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Original Contributions

PHYSICIAN, INTERRUPTED: WORKFLOW INTERRUPTIONS AND PATIENT CARE IN THE EMERGENCY DEPARTMENT

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☐ **Abstract—Background: It is unclear how workflow interruptions impact emergency physicians at the point of care. Objectives: Our study aimed to evaluate interruption characteristics experienced by academic emergency physicians. Methods: This prospective, observational study collected interruptions during attending physician shifts. An interruption is defined as any break in performance of a human activity that briefly requires attention. One observer captured interruptions using a validated tablet PC-based tool that time stamped and categorized the data. Data collected included: 1) type, 2) priority of interruption to original task, and 3) physical location of the interruption. A Kruskal-Wallis H test compared interruption priority and duration. A chi-squared analysis examined the priority of interruptions in and outside of the patient rooms. Results: A total of 2355 interruptions were identified across 210 clinical hours and 28 shifts (means = 84.1 interruptions per shift, standard deviation = 14.5; means = 11.21 interruptions per hour, standard deviation = 4.45). Physicians experienced face-to-face physician interruptions most frequently (26.0%), followed by face-to-face nurse communication (21.7%), and environment (20.8%). There was a statistically significant difference in interruption duration based on the interruption priority, $\chi^2(2) = 643.98$, $p < 0.001$, where durations increased as priority increased. Whereas medium/normal interruptions accounted for 53.6% of the total interruptions, 53% of the interruptions that occurred in the patient room (n = 162/308) were considered low priority (χ^2 [2, n = 2355] = 78.43, $p < 0.001$). Conclusions: Our study examined interruptions over entire provider shifts and identified patient rooms as high risk for low-priority interruptions. Targeting provider-centered interventions to patient rooms may aid in mitigating the impacts of interruptions on patient safety and enhancing clinical care.** © **2017 Elsevier Inc. All rights reserved.**

☐ **Keywords—interruptions; workflow; patient safety; human factors**

INTRODUCTION

Emergency medicine is a dynamic environment characterized by unpredictable workloads, time-critical activities, medically complex cases, and the concurrent management of multiple patients. To meet the demands of the emergency department (ED), physicians must actively engage with a number of team members, including other clinicians, nurses, residents, and technicians. Although interaction with ED staff members is absolutely necessary for patient care and management, at many times these interactions can interrupt physicians

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from their current task. In an already challenging environment, frequent interruptions can add to the demands placed on clinicians in the ED.

Emergency physicians are interrupted six to 11 times per hour—nearly three times more than primary care providers (1–4). Interruptions are commonly characterized as having negative implications for patient safety. They can delay clinician responses to patients and increase the risk for errors by disrupting clinicians' thought processes and increasing cognitive demands (5,6). Yet, interruptions in the clinical work process can also be beneficial by providing critical, time-sensitive information that relates to patient care (7). In the moment, interruptions can provide a "fresh set of eyes" on the task, giving the clinician an opportunity to evaluate the current task and change accordingly. Pausing the current task—as a result of an interruption—and subsequently performing a task assessment can prevent error occurrences due to performance degradation.

Relatively few studies examined interruptions in the ED to understand their impact on cognitive workload and workflow at the point of care (8–11). As a result, development of practical solutions to improve information transmission and reduce interruptions in this high-risk environment is limited. Interruptions studies related to patient safety in the ED are traditionally performed over short time periods, which provide only a superficial understanding of the nature of interruptions occurring (7,8). Our study aimed to examine interruptions experienced by emergency physicians over the duration of entire shifts. Using observations and surveys, our study quantified interruptions based on frequency, duration, type, priority, and location of interrupted physicians to further develop opportunities to intervene in avoiding interruptions of low value.

METHODS

Setting and Participants

We conducted an observation-based, prospective study in an academic ED located in the Midwest. The ED was fitted with 72 rooms, including seven dedicated resuscitation bays and 11 pediatric rooms. Annually, the ED receives 73,000 patient visits, with 35% of adult patients admitted to inpatient care. The Institutional Review Board approved this study.

We approached attending physicians during a monthly meeting to discuss the study goals. Participation was voluntary and physicians could opt out at any time. Based on those who provided consent and researcher availability, we utilized a convenience sampling in selecting which attending physician shifts to observe.

Research Protocol

One experienced health-care systems engineering researcher (HJH) shadowed emergency medicine attending physicians during their regularly scheduled work shifts. At the beginning of a shift, the researcher introduced himself to the participating attending. During the shift, the researcher collected data on interruptions using a tablet data collection tool and observed the physician workflow—including patient care. If at any point a patient did not want to be observed, the researcher stepped outside the patient room and continued observation when the physician exited the patient room. For the purposes of this study, we defined an interruption as "any break in the performance of a human activity initiated by a source internal or external to the recipient, that very briefly requires the attention of the participant and does not inherently necessitate the clinician change tasks" (2).

We captured interruptions using a validated tablet PC-based tool that time stamped and categorized interruptions in real time according to 1) type, 2) priority (i.e., low, normal/medium, high/critical), and 3) the physical location where the interruption occurred (12). A description of the interruption types can be found in Table 1. The researcher determined interruption priority by comparing the interruption in relation to the current task. For instance, if a current task involved checking patient blood pressure and the physician is interrupted with a trauma page, the interruption would be recorded as "high/critical" priority in relation to the blood pressure task. Such examples were confirmed with ED staff prior to the study. Interruption location included in Patient Room, Outside Patient Door, Hallway, Staff Station, or Dictation Room/Area.

Data Analysis

We analyzed the observation data using the statistical software RStudio (Version 0.99.489, Boston, MA), and Microsoft Excel (Microsoft Corporation, Redmond, WA). Interruption duration was calculated from the time stamps. Descriptive statistics included means (M), medians (Mdn), and standard deviations (SD). A Kruskal-Wallis H test analyzed the effect of interruption priority on duration, and a chi-squared test examined interruption priority in and outside of the patient rooms. We designated the interruption locations outside patient door, hallway, staff station, and dictation room/area as "Out of Patient Room."

RESULTS

Of the 46 attending physicians working at this institution, 28 (n = 28/46, 60.9%) participated in our study. Our study

Table 1. Types of Interruptions

Type	Examples
Face-to-face physician verbal communication	Another physician provides patient status update Handoff communication
Face-to-face nurse verbal communication	Patient status updates
	Medication requests
Face-to-face other verbal communication	Social work provides updates
	Patient transport escort discussions
	ECG technician handing off ECGs and rhythm strips Law enforcement discussion
Environment	Alarms
	Overhead announcements
Page	Resuscitation team notification
Phone call	Out-of-hospital patient transfer communication
Direct patient care	Patient or patient family member approach staff station with questions
Other	Lost documents
	Technology failure (e.g., switching pager batteries, software issues causing delay)

ECG = electrocardiogram.

identified a total of 2355 interruptions across 210 clinical hours (means = 84.1 interruptions per shift, standard deviation = 14.5; means = 11.21 interruptions per hour, standard deviation = 4.45). The average number of interruptions increased from the morning to evening hours (Figure 1). The median duration per interruption was 14.0 s. The maximum duration was 1630.0 s, or 27.2 min (Type: Direct patient care). The minimum was 1.0 s (Type: Environment). The middle 50% of interruption durations fell between 5.0 and 38.0 s.

Interruption Type

Of the 2355 interruptions, face-to-face physician verbal communications were most frequently observed (n = 613, 26.0%; Figure 2). Other frequent interruption types included face-to-face nurse verbal communication (n = 512, 21.7%), environment (n = 489, 20.8%), and face-to-face other verbal communication (n = 396, 16.9%). Yet, phone calls had the longest median duration (Mdn = 79 s), followed by equipment malfunctions

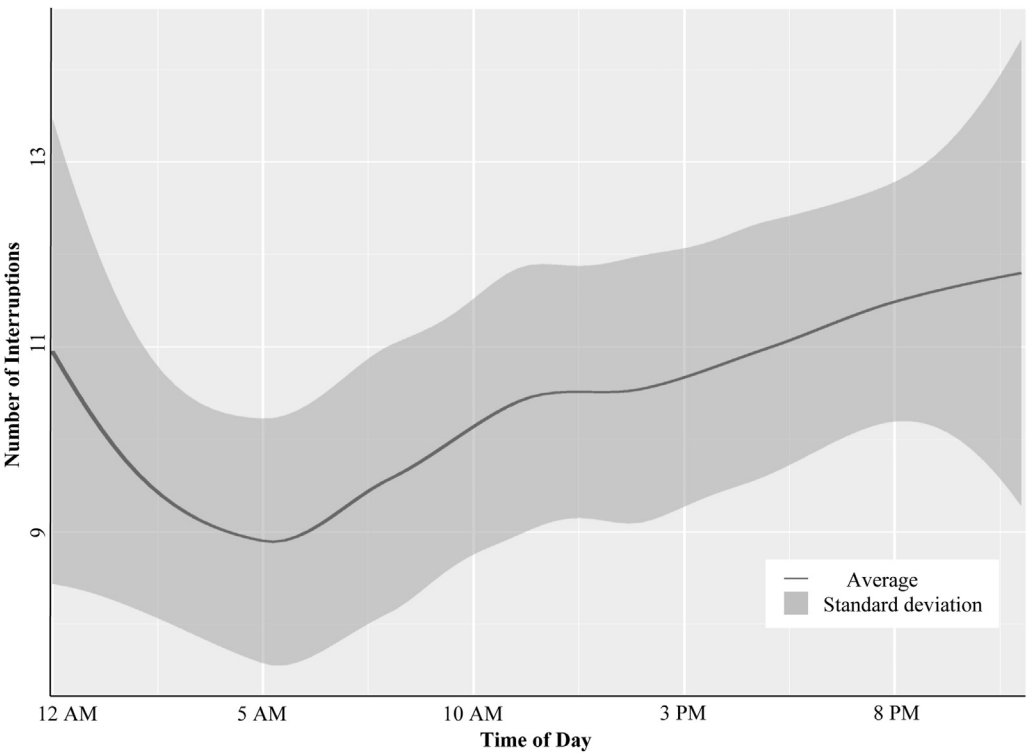

Figure 1. Average number of interruptions per hour across a day.

(Mdn = 47 s) and face-to-face physician verbal communication (Mdn = 30 s).

Interruption Priority

Medium/normal priority interruptions were most prevalent (n = 1262, 53.6%), followed by low priority (n = 760, 32.3%) and high/critical priority (n = 333, 14.1%). However, high/critical priority interruptions had the longest median duration (Mdn = 36 s) followed by medium/normal priority (Mdn = 23 s) and low priority (Mdn = 5 s) interruptions. A Kruskal-Wallis H test analysis demonstrated statistically significant difference in interruption duration based on the interruption priority, $\chi^2(2) = 643.98$, $p < 0.001$, with a mean rank priority score of 664.12 for low priority, 1410.26 for medium priority, and 1470.62 for critical/high priority.

Interruptions by Location

Interruptions varied by location, with the most interruptions occurring at the staff station (n = 1932, 82.0%) followed by patient room (n = 308, 13.1%), and outside patient door (n = 76, 3.2%). Interruptions in the dictation room had the longest median duration (Mdn = 33 s), followed by the hallway (Mdn = 21 s), outside the patient door (Mdn = 20 s), at the staff station (Mdn = 17 s), and lastly, in the patient room (Mdn = 6 s).

A chi-squared analysis revealed significant differences in interruption priority based on whether the interruption occurred inside or outside of a patient room, χ^2 (2, n = 2355) = 78.43, $p < 0.001$. More than half (n = 162/308, 53%) of the interruptions that occurred in the patient room were considered low priority (Figure 3) and were environmental in nature (Figure 4).

DISCUSSION

Our study examined interruptions experienced by emergency physicians across their entire shifts in an academic setting. Interruptions occurred in all areas of the ED, varying by type and priority. Grouping interruption locations outside the patient room provided the means to understand how workflow interruptions impacted emergency physicians at the point of care.

Results from our study suggest that emergency physicians are interrupted more than initially reported (1,2). Emergency physicians experienced face-to-face physician interruptions most frequently. Given the need for supervision and communication between attending physicians and residents in this academic setting, such a result is expected. Face-to-face nursing communication as the second most frequent interruption is also expected given the dynamic nature of patient conditions and ongoing assessments of patient needs. Previous studies similarly found face-to-face conversations as the most prevalent interruption type (3,4,13,14). Regardless, communication is regularly interfering with physician tasks. Understanding how to communicate information in a way that does not introduce potential for cognitive errors is important, and low-priority conversational interruptions should be eliminated as much as possible. Potential opportunities to combat such issues could include creating a culture of awareness around the risks of interruptions, utilizing other communication methods (e.g., e-mail, electronic health record notes), and developing communication tools that create a shared awareness (e.g., multi-patient dashboards).

Considering interruptions based on their priority to the interrupted task introduced a novel concept to interruptions research. Evaluating interruption priority revealed

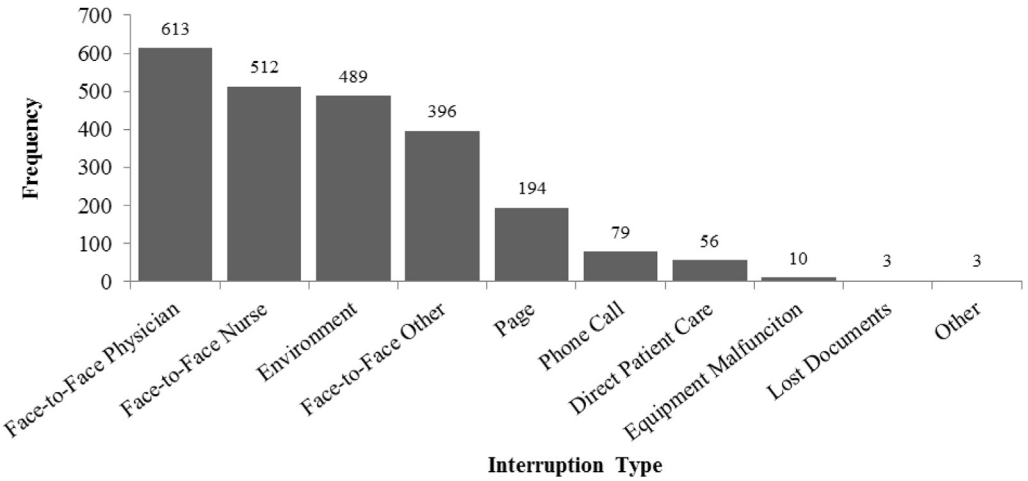

Figure 2. Prevalence of interruptions types across all locations.

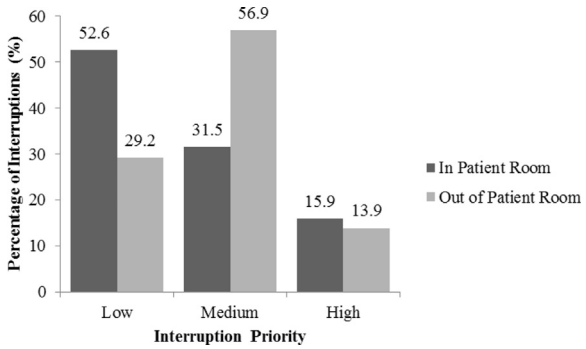

Figure 3. Priority of interruptions by location.

an interesting trend related to duration. As the priority level of the interruption increased, the length of time that physicians' workflows were disrupted increased as well. Our data highlighted a small frequency of high/critical interruptions, but those interruptions lasted the longest. Even though they are long in duration, the high/critical interruptions are the most relevant and crucial to patient care, meaning these interruptions are needed and generally should not be mitigated or eliminated. However, our primary concerns are the majority of low and medium/normal priority interruptions that last upwards of a minute. These interruptions may be adding to the cognitive and physical workload of the physician and putting them at risk of medical errors and burnout (15). Developing interventions for eliminating low priority interruptions for physicians and mitigating medium/normal priority interruptions is warranted given the harmful effects that these interruptions can have on patient care and the broader health care system.

Results indicated that interruptions are *organizationally induced*—meaning where the interruptions physically occurred (i.e., location) affected the interruptions' characteristics (13,14). For example, many of the interruptions that occurred at the staff station were physicians verbally interrupting each other. Constant interruptions by colleagues may increase one's cognitive burden and cause mishaps, delays, and unintentional errors downstream (16,17). Interruption priority levels were also significantly different, depending on if the interruption occurred inside or outside the patient room. More than half of the interruptions in the patient room were considered low priority, indicating an opportunity to intervene and eliminate unnecessary distraction so that the physician can concentrate solely on immediate patient care. Although a relatively small number of interruptions actually occurred in the patient room, there is opportunity to reduce those interruptions and their impact at the "sharp end" of care (18). Potential ways to mitigate interruptions at the point of care could include treating the patient room as a "sterile cockpit" or "interruption free zone" (19). It is important to note that these interventions may be more relevant to human-initiated interruptions vs. technology or environmentally induced interruptions; additional work is needed to evaluate the intersection of technology, interruptions, and their management.

Limitations

Limitations to this study include those inherent to observational studies. Attending physicians and ED staff were not blinded to the nature of this study, making both more

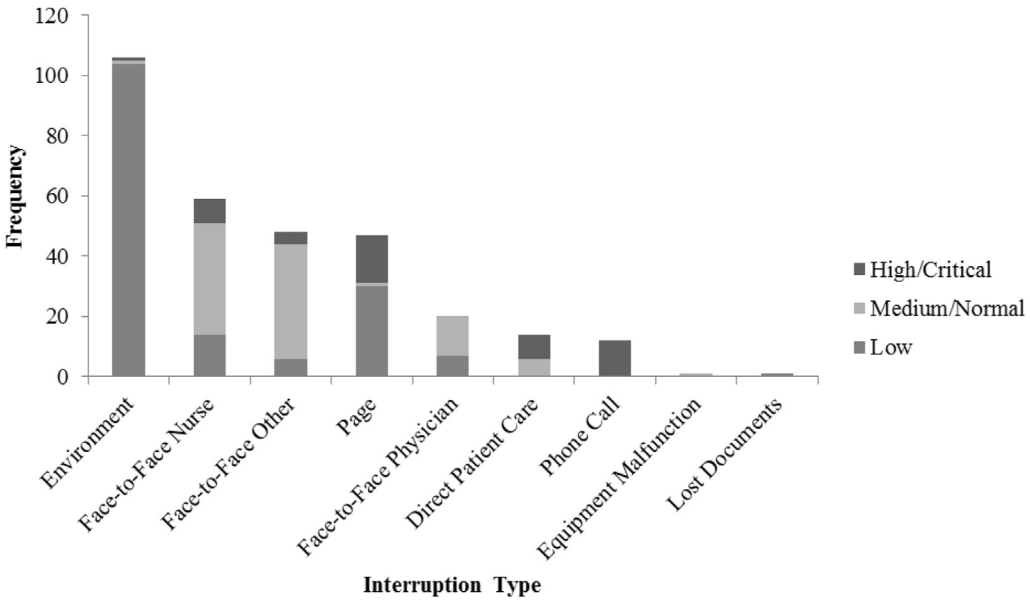

Figure 4. Interruptions occurring in the patient room.

aware of their behavior and potentially altering their actions when the researcher was present. The presence of the researcher could also have been the cause of interruptions as well. Yet multiple days and times of day were used in an attempt to reduce these effects. Due to the sensitive nature of certain cases, some patients requested to not be observed, potentially missing interruptions. The researcher took a 30-min break at the shift mid-point that did not always correlate with the physician's break, also leading to potential missed interruptions. Additionally, due to the nature of in vivo data collection, interruptions may have been incorrectly categorized. In an attempt to standardize the identification of interruption priority, the research team consisting of researchers and clinicians discussed examples of each priority group. Results from this study provide insight into interruption characteristics and intervention opportunities; however, further work needs to be done beyond academic institutions and in more diverse locations to understand the mechanisms of interruptions in those settings.

CONCLUSIONS

Our study provided a unique examination of ED interruptions and indicated that emergency physicians are interrupted more often than initially reported. Introducing interruption priority level helped identify relationships in interruption durations and identified patient rooms as a high-risk area for low-priority interruptions. Targeting provider-centered interventions to patient rooms may aid in mitigating the impacts of interruptions, protecting patient safety, and enhancing clinical care.

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ARTICLE SUMMARY

1. Why is this topic important?

This topic is important because interruptions are ubiquitous in the emergency department (ED) and the health care field more broadly. It addresses where our efforts should be directed with respect to improving efficiency in providing safe care and the overall patient experience in the ED.

2. What does this study attempt to show?

This study shows that one-third of interruptions experienced by physicians in the ED are low priority when compared with their interrupted task. This predisposes physicians to a higher risk of errors, which may impact patient care provided in the ED or further downstream.

3. What are the key findings?

The key finding in this study is that one-third of interruptions are considered low priority (n = 760; 32.3%). When evaluating interruptions within the patient room, more than half of the interruptions experienced by physicians are of low priority. This rate is particularly high, given that physicians are providing patient care during this time.

4. How is patient care impacted?

This study shows the prevalence of interruptions across different spaces of the ED. Despite interruptions generally less than a minute per event, physicians experienced over 80 interruptions per shift. These events impose a cognitive burden on the physician to change task and presumably return to the original task shortly thereafter—which increases the risk of human error and threatening patient safety. These findings suggest opportunities to eliminate low-priority interruptions, mitigate normal/medium-priority ones, and acknowledge the value of high-priority interruptions.