

Original Contributions

QUANTIFYING EMERGENCY PHYSICIAN INTERRUPTIONS DUE TO ELECTROCARDIOGRAM REVIEW

Kimon L. H. Ioannides, MD,* Daniel James Brownstein, BS† Andrew J. Henreid, BA,‡ Sam S. Torbati, MD,‡ and
Carl T. Berdahl, MD MS‡

*Department of Emergency Medicine, University of California Los Angeles, Los Angeles, California, †David Geffen School of Medicine, University of California Los Angeles, Los Angeles, California, and ‡Department of Emergency Medicine, Cedars-Sinai Medical Center, Los Angeles, California

Reprint Address: Kimon L.H. Ioannides, MD, National Clinician Scholars Program and Department of Emergency Medicine, University of California Los Angeles, 1100 Glendon Ave, Suite 900, Los Angeles, CA 90024

Abstract—Background: Interruptions are recognized as potentially harmful to safety and efficiency, and are especially prevalent in the emergency department (ED) setting. Policies urging immediate review of all electrocardiograms (ECGs) may lead to numerous and frequent interruptions. **Objective:** We assessed the role of ECG review as a source of ED interruptions to characterize a potential target for interventions. **Methods:** We analyzed emergency physician time use during the course of a clinical shift using a time-and-motion design. A research assistant observed a convenience sample of shifts, observing and logging transitions between different tasks using an electronic device. Instances of ECG review were tallied, with start and ending times of ECG review recorded to the nearest second. An ECG review was considered an interruption if the immediate prior and subsequent tasks were the same. **Results:** Twenty shifts were observed for a total of 149 h. There were 211 ECG reviews, (mean rate 1.4 per hour), with more frequent review among physicians staffing a zone with higher-acuity patients (2.8 per hour), where clustering of multiple ECG reviews in succession was more common. Seventy-five percent of ECG reviews required < 30 s. Of all 211 ECG reviews, 102 (48%) were an interruption. The tasks most frequently interrupted were electronic medical record system use (68 of 102, 67%) and communicating with ED staff in person (18 of 102, 18%). **Conclusions:** Review of ECGs was a substantial driver of interruptions for emergency physicians. Interventions to integrate ECG review more naturally into physician

workflow may improve patient safety by reducing these interruptions. © 2020 Elsevier Inc. All rights reserved.

Keywords—interruptions; electrocardiogram interpretation; time-in-motion

INTRODUCTION

“Doc, can you sign this ECG [electrocardiogram]?” Every emergency physician has heard this, perhaps multiple times during a shift. Although interruptions like this have long frustrated emergency department (ED) staff, they are still often perceived as intrinsic and unavoidable aspects of emergency care. However, systems of emergency care in many ways exist largely to streamline workflows and minimize intrusions into an otherwise “interrupt driven” workflow (1). In other fields, for example, among airplane pilots, interruptions have long been explicitly recognized as a serious threat to safety and team effectiveness, but even though interruptions in the ED are common, they have only recently been recognized by professional societies as threats to patient safety and provider wellness (2,3).

Research into direct impact of interruptions on patient care is sparse. Observational studies have noted the harmful effects of interruptions on nurses, radiologists, and

Table 1. Observed Emergency Physician Task Types

Task	Total Duration, in Hours (%)	Number of Task Instances	ECG Interruptions (Interrupted for ECG Review)	
			Number of Task Instances (%)	
Reviewing an ECG	1.4 (0.9%)	211	n/a	
Direct patient care	43.4 (29.0%)	1091	2 (2.0%)	
Electronic medical record system use	50.8 (34.0%)	2519	68 (66.7%)	
Communicating with ED staff in person	20.0 (13.4%)	1950	18 (17.6%)	
Communicating via telephone	14.6 (9.8%)	748	5 (4.9%)	
Personal tasks	6.4 (4.3%)	205	0 (0%)	
Miscellaneous	12.8 (8.6%)	2381	9 (8.8%)	
Total	149.4 (100%)	9105	102 (100%)	

ECG = electrocardiogram; ED = emergency department.

primary care physicians (4–6). Qualitatively, emergency physicians employ a number of mechanisms to compensate for interruptions, including stopping the interrupted task, ignoring the interruption, multitasking, or “task switching” (7,8). However, these strategies increase cognitive load and lead to errors: experimental evidence has suggested that multitasking can cause mistakes in diagnostic decision-making and medication prescribing (9–11). Furthermore, interruptions have been shown to worsen physician workload, provider stress, perceived quality of care, and patient satisfaction, as well as efficiency, in particular for cognitively complex tasks among novice practitioners (12–17). Whereas general interventions to reduce interruptions are supported by only weak evidence, targeted interventions to reduce specific types of interruptions have shown more promise (18,19). Herein, we examine the role of ECG review as a source of inter-

ruptions in the ED, and assess its suitability as a target for interventions to reduce harm to patients. Specifically, we quantify the frequency and duration of interruptions to review ECGs (hereafter called ECG interruptions), and assess which tasks were most frequently interrupted for ECG review.

MATERIALS AND METHODS

We performed a secondary analysis of an observational, cross-sectional time-and-motion study of emergency physician time use during the course of a clinical shift (primary study currently under review) as recorded by an observer using an online application (20). A trained research assistant (who understood the broader objective to understand physician efficiency, but was not aware of any particular hypothesis or interest relating to interruptions or ECGs) “shadowed” a convenience sample of

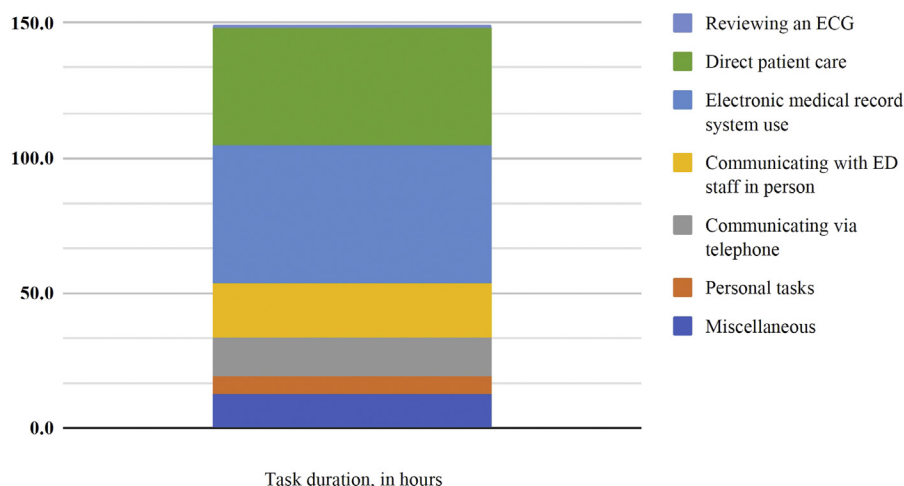
Duration of Emergency Physician Tasks

Figure 1. Duration of emergency physician tasks. Stacked bar chart showing duration of time occupied by each task category amongst all physician shifts observed. ECG = electrocardiogram; ED = emergency department.

Table 2. ECG Interruptions to Emergency Physicians

ED Zone	Number of Shifts	Time Observed, in hours	ECG Review, n = 211			ECG Interruptions, n = 102		
			Duration, Minutes per hour	Number of ECGs per hour	Mean Duration, Minutes per ECG (Equivalent in seconds)	Duration, Minutes per hour	Number of ECGs per hour	Mean Duration, Minutes per ECG (Equivalent in Seconds)
High-acuity	5	40.2	1.1	2.8	0.4 (23 s)	0.5	1.4	0.4 (21 s)
Medium-acuity	12	88.5	0.4	1.0	0.4 (23 s)	0.2	0.4	0.4 (24 s)
Low-acuity	3	21.4	0.2	0.6	0.4 (21 s)	0.1	0.3	0.4 (22 s)
Total	20	150.1	0.5	1.4	0.4 (23 s)	0.2	0.7	0.4 (23 s)

ECG = electrocardiogram; ED = emergency department.

daytime emergency physicians (with the physicians' consent) throughout an 8–9-h clinical shift (one shift per physician, with sample size determined after consultation with time-and-motion experts), except for a short lunch break, and for direct patient interactions (patient consent was not obtained because the study posed only very minimal risk to patients, in accordance with our Institutional Review Board). The study took place at Cedars-Sinai Medical Center in Los Angeles, California, a busy urban referral center with some academic programs, but with most care not provided by trainees, and physician-staffed high-, medium-, and low-acuity clinical areas. Using an online application (TimeCaT version 3.9, available at <https://lopetegui.net/timecat/39/>), the nature of activities the physician performed and the beginning and ending times of each task were noted to the nearest second. During a preceding pilot observation of a 4-h portion of a single emergency physician shift (that was not included in this study), the research assistant labeled tasks with as much detail as possible in real time. This list of tasks was subsequently narrowed by consensus with the study team to a classification that could realistically be sustained throughout a shift. Ultimately, tasks were categorized as either reviewing an ECG, direct patient care, electronic medical record system use, communicating with ED staff in person, communicating via telephone, personal tasks, or miscellaneous (a few tasks accounting for < 1% of time observed were later folded into this category). Instances of ECG review were abstracted from these data, with counts and duration of ECG review tallied on a per-hour basis. A task was defined as an *interruption* if the physician subsequently returned directly to their prior task. Data were tabulated using Tableau Desktop version 2019.4 (Tableau Software, Seattle, WA).

RESULTS

Twenty emergency physician shifts were observed for a total of 149.4 h, a mean of 7.5 h each (Table 1 and Figure 1). One physician in the medium-acuity zone did not record any ECG-related tasks during the observation period, but was still included in the analysis. There were 211 ECG reviews observed, a rate of 1.4 per hour, on average (Table 2). This rate was increased among physicians staffing a zone with high-acuity patients, 2.8 per hour, with a suggestion of more temporal clustering among higher acuity shifts (Figure 2). Time required to review each ECG demonstrated a right skew (Figure 3), with < 25% of ECGs requiring more than 30 s. Of all 211 ECG reviews, 102 (48%) were an interruption, highest among all tasks. The most frequent task overall was electronic medical record system use (Figure 1), and this was also the task most frequently interrupted by an ECG, but with a share roughly twice the underlying share

of all time devoted to electronic medical record system use (68 of 102 interruptions, 67%, vs 34% of time, Table 1).

DISCUSSION

We find that prompts to review ECGs are a significant source of interruptions during emergency physician shifts, particularly in our high-acuity areas. Prior studies have shown that emergency physicians are interrupted between 5.6 and 12.3 times per hour, more than other specialties, and especially in academic EDs (21–25). Our study adds to this literature by providing specific data on interruptions for ECG review. Although these interruptions are anecdotally known to be irritating to many emergency physicians, we provide data on how they may actually impact workflow. Though most of these interruptions last just seconds, their impact on productivity may be magnified by their tendency to cluster in short temporal succession, in particular during physician ordering or charting in the electronic medical record.

Departmental policies requiring emergency physician review of ECGs largely grew from a 2004 American Heart Association guideline based on a Class 1C recommendation (strong recommendation with limited data) that patients with any anginal equivalent should have an ECG performed and reviewed by an emergency physician within 10 min of arrival (26). Although simulation studies have shown that interruptions lead to more errors in ECG review, we know of no structured assessments of the converse: what is the impact of ECG interruptions on

emergency care overall (8)? We hope this study can provide preliminary data that prompt institutions to consider interventions that reduce ECG interruptions and may ultimately allow inference of potential benefits to overall patient care from reductions in interruptions overall, as well as ECG interruptions specifically. As Raban et al. have noted, interventions that target specific sources of interruptions have demonstrated more promising benefits than general interruption reduction interventions, and our findings suggest that ECGs may be a fruitful starting point (18). With some arguing that a computerized ECG interpretation reading “normal ECG” dramatically reduces the risk of time-sensitive pathology, batching or delaying interpretation of such ECGs so they can be reviewed consecutively or in the course of bedside clinical care may be one strategy to reduce the impact of interruptions (27).

Limitations

Because we observed physicians at only one hospital, external validity to other settings is necessarily limited. However, because our setting has relatively few trainee physicians and because trainees are not responsible for acknowledging ECGs, it more closely approximates a community hospital than an academic center in this respect. We are also unable to distinguish between interruptions attributable to different types of ECGs, for example, those performed at triage or those ordered for a patient already under a physician’s care, and for which

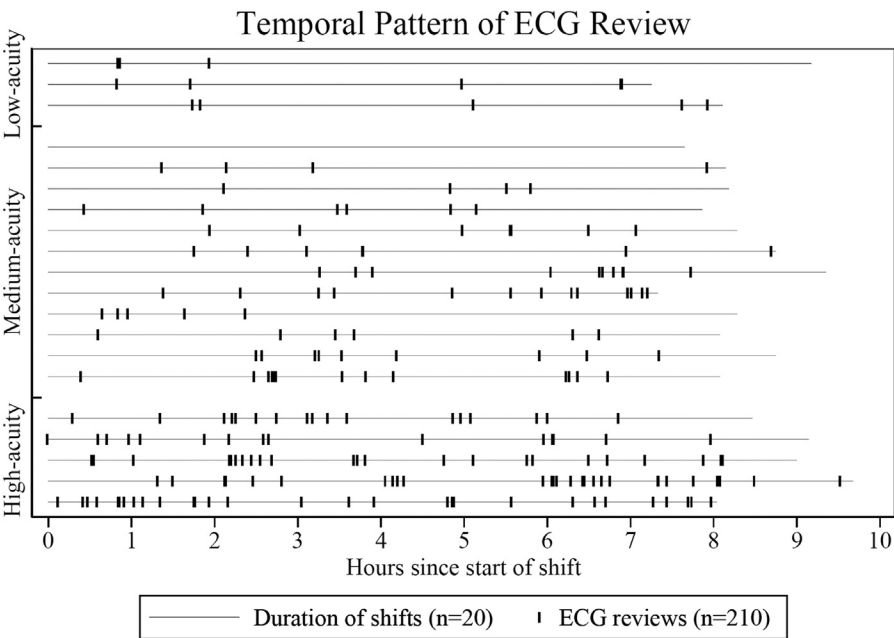


Figure 2. Temporal pattern of electrocardiogram (ECG) reviews during shifts. Each vertical bar represents an instance of ECG review within a shift, which is represented as a horizontal line. ECG reviews were more frequent during high-acuity shifts, and tended to cluster in close sequence.

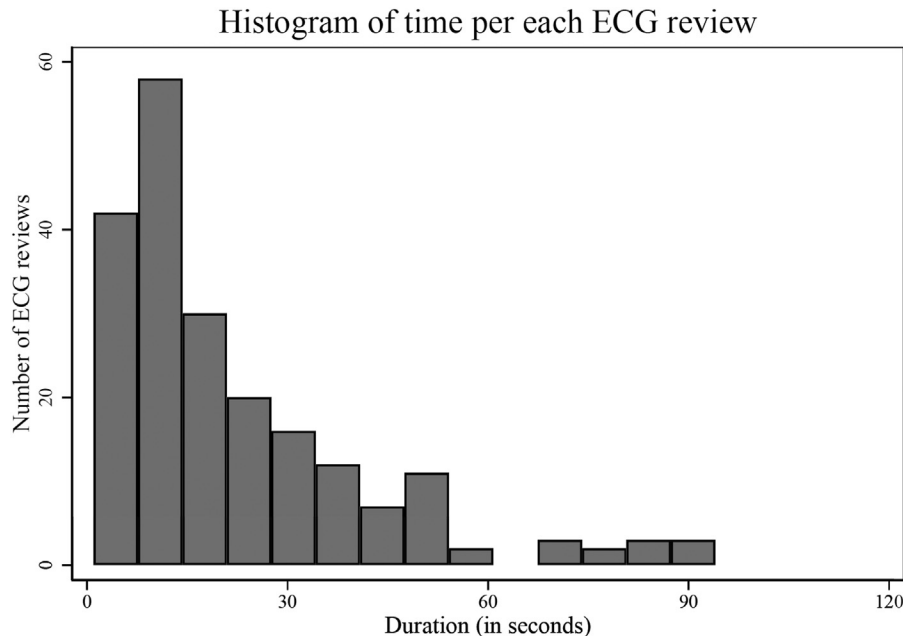


Figure 3. Histogram of time per each electrocardiogram (ECG) review. The right skewed distribution of ECG review time, with median of 16 s less than mean of 23 s. A single ECG review lasting more than 3 min (190 s) is censored from this graph, but still included in analysis.

the physician may want to be interrupted; however, in our clinical experience at this site, the majority of tracings interpreted during high-acuity zone shifts are screening ECGs for patients not yet assigned to a physician. Likewise, we were unable to categorize the broad category of electronic medical record use into more granular tasks. Additionally, what constitutes an interruption is necessarily subjective, so we have chosen a definition that is conservative for short duration tasks like ECG review because after some interruptions a physician may be distracted or unable to return to their prior task. For other task types of longer duration, a physician may incidentally return to their prior task, making our definition less appropriate for this purpose. Finally, without any exogenous variation in the number of interruptions, we are unable to evaluate their impact on patient-centered outcomes with the current data, but we hope to perform such evaluations in future studies.

CONCLUSION

Immediate review of ECGs was a substantial driver of interruptions for emergency physicians. Interventions to batch ECGs or integrate review more naturally into physician workflow may improve patient safety by reducing these interruptions.

Acknowledgments—Dr. Ioannides was supported by the UCLA National Clinician Scholar Program at the David Geffen School

of Medicine, University of California, Los Angeles, United States at UCLA, which provided in-kind support to this study.

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ARTICLE SUMMARY

1. Why is the topic important?

Immediate electrocardiogram (ECG) review policies could undermine patient safety by increasing interruptions.

2. What does this study attempt to show?

ECG review may substantially disrupt physician workflow.

3. What are the key findings?

The overall average of 1.4 ECG reviews per hour was increased to 2.8 per hour during shifts in a high-acuity zone, where they tended to cluster in close succession.

4. How is patient care impacted?

Departments may consider policies to integrate ECG review more naturally into physician workflow.