

BRIEF REPORT

The Practice of Emergency Medicine

Does the number of pages received per hour affect resident productivity?

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Abstract

Background: Workflow interruptions are common for emergency physicians and are shown to have downstream consequences such as patient dissatisfaction, delay in clinical response, and increase in medical error. However, the impact of passive interruptions on physician productivity is unclear and has not been well studied. We sought to evaluate if the number of pages received per hour significantly affects the number of patients seen per hour.

Methods: Retrospective data was collected on resident physician (RP) emergency department shifts from July 1st, 2021 to June 30th, 2022 at an academic medical center with an annual census of 55,000 patients. A total of 2865 RP shifts were collected among the 26 postgraduate year (PGY) 1 and PGY2 residents. For each RP shift, we identified the number of pages received per hour and the number of new patients seen per hour. Pages consist of any transmitted message that was sent to the RP's personal pager, which includes both automatic (eg, bed assignments, abnormal lab values) and personalized pages from other healthcare practitioners (eg, nursing, consultants). Data were analyzed using Poisson regression controlling for clustering at the physician level to determine if the number of patients seen per hour is significantly affected by the number of pages (divided into quartiles) received.

Results: We found the number of pages received per hour did not decrease the number of patients seen per hour. Contrary to our hypothesis, there was a strong positive relationship between the number of pages received per hour and the number of patients seen by RPs in that hour and subsequent hours. During the middle of a shift (hours 3, 4, and 5), RPs receiving pages in the third and fourth quartile (top 50% of pages) saw significantly more patients during that same hour and the next hour ($p < 0.001$).

Conclusion: The number of pages received by RPs per hour did not decrease the number of patients seen per hour. When RPs receive a higher number of pages, there is a positive association with the number of patients they see in that hour and subsequent

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hours. Further studies will be needed to determine whether the content of pages affects resident productivity.

KEYWORDS

efficiency, interruptions, pages, productivity, resident physician, workflow

1 | INTRODUCTION

1.1 | Background

Interruptions are common in the emergency department and are frequent sources of distraction for emergency physicians. An interruption can be defined as a break in performance of an activity due to an external or internal stimulus that results in the suspension of the primary task in order to perform an unplanned secondary task.¹ Workflow interruptions are integral to the practice of emergency medicine as emergency physicians manage many patients in parallel and need to constantly adjust priorities based on new available information. Nevertheless, interruptions are known to have multiple downstream consequences, including patient dissatisfaction, delay in clinical response, decreased situational awareness and increase in medical error.^{1,2} Since the American Academy of Emergency Medicine (AAEM) released its first collaborative statement on interruptions in the ED in 2020, there has been an increase in literature identifying types of interruptions, their frequency, and their subsequent downstream effects.

Interruptions in the ED consist primarily of in-person communication (nursing, technicians, consultants, front desk, patients, visitors, etc), pages, phone calls, electrocardiogram (ECG) interpretations, or an alert message in the electronic medical record. A prospective observational study at an urban, level 1 trauma center noted that emergency physicians are interrupted once every 4.3 min, but this study did not evaluate pages as a source of interruption.³ Another prospective observational study at 3 different urban EDs found that emergency physicians were interrupted 12.5 times per hour and engaged the interruptive task 75.4% of the time, followed by multitasking to continue the primary task.⁴ An additional prospective observational study found that emergency physicians fail to return to 18.5% of initial interrupted tasks.⁵ Within these studies, pages were either not included or evaluated only as a small subtype of interruptions.

1.2 | Importance

As a whole, interruptions are known to have downstream ramifications in delivery of bedside care, but it is unclear whether various subtypes of interruptions differ in their effects. For example, to our knowledge, there is no prior literature on whether ECG interpretations might carry more weight as an interruption compared to a page. A prospective observational study at a large urban ED found that 48% of ECG readings were initiated as interruptions but did not evaluate or compare this to other types of ED interruptions.⁶

At our institution, both automated and manually generated pages via our electronic ED dashboard are commonly used to facilitate asynchronous communication between attendings, residents, nurses, consultants, laboratory, and imaging. This use of the paging system as a means for communication among the ED care team at our institution allows us to study the potential impact of pages on task interruption. Additionally, despite the robust literature on interruptions, there are minimal data on whether interruptions have an effect on physician productivity or efficiency. A large systematic review of ED interruptions found that only 5 of 44 studies mentioned implications of interruptions on “workload” but did not specifically evaluate physician productivity or patients per hour.¹

In their 2022 collaborative clinical practice statement, the AAEM set a goal to raise awareness on ED interruption consequences and encouraged further research on this topic.⁷ However, despite their call to action, it is still unclear which interruptions are the most detrimental and how this affects physician productivity.

1.3 | Goals

The objective of this study is to evaluate the effect of pages per hour, as a specific interruption common in our ED, and whether it significantly affects physician productivity as measured by the number of patients seen per hour. We hypothesize that increased task interruption will decrease resident productivity.

2 | METHODS

2.1 | Study design

This is a retrospective analysis of data from resident physician (RP) ED shifts between July 2021 and June 2022 at an academic medical center with an emergency medicine residency program. A total of 2865 RP shifts were collected among emergency medicine postgraduate year (PGY) 1 and PGY 2 residents within 1 complete academic year.

2.2 | Setting

This study was conducted at Beth Israel Deaconess Medical Center in Boston, Massachusetts, which functions as an academic Level 1 Trauma Center and Comprehensive Stroke Center with an annual

census of ~55,000 patients per year. During this study time period, the average daily ED census was 137 patients with a total of 50,263 annual encounters. The average length of stay for admitted patients was 523 min (Q1–Q3: 361–790) and 308 min (Q1–Q3: 214–428) for discharged patients. The residency program at this institution is 3 years in length with a total of 39 residents (13 per class). A total of 2865 RP shifts were collected among emergency medicine postgraduate year (PGY) 1 and PGY 2 residents within 1 complete academic year. RP ED shift length varies between 8 or 9 h, with the vast majority lasting 8 h. Additionally, this institution has a medicine team consisting of an internal medicine resident and attending who take over care for many boarding patients in the ED, which helps to reduce the load on the ED RPs.

2.3 | Selection of subjects

This study evaluated PGY1 and PGY2 emergency medicine residents. Off-service rotating residents and PGY3 emergency residents were excluded from this study. At this institution, PGY3 residents serve primarily in a supervisory role and do not see patients as the primary resident. Therefore, there are very few pages that are sent as duplicates to both the junior resident (PGY1 or PGY2) and the PGY3 resident. However, these pages are prompted to trigger a response from the primary resident while the PGY3 resident oversees to ensure it is done correctly. Therefore, the PGY3 does not field or offload any responsibility from a junior resident that is prompted from an automated page.

2.4 | Exposure and outcome

The number of pages received per hour was our exposure variable, and the number of patients seen per hour was our outcome variable. Through a secure ED database, information was collected on each individual RP shift throughout the study period. For each shift, we identified the number of pages received per hour and the number of new patients seen per hour for each individual RP.

Pages at this institution consist of any transmitted message that was sent to the RP's personal pager device, which includes both automatic and personalized pages. These are tracked through the electronic paging system with timestamps when the message was transmitted. Automatic pages consist of messages regarding bed assignments, acceptance by admitting team, critical lab values, completed registration, and expired restraints. For example, the primary resident will receive an automated page when their patient is assigned a bed, which then prompts that resident to initiate electronic sign-out with the admitting team. The primary resident will receive an automated page when the admitting team accepts the patient, which then triggers the primary resident to place holding orders and allows the patient to be transported to the floor. The number of new patients seen per hour is tracked through automatic timestamps in our electronic health record system.

The Bottom Line

This retrospective analysis examined the relationship between the hourly number of pages received by emergency medicine residents and the number of patients seen per hour. Using Poisson regression, 2,865 shifts were analyzed for 26 residents. The number of pages received was not associated with decreased patients seen per hour.

2.5 | Data analysis

Extracted data were analyzed using Poisson regression controlled for clustering at the physician level to determine if the number of patients seen per hour by RPs is significantly affected by the number of pages they receive per hour. The number of pages received per shift hour was divided into 4 quartiles. For example using hour 3 of the shift, the first quartile was the bottom 25% of pages within that hour (0–1 pages), the second quartile was the lower middle 25% of pages (2–3 pages), the third quartile was the upper middle 25% of pages (4–5 pages) and the fourth quartile was the top 25% of pages within that shift hour (6+ pages). We used these quartiles for every hour of the shift (Table 1). Toward the end of an ED shift (hour 8 and hour), <4% of emergency physicians signed up for new patients. With a known decrease in patients per hour toward the end of the shift and limited paging data extracted, these hours were excluded from the study. This pattern has been previously demonstrated at our institution and is consistent with standard behavior where minimal new patients are seen at the end of a shift.⁸

For each paging quartile, we calculated the coefficient factor of patients per hour for the same hour that the pages were received, 1 h later, 2 h later, and 3 h later. Each coefficient represents the mean difference in patients per hour with lowest quartile of pages as the reference value. Analyses were performed using Stata 18.0 (College Station, Texas). The statistical significance threshold a priori was set at $p < 0.05$. Subsequent hours were used to help evaluate if receiving an increased number of pages has an immediate or downstream effect on ability to pick up more patients.

3 | RESULTS

A total of 2865 RP shifts were collected among the 26 PGY1 and PGY2 residents. The residents combined saw a median of 11 (interquartile range [IQR]: 8, 14) total patients per shift; PGY1 had a median of 8 patients per shift (IQR: 6, 10) versus 14 patients per shift (IQR: 12, 15) for PGY2. For all residents, the median number of patients seen per hour of the shift were as follows: 3 patients at hour 1 (IQR: 2, 4), 2 patients at hour 2 (IQR: 1, 2), 1 patient at hour 3 (IQR: 1, 2), 1 patient at hour 4 (IQR: 1, 2), 1 patient at hour 5 (IQR: 1, 2), 1 patient at hour 6 (IQR: 0, 2), 1 patient at hour 7 (IQR: 0, 1), 0 patients at

TABLE 1 Change in patients seen per hour across paging quartiles.

Hour	Same hour	p value	1 hour later	p value	2 hours later	p value	3 hours later	p value
Hour 3								
Quartile 1: 0–1 pages	reference		reference		reference		reference	
Quartile 2: 2–3 pages	0.09 (0.02–0.16)	0.013	0.10 (0.03–0.17)	0.007	0.16 (0.07–0.25)	0.001	0.15 (0.07–0.22)	<0.001
Quartile 3: 4–5 pages	0.19 (0.12–0.25)	<0.001	0.18 (0.09–0.27)	<0.001	0.24 (0.15–0.32)	<0.001	0.28 (0.20–0.36)	<0.001
Quartile 4: 6+ pages	0.28 (0.19–0.36)	<0.001	0.23 (0.11–0.35)	<0.001	0.35 (0.24–0.46)	<0.001	0.36 (0.26–0.46)	<0.001
Hour 4								
Quartile 1: 0–2 pages	reference		reference		reference		reference	
Quartile 2: 3 pages	0.07 (–0.02–0.16)	0.133	0.12 (0.03–0.22)	0.014	0.12 (0.04–0.20)	0.004	0.11 (–0.02–0.25)	0.109
Quartile 3: 4–5 pages	0.18 (0.07–0.28)	0.001	0.22 (0.14–0.31)	<0.001	0.21 (0.13–0.29)	<0.001	0.29 (0.20–0.37)	<0.001
Quartile 4: 6+ pages	0.23 (0.11–0.35)	<0.001	0.29 (0.19–0.40)	<0.001	0.36 (0.23–0.48)	<0.001	0.43 (0.33–0.54)	<0.001
Hour 5								
Quartile 1: 0–2 pages	reference		reference		reference		reference	
Quartile 2: 3–4 pages	0.15 (0.05–0.24)	0.003	0.21 (0.13–0.29)	<0.001	0.07 (–0.01–0.14)	0.098	0.08 (–0.11–0.26)	0.401
Quartile 3: 5–6 pages	0.24 (0.15–0.34)	<0.001	0.24 (0.12–0.35)	<0.001	0.16 (0.05–0.27)	0.004	0.14 (–0.09–0.37)	0.237
Quartile 4: 7+ pages	0.34 (0.21–0.48)	<0.001	0.41 (0.27–0.55)	<0.001	0.48 (0.38–0.58)	<0.001	0.52 (0.30–0.74)	<0.001
Hour 6								
Quartile 1: 0–2 pages	reference		reference		reference		reference	
Quartile 2: 3–4 pages	0.21 (0.12–0.30)	<0.001	0.10 (–0.002–0.21)	0.055	–0.08 (–0.24–0.09)	0.382	0.24 (–0.39–0.87)	0.457
Quartile 3: 5–6 pages	0.31 (0.19–0.44)	<0.001	0.26 (0.12–0.40)	<0.001	0.05 (–0.14–0.24)	0.592	0.97 (0.40–1.54)	0.001
Quartile 4: 7+ pages	0.39 (0.25–0.54)	<0.001	0.39 (0.28–0.51)	<0.001	0.13 (–0.06–0.32)	0.168	1.27 (0.82–1.72)	<0.001

hour 8 (IQR: 0, 1), and 0 patients at hour 9 (IQR: 0, 0). The residents in total received a median of 27 (IQR: 19, 39) pages per shift. PGY1 received a median of 20 pages per shift (IQR: 14, 27) versus 35 (IQR: 26, 46) for PGY2 ($p < 0.001$). We found the number of pages received per hour did not decrease the number of patients seen per hour. Contrary to our hypothesis, there was a strong positive relationship between the number of pages received per hour and the number of patients seen in that hour and subsequent hours. During the middle of a shift (hours 3, 4, and 5), RPs receiving pages in the third and fourth quartile demonstrated a positive relationship with the number of patients seen during that same hour and the next hour ($p < 0.001$) (Table 1) compared to patients in the first quartile. Overall, there was a consistent increase in patient load as the number of pages received per hour increased. This positive relationship was consistent for every hour of the shift (hour 1 through hour 8) and consistent for every increasing paging quartile (2 through 4). Therefore, contrary to our hypothesis, an increased number of pages was not associated with a decrease in the number of patients seen per hour by resident physicians.

4 | LIMITATIONS

Although this study was performed at a large academic, tertiary care center, the data are limited to a single institution ED and evaluated

only RPs. This may limit both the generalizability of the conclusions and introduce institution and practice-specific bias, as different centers may have inherent deviation in acuity, volume, paging methods, and physician efficiency. In addition, this study was performed retrospectively, which allows for the possibility of covariates and potential confounders. We did not control for patient acuity, individual RP characteristics, or type of shift worked. Additionally, we did not differentiate the nature of each page and whether it contained high-acuity versus low-acuity information.

Given that correlation does not always infer causation, it is not appropriate to conclude that if RPs receive more pages, they will consequently see more patients. The sample size of this study was small with a total of 26 RPs, of which speed and efficiency vary and is therefore not fully representative of all RPs in training. Further research across multiple institutions and EDs would be beneficial to improve generalizability.

5 | DISCUSSION

Contrary to our hypothesis, an increased number of pages does not decrease RP efficiency as measured by number of patients seen per hour. Instead, our data demonstrate that there is a positive relationship between the number of pages RPs receive and the number of patients they see in that hour and subsequent hours.

There are several possible explanations for this observation. Namely, patient load could be driving the positive relationship between pages and patients seen per hour as the more patients an RP sees, the more pages that are generated simply from carrying an increased patient load. Individual RP characteristics are likely contributing as well; RPs who typically see a large volume of patients overall (and thus generate a large volume of pages) are likely to continue to see a large volume of patients throughout the entirety of their shift. The overall volume of the department during a shift can also be contributory. If there is sufficiently high volume for an RP to see many patients and therefore generate a large number of pages, there probably will be persistently high volumes at subsequent hours leading to more patients seen per hour due to demand. Although we did not control for shift type worked, PGY-1 and PGY-2 RPs at our institution work a similar distribution of shifts and we expect their exposure to high patient volume hours is distributed evenly.

Even though individual shift volume, intrinsic physician factors, and overall department volume might explain the positive relationship observed, our analysis still reveals that during the main part of a shift, RPs are able to see more patients in subsequent hours if they received more pages. Importantly, productivity does not appear to be inhibited by the higher number of paging interruptions. This suggests that although some previously studied interruptions might decrease productivity, interruptions received via a page could actually help increase emergency physician productivity. Although we define receiving a page as a task interruption, we do not know whether the RP actually checked the message when it was received on their pager. It is possible RPs are batching their review of pages and rather than being interrupted in the midst of cognitive or physical task, they are actually inputting the interruption into their own workflow. This could explain the positive relationship observed, as batching pages and reviewing them at opportune times would represent more of a "controlled" interruption, as the RP can choose when to look at and when to act on the message.

There are other reasons why pages may actually increase productivity. We speculate that many pages contain disposition-changing data that would allow the RP to advance a patient's care plan. For example, if an RP receives a page informing them that their patient is ready for discharge or that the patient has a bed assignment, the RP has now removed a patient from their workload and has new bandwidth to pick up more patients. Another example could be if an RP receives a page about an abnormal lab value that will now require admission, this automatically creates a disposition for the patient. Thus, pages that contain disposition-changing data may help to offload an RP's cognitive load and thereby free capacity to pick up new patients.

Overall, our data suggest that increased number of pages does not negatively affect clinical productivity or efficiency. The AAEM Clinical Practice Committee released a statement in early 2022 regarding interruptions in the ED that emphasized the point that "not all inter-

ruptions are bad." In fact, many interruptions in the ED are necessary and lifesaving. Further research is required to identify which interruptions are problematic and which ones we should aim to lessen. This study illustrates that pages are likely not a harmful subtype of interruptions and may, in fact, be helpful. ED operations and education leaders should assess possible opportunities for incorporating paging systems into ED workflows. Further studies need to be performed to help identify which interruptions are detrimental and worth attempting to eliminate.

AUTHOR CONTRIBUTIONS

Alyssa Mangino, Bryan A. Stenson, and David T. Chiu conceived the study and designed the analysis. Evan L. Leventhal and David T. Chiu led the data collection. Alyssa Mangino and Bryan A. Stenson conducted the data analysis, statistics and drafted the manuscript. Evan L. Leventhal, Deesha Sarma, Peter S. Antkowiak and David T. Chiu contributed to manuscript revising. Alyssa Mangino and Bryan A. Stenson take responsibility for the manuscript as a whole.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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