusters in the Emergency Department. Proceedings of the 2014 National Human Factors and Ergonomics Society Conference.

Ratwani, R.M, Hettinger, A. Z., Brixey, J. Rivera, A.J. & Colligan, L. (2014) *Managing Interruptions in Healthcare: From Theory to Practice*. Proceedings of the 2014 National Human Factors and Ergonomics Society Conference.

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