Characterizing Multitasking and Workflow Fragmentation in Electronic Health Records among Emergency Department Clinicians: Using Time-Motion Data to Understand Documentation Burden

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Abstract

Background The impact of electronic health records (EHRs) in the emergency department (ED) remains mixed. Dynamic and unpredictable, the ED is highly vulnerable to workflow interruptions.

Objectives The aim of the study is to understand multitasking and task fragmentation in the clinical workflow among ED clinicians using clinical information systems (CIS) through time-motion study (TMS) data, and inform their applications to more robust and generalizable measures of CIS-related documentation burden.

Methods Using TMS data collected among 15 clinicians in the ED, we investigated the role of documentation burden, multitasking (i.e., performing physical and communication tasks concurrently), and workflow fragmentation in the ED. We focused on CIS-related tasks, including EHRs.

Results We captured 5,061 tasks and 877 communications in 741 locations within the ED. Of the 58.7 total hours observed, 44.7% were spent on CIS-related tasks; nearly all CIS-related tasks focused on *data-viewing* and *data-entering*. Over one-fifth of CIS-related task time was spent on multitasking. The mean *average duration* among multitasked CIS-related tasks was shorter than non-multitasked CIS-related tasks (20.7 s vs. 30.1 s). Clinicians experienced 1.4 ± 0.9 task switches/min, which increased by one-third when multitasking. Although multitasking was associated with a significant increase in the *average duration* among *data-entering tasks*, there was no significant effect on *data-viewing* tasks. When engaged in CIS-related task switches, clinicians were

Keywords

- electronic health records
- time-motion studies
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- physician assistants
- documentation burden
- emergency department

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more likely to return to the same CIS-related task at higher proportions while multitasking versus not multitasking.

Conclusion Multitasking and workflow fragmentation may play a significant role in EHR documentation among ED clinicians, particularly among *data-entering* tasks. Understanding where and when multitasking and workflow fragmentation occurs is a crucial step to assessing potentially burdensome clinician tasks and mitigating risks to patient safety. These findings may guide future research on developing more scalable and generalizable measures of CIS-related documentation burden that do not necessitate direct observation techniques (e.g., EHR log files).

Background and Significance

The Health Information Technology for Economic and Clinical Health (HITECH) Act and Meaningful Use incentives dramatically altered the health care regulatory environment. While these initiatives facilitated the rapid implementation of electronic health records (EHRs), they have also contributed to EHR documentation burden among physicians—defined as added work (e.g., documentation) or actions (e.g., clicks) performed in the EHR beyond that which is required for good clinical care.[1] Historically, clinical documentation served as a conduit for communicating clinically relevant information (e.g., patient narratives) among staff[2]; however, EHR design and development have unwittingly shifted the focus of EHR clinical documentation from clinical decision-making, to reimbursement and regulatory reporting.[3] EHRs have significantly enhanced accessibility to patient information, improving diagnostic accuracy,[4] and care quality[5]; however, EHRs have been significantly associated with increased documentation time, reduced direct patient contact, and added cognitive burden.[6] Evidence demonstrates these factors contribute to clinician burnout, defined as long-term work-related stress.[3,7–9] Nearly half of physicians in the U.S. report experiencing some degree of burnout,[10] which is particularly prevalent among emergency department (ED) physicians.[3,10]

The ED is a high-intensity and high-volume setting dictated by patient acuity and frequently shifting care priorities, rendering the ED highly vulnerable to workflow changes.[11] Compared with their primary care counterparts, ED physicians experience three times more interruptions per hour which is greater in academic than community practice settings.[12] Interruptions and distractions often result in task-switching[13] defined as "the alternating or changing between two separate tasks sometimes rapidly but observably"[14] and/or multitasking defined as "the observable performance of two or more tasks" concurrently.[15,16] Diverting attention from a primary task, interruption and distractions impede decision-making capacities[15] and thought processes. Past studies suggest that interruptions and distractions are a major cause of clinical errors, posing a risk to patient safety and care quality.[13] Research demonstrates that perceived interruptions and distractions among ED physicians alone may exacerbate existing cognitive fatigue associated with actual experience of interruptive or disruptive events, and may further contribute to provider burnout.[17]

While the sources of interruptions and distractions in the ED are multifaceted,[11] studies investigating the added role of EHRs and other clinical information systems (CISs) on the ED workflow remain mixed.[6,18] In some studies, limited usability and integration of EHRs into the clinical workflow[19] coupled with more stationary work,[6] have been shown to exacerbate multitasking and fragmentation in the ED workflow.[6] However, the ED practice environment is also intrinsically chaotic and prone to interruptions and multitasking. Coiera and colleagues found that approximately one-third of communication events in the ED were interruptive, while one-tenth involved multiple simultaneous conversations.[20] Multitasking and interruptions may benefit patients and staff by expediting communication and the timely passage of essential information.[13] This tradeoff between efficiency and safety in the ED is poorly understood.[13,21]

Prior studies have employed laboratory-based simulations[21] and time-motion studies (TMSs) to examine ED physician activities and task times,[11,12,22] and EHR log files to investigate the relationship between physician EHR use and ED throughput and efficiency,[19] but few have specifically examined CIS-related fragmentation in ED workflows as a potential measure of documentation burden.[7,19,21,23] We previously reported the results of our interprofessional TMS data across four practice settings (i.e., ED, ambulatory, acute care, intensive care) where we examined workflow fragmentation and the nature of task switches among advanced practice providers and registered nurses. We found that task-switching may serve as a proxy measure for *burden*.[23] In this analysis, we further investigate multitasking and workflow fragmentation as potential proxies for measuring CIS-related documentation burden among ED clinicians using these TMS data.

Objectives

The aim of the study is to inform our understanding of multitasking and fragmentation in the ED clinical workflow as potential measures of CIS-related documentation burden using TMS data and how they can be applied to more robust and generalizable measures of *burden*.

Methods

Study Setting and Data Collection

Between January 2019 and January 2020, we conducted TMS observations in the ED of a large, urban northeastern medical center in the United States for a wider evaluation study on the implementation of a new commercial EHR system. During this pre-implementation phase of the project, the ED operated under the Allscripts Sunrise EHR system. A locally developed, interoperable system for viewing archived patient data across multiple EHRs was also available. Fifteen clinicians, including 10 resident physicians and five physician assistants, were invited to join the study based on their availability and willingness to participate. Trained observers, defined as observers who obtained adequate reliability scores on three domains (i.e., proportion, duration and sequence) described in Lopetegui et al within two of three reliability sessions and demonstrated an upward improvement trend,[24,25] consented each participant prior to observation sessions; all data were collected anonymously. Additional details regarding the observer training process and calculation of interobserver reliability scores are described elsewhere.[24,25] Observers performed observations on weekdays and weekends for both day and night shifts (►Fig. 1). Using an interprofessional taxonomy that our team developed and validated in a previous study,[24] observers followed clinicians for 3 to 4 hours at a time. Observers used tablets and the Time Capture Tool (TimeCAT)[25] to concurrently capture tasks clinicians performed, their physical location, and the communication activities they engaged in. TimeCaT is a time-motion web application that supports the ability to simultaneously and electronically record task, location, and communication data,[25] and subsequently, capture instances of multitasking.[16] According to Lopetegui et al,[25] the three overarching groups consist of mutually exclusive tasks where logistically, within-group tasks cannot be performed concurrently; therefore, only physical tasks and communication tasks can be multitasked (e.g., data viewing while talking on phone).

The interprofessional taxonomy is comprised of three broad functional categories: (1) physical tasks performed by the clinician, including CIS-related tasks, defined as any of the following 12 tasks requiring the EHR or other computerized systems (e.g., telemetry monitor): *viewing patient list/schedule, viewing data, entering orders, entering data, smartphone clinical messaging app, log into EHR, documenting handoff/sign-out, transcribing, medication reconciliation, log out of EHR, medication administration,* and *use of other CIS*, such as telemetry monitor; (2) clinician physical location: *hallway, inaccessible patient room, patient room, supply room or medication administration room, team area, waiting room*; and, (3) communication clinicians engaged in: *handoff/sign-out, phone talking, rounding and meetings, verbal care-related with staff, verbal non-care-related with staff, verbal with patient or family, code or rapid response team*. Further information regarding the development of the taxonomy is described elsewhere.[24] We conducted descriptive and sequence analyses to assess: (1) EHR documentation burden, (2) workflow fragmentation,[26] and (3) multitasking.[16]

Study Measures

EHR Documentation Burden

We operationalize EHR documentation burden as *data-entering* or *data-viewing* tasks involving the EHR. *Data-entering* tasks consist of: *entering orders, entering data,* and *documenting handoff/sign-out*. *Data-viewing* tasks consist of: *viewing patient list/schedule* and *viewing data*.

Multitasking

Multitasking is defined as observably engaging in two or more concurrent tasks.[16] We operationalize multitasking as performing a physical task (including CIS-related tasks) and communication task simultaneously[16,25] as two within-group tasks cannot be practically performed concurrently (e.g., order entry and medication reconciliation).[25] We performed calculations for the duration of multitasking by aligning the clock time of concurrent sequences of physical tasks and communication tasks to the second within each observation; one physical task recorded may be divided into multiple tasks depending on the presence of communication tasks (►Fig. 2). We examined the top 80% task pairs (i.e., physical and communication) that were frequently multitasked.[27]

Workflow Fragmentation

Consistent with our previous analysis,[23] we used Zheng and colleagues' workflow quantifiers to examine task-switching.[26]

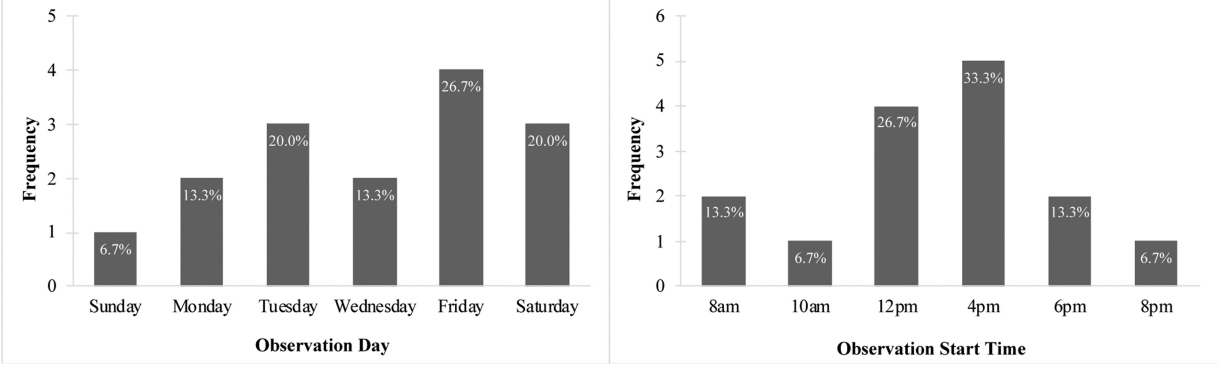

Fig. 1 Distribution of observation days and start times in the emergency department.

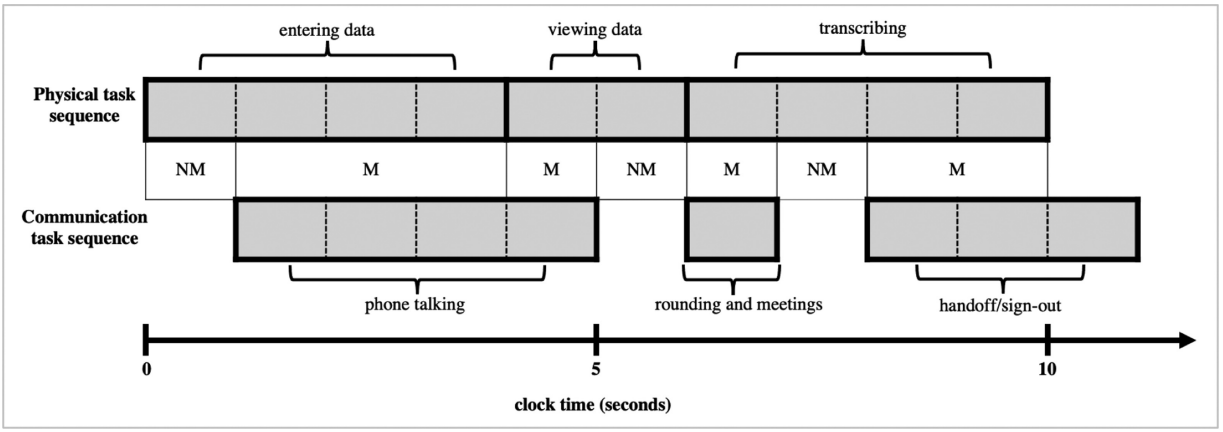

Fig. 2 Fictional workflow demonstrating the alignment and calculation of the duration of multitasking between physical and communication task sequences based on clock time. The figure above, depicts three physical and three communication tasks at baseline which, combined, generate three non-multitasked and four multitasked tasks. M, multitasked; NM, not multitasked.

We operationalized: (1) *workflow fragmentation*[26] as the frequency of task-switches that occur *per minute* (i.e., *task-switch rate*) for each observation, and (2) *magnitude of workflow fragmentation*[26] as the average *seconds(s)* spent on a single task (i.e., *average duration*) prior to switching to another task in the workflow for each observation. We note that we do not assume that actual task durations were captured without interruption. We performed two-sided Welch's *t*-tests to assess whether significant differences in *average duration* existed between tasks that were multitasked and non-multitasked.

Results

We captured 58.7 hours of data in the ED across 15 observations. The largest proportion of observations was conducted on Fridays (26.7%) and evenings (53.3%) (►Fig. 1). Among the 15 observations (►Table 1), 5,061 physical tasks and 877 communication tasks were captured among 741 locations in the ED. Of those, four tasks had no duration and were not included in the analysis. Most clinicians were aged 25 to 34 (73.3%); clinician sex and years of clinical experience were largely balanced across within demographic categories (►Table 1). Of the 58.7 hours observed, 44.7% (26.2 hours) were spent on CIS-related tasks. For both non-CIS-related tasks and CIS-related tasks, the majority were performed in the *hallway* (39.1 vs. 48.2%), *team area* (13.5 vs. 50.8%), and *patient room* (22.9 vs. 0.6%) (►Fig. 3). When multitasking, the top three communication tasks were similar regardless of whether they were multitasked with a non-CIS-related task or CIS-related task, respectively; communication primarily involved *verbal with patient or family* (57.1 vs. 5.8%), *verbal care related with staff* (36.2 vs. 66.9%), and *phone talking* (5.9 vs. 20.8%).

EHR Documentation Burden

Data-viewing and *data-entering* tasks accounted for 94.7% of the 2,827 CIS-related tasks captured (►Table 2). *Data-viewing* represented over two-thirds of CIS-related tasks, while *data-entering* represented nearly a quarter of CIS-related tasks. Overall, *data-entering* tasks had longer *average durations* than *data-viewing* tasks at baseline. These baseline *average durations* for CIS-related tasks were reported in our previous paper (►Table 2).[23]

Multitasking

Triangulating physical ($n = 5{,}057$) and communication ($n = 877$) task sequences (►Fig. 2) to appraise multitasking, we identified 6,646 tasks among the 15 observations. Forty-four percent of the total observation time was spent multitasking with communication tasks—the majority of which involved *verbal with patient or family* (45.7%), *verbal care-related with staff* (43.1%), and *phone talking* (9.3%). Furthermore, 21.9% of the time spent performing a physical task and communication task involved a CIS-related task (►Table 2). Multitasking among non-CIS-related tasks was largely performed in the *hallway* (45.6 vs. 54.1%), *patient room* (35.0 vs. 2.4%), and *team area* (17.9 vs. 43.2%; ►Fig. 3). The top ranked 80.0% multitasked non-CIS-related tasks involved the following communication tasks: *verbal care-related with staff* (48.8%), *verbal with patient or family* (46.4%), and *phone talking* (4.8%); the top three represented were *other and verbal care-related with staff* (33.3%), *other and verbal with patient or family* (28.1%), *travel and verbal care-related with staff* (10.3%; ►Fig. 4). Meanwhile, the top ranked 80.0% multitasked CIS-related tasks involved the following communication tasks: *verbal care-related with staff* (84.5%) and *phone talking* (15.4%); the top three represented were *viewing patient list/schedule and verbal care-related with staff* (33.2%), *viewing data and verbal care-related with staff* (22.4%), and *entering data and verbal care-related with staff* (14.8%).

Workflow Fragmentation

On average, ED clinicians experienced 1.4 ± 0.6 task switches/min among physical tasks alone (reported in our previous study[19]) and 1.9 ± 0.7 task switches/min while multitasking with communication tasks. The *average durations* among multitasked and non-multitasked CIS-related tasks were 20.7 s and 30.1 s, respectively (►Table 2). Multitasked CIS-related tasks on average had shorter *average durations* for all tasks compared with non-multitasked

Table 1 Clinician demographics, task-switching, and time multitasked stratified by health care professional role

	Resident physician *N* (%)	Physician assistant *N* (%)	Overall *N* (%)
Total[a]	10 (66.7)	5 (33.3)	15 (100.0)
Sex			
Female	3 (30.0)	3 (60.0)	6 (40.0)
Male	5 (50.0)	1 (20.0)	6 (40.0)
Unknown/Not specified	2 (20.0)	1 (20.0)	3 (20.0)
Age			
25–34	8 (80.0)	3 (60.0)	11 (73.3)
45–54	–	1 (20.0)	1 (6.7)
Unknown/Not specified	2 (20.0)	1 (20.0)	3 (20.0)
Years of clinical experience			
<1	3 (30.0)	–	3 (20.0)
1–2	2 (20.0)	–	2 (13.3)
3–5	3 (30.0)	3 (60.0)	6 (40.0)
21+	–	1 (20.0)	1 (6.7)
Unknown/Not specified	2 (20.0)	1 (20.0)	3 (20.0)
	Mean ± SD (per minute)	Mean ± SD (per minute)	Mean ± SD (per minute)
Task switch rate			
Overall	1.4 ± 0.6	1.5 ± 0.5	1.4 ± 0.6
Factoring multitasking	1.9 ± 0.8	1.9 ± 0.6	1.9 ± 0.7
	Proportion of time mean (%)	Proportion of time mean (%)	Proportion of time mean (%)
Time multitasked			
Overall	44.8	41.8	43.8
CIS-related tasks	9.8	9.6	9.7
Non-CIS-related tasks	35.0	32.4	34.0

Abbreviation: SD, standard deviation.
[a]Row percentage.

with the exception of *viewing patient list/schedule* (17.2 s vs.16.3 s), *viewing data* (22.5 s vs.18.4 s), and *medication reconciliation* (44.0 s vs. 33.1 s) (►**Table 2**). These between-group differences in *entering orders* ($p < 0.001$), *entering data* ($p < 0.001$), and *documenting handoff/sign-out* ($p = 0.04$) were statistically significant (i.e., significantly lower when multitasking; ►**Table 2**); differences in *viewing data* trended toward significance ($p = 0.07$).

After stratifying CIS-related task-switches by multitasked and non-multitasked tasks (►**Fig. 5A** and **B**), we found that clinicians were more likely to *switch from* the same task following multitasking compared with non-multitasking in all CIS-related switches (10.0–87.2% difference among tasks) with the exception of *transcribing*, which was higher among non-multitasked tasks (0.0% multitasked vs. 10.0% non-multitasked). Clinicians also *returned to* the same CIS-related task at larger proportions (12.0–100.0% difference; ►**Fig. 5C** and **D**) following multitasking compared with non-multitasking in all CIS-related switches with the exception of *log into EHR* (9.1% multitasked vs. 30.0% non-multitasked); the greatest differences in distribution of task switches were observed among *medication reconciliation* (87.5% difference; $n = 9$) and *transcribing* (100.0% difference; $n = 11$). While few of these tasks were observed, multitasking among *medication reconciliation* ($n = 1$) and *transcribing* ($n = 1$) was followed by the same task; non-multitasking was nearly always (94.4%) followed by a different task.

Discussion

We conducted an in-depth exploration of TMS data collected among ED clinicians to investigate multitasking and fragmentation in the ED clinical workflow as potential measures of CIS-related documentation burden and to understand its broader applications to more scalable and generalizable measures of *burden*. In this analysis, we found that nearly half of the time spent among the 15 observed clinicians was on CIS-related tasks. Among CIS-related tasks, 94.7% of the time was spent on *data-viewing* (i.e., *viewing patient list/schedule, viewing data*) and *data-entering* tasks (i.e.,

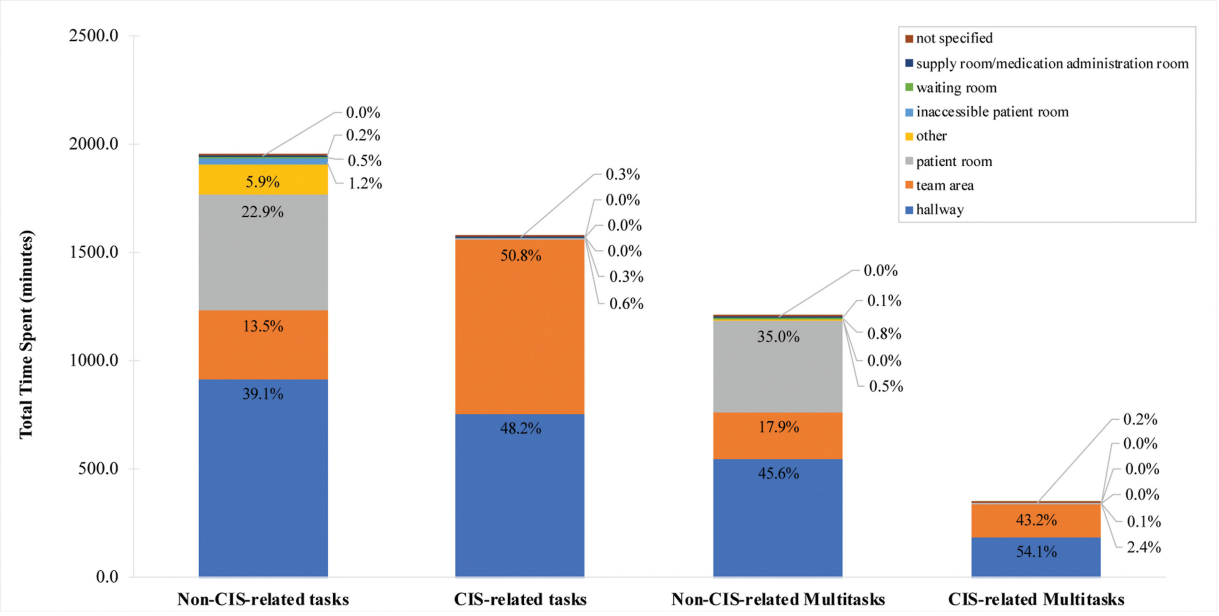

Fig. 3 Task type stratified by physical location of clinician when task was performed.

Table 2 Proportion of time spent multitasking CIS-related tasks, and total task count and average duration of CIS-related tasks stratified by the presence or absence of multitasking compared with baseline physical tasks

CIS-related task	Time spent multitasking	Total physical tasks at baseline[e]	Total tasks factoring multi-tasking[f]	Tasks non-multitasked	Tasks multitasked
	Proportion (%)	Total *N*/mean (seconds)	Total *N*/mean (seconds)	Total *N*/mean (seconds)	Total *N*/mean (seconds)
Viewing patient list/ schedule[b]	30.6	1,107 (19.6)	1,310 (16.5)	925 (16.3)	385 (17.2)
Viewing data[b]	30.6	919 (21.6)	1,016 (19.5)	746 (18.4)	270 (22.5)
Entering orders[a,c]	19.7	341 (52.4)	464 (38.5)	330 (43.4)	134 (26.3)
Entering data[a,c]	11.0	298 (102.4)	454 (67.2)	302 (89.9)	152 (22.1)
Smartphone clinical messaging app	29.7	106 (21.4)	129 (17.6)	91 (17.5)	38 (17.8)
Log into EHR	33.7	24 (34.4)	31 (26.6)	20 (27.4)	11 (25.3)
Documenting handoff/ sign-out[a,c]	9.6	12 (68.3)	22 (37.2)	16 (46.3)	6 (13.2)
Transcribing	0.8	10 (24.2)	11 (22.0)	10 (24.0)	1 (2.0)
Medication reconciliation	14.2	7 (44.1)	9 (34.3)	8 (33.1)	1 (44.0)
Log out of EHR	0.0	2 (8.0)	2 (8.0)[d]	2 (8.0)	–
Medication administration	100.0	1 (5.0)	1 (5.0)	–	1 (5.0)
Use of other CIS	–	–	–	–	–
Overall	21.9	2,827 (33.4)	3,449 (27.4)	2,450 (30.1)	999 (20.7)

Abbreviations: CIS, clinical information systems; EHR, electronic health record.
[a]Data entry-related tasks.
[b]Data viewing-related tasks.
[c]Significant difference in groups based on p-value ≤ 0.05; Welch's *t*-test performed for groups with $N \geq 5$.
[d]Different from our previous study[23] as we eliminated all tasks with zero seconds captured in this study.
[e]Counts of physical task sequence only.
[f]Counts of concurrent physical and communication task sequences combined (i.e., multitasking).

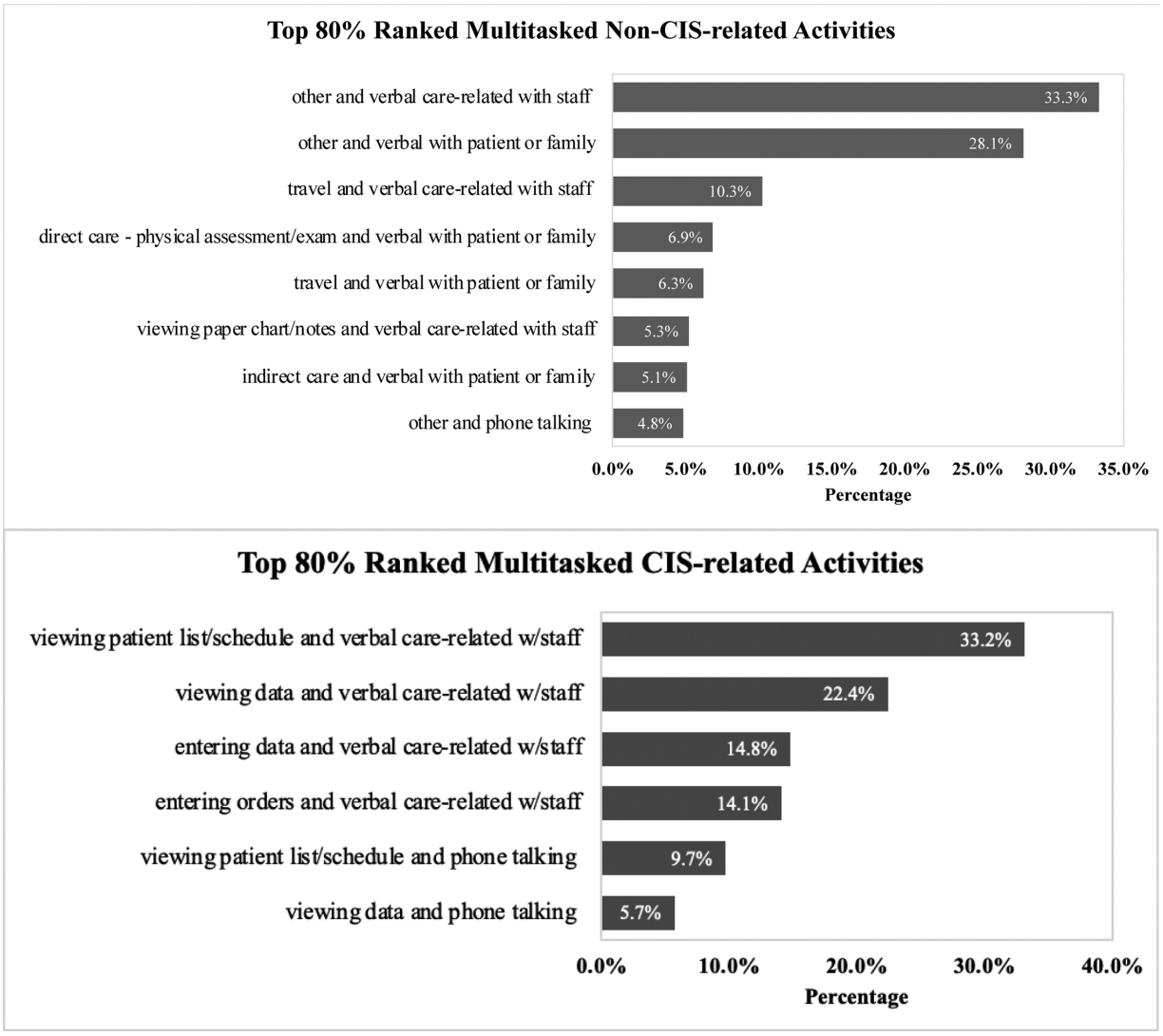

Fig. 4 Top 80% multitasked tasks stratified by non-CIS and CIS-related tasks. CIS, clinical information system.

entering orders, entering data, documenting handoff/sign-out). Given the high volume of CIS-related tasks performed among clinicians, these results suggest that EHR log files (i.e., metadata on user actions performed in the EHR while logged in) may be a feasible alternative to direct observation techniques in quantifying CIS-related documentation burden in the ED. However, potential limitations exist in the use of EHR log files to understand clinician activities due to the paucity of standards dictating their content and structure,[28] specifically, ascertaining an activity's location and whether multitasking occurred.

Through TMS data, we were able to distinguish that CIS-related tasks were largely performed in the *hallway* and *team area*, and less frequently, in the *patient room*. Our results indicated that clinicians communicate with patients/family at low proportions while performing CIS-related tasks (►Table 3). Higher proportions of multitasking in the patient room involve non-CIS-related tasks. At our institution, desktop computers and mobile workstations are available in the *hallway* and *team area*, while few desktop computers are in patient rooms. Further qualitative analysis is necessary to determine whether this is due to cognitive burden and/or clinician preference to document in the *hallway* and *team area*, or simply an artifact of where desktop computers and/or workstations for accessing EHRs and other systems are located in the ED. Future studies should examine how the physical design and configuration of EDs, and access to CIS impact the experience of burden among clinicians.[29,30] At many institutions, EHR log files rarely provide data that are sufficiently granular to indicate the precise terminal or location in which a CIS-related task is performed among users.[31] Based on HIPAA and meaningful use mandates, EHR log files (like other audit and disclosure logs for monitoring use) are only required to comply with ASTM International's four specifications for data capture[32,33]: (1) user or clinician identification number, (2) type of actions performed in the EHR, (3) patient record number accessed, and (4) time accessed.[32,34] Given the growing interest of the Office of the National Coordinator for Health Information Technology (ONCHIT) in cultivating the use of EHR log files to gain insights on EHR use and address documentation burden,[35] policymakers should consider extending recommendations

A

Multitasked	CIS-related task	Entering Data	Viewing Data	Viewing Patient List/Schedule	Documenting Handoff/Sign-out	Log into EHR	Log out of EHR	Medication Administration	Medication Reconciliation	Smartphone Clinical Messaging App	Entering Orders	Transcribing
		Task From which Switch Occurred (Preceding Task)*										
	Entering Data	**60.5%**	10.5%	8.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	0.7%	0.0%
	Viewing Data	4.8%	**23.0%**	44.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	4.4%	0.0%
	Viewing Patient List/Schedule	4.4%	27.3%	**27.0%**	0.0%	1.3%	0.0%	0.0%	0.0%	1.0%	7.0%	0.0%
	Documenting Handoff/Sign-out	0.0%	0.0%	0.0%	**66.7%**	0.0%	0.0%	0.0%	0.0%	0.0%	16.7%	0.0%
	Log into EHR	0.0%	0.0%	0.0%	0.0%	**54.5%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Log out of EHR	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**	0.0%	0.0%	0.0%	0.0%	0.0%
	Medication Administration	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**	0.0%	0.0%	0.0%	0.0%
	Medication Reconciliation	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**100.0%**	0.0%	0.0%	0.0%
	Smartphone Clinical Messaging App	0.0%	2.6%	5.3%	0.0%	0.0%	0.0%	0.0%	0.0%	**42.1%**	2.6%	0.0%
	Entering Orders	2.2%	16.4%	21.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**46.3%**	0.0%
	Transcribing	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**

B

Not Multitasked	CIS-related task	Entering Data	Viewing Data	Viewing Patient List/Schedule	Documenting Handoff/Sign-out	Log into EHR	Log out of EHR	Medication Administration	Medication Reconciliation	Smartphone Clinical Messaging App	Entering Orders	Transcribing
		Task From which Switch Occurred (Preceding Task)*										
	Entering Data	**21.5%**	24.5%	20.9%	0.7%	0.3%	0.0%	0.0%	0.7%	1.3%	4.6%	0.3%
	Viewing Data	7.0%	**12.6%**	56.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	5.8%	0.5%
	Viewing Patient List/Schedule	7.1%	38.3%	**11.8%**	0.3%	1.1%	0.1%	0.0%	0.2%	3.2%	14.4%	0.3%
	Documenting Handoff/Sign-out	6.3%	6.3%	25.0%	**50.0%**	0.0%	0.0%	0.0%	0.0%	6.3%	0.0%	0.0%
	Log into EHR	5.0%	0.0%	5.0%	0.0%	**5.0%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Log out of EHR	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**	0.0%	0.0%	0.0%	0.0%	0.0%
	Medication Administration	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**	0.0%	0.0%	0.0%	0.0%
	Medication Reconciliation	37.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**12.5%**	0.0%	25.0%	0.0%
	Smartphone Clinical Messaging App	6.6%	15.4%	30.8%	0.0%	0.0%	0.0%	0.0%	0.0%	**7.7%**	14.3%	0.0%
	Entering Orders	4.8%	24.8%	32.1%	0.0%	0.0%	0.0%	0.0%	0.0%	1.8%	**18.8%**	0.0%
	Transcribing	0.0%	30.0%	30.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**10.0%**

Fig. 5 Heatmaps of CIS-related tasks and its preceding or following task stratified by the presence of multitasking. CIS, clinical information system.

by revising existing data standards with stakeholders to meet the evolving demands of EHR design and evaluation.

Among the 2,827 CIS-related tasks captured in this study (►Table 2), 622 (22.0%) involved at least one communication task at some point in time. Consistent with the literature similarly reporting moderately high levels of multitasking in the ED,[13] our results indicate that nearly half of the overall ED clinician workflow was spent multitasking with communication tasks—the majority of which involved *care-related communication with staff* and *speaking with patients or families*.[13] Over one-fifth of multitasking involved CIS-related tasks and between 10.0 and 31.0% of time spent on *data-viewing* and *data-entering* tasks were multitasked (►Table 2); these communication events would be lost in EHR log files. Even more challenging is the fact that many CIS-related activities involving *data-viewing* and information retrieval—which represent over two-thirds of multitasked events in our study—are virtually indistinguishable from user idle time in EHR log files.[36,37]

With the exception of *viewing patient list/schedule*, *viewing data,* and *medication reconciliation*, multitasked tasks on average were shorter in *average duration* compared with those non-multitasked (►Table 2). Among *data entry-related* tasks, multitasking was associated with much shorter *average duration* on average compared with non-multitasking; these differences were statistically significant. Conversely, marginal differences existed between *data viewing-related* multitasking and non-multitasking. While it is difficult to draw conclusions based on these findings, these multitasking-related differences in *average duration* between *data-entry* and *data-viewing* tasks warrant further investigation. It is crucial to note that some of these multitasked activities may represent workflow interruptions (►Table 2). Additional efforts should focus on reconceptualizing existing measures of multitasking and how to optimally capture clinician communication and contextual information on workflow interruptions using passive data collection methods that complement information obtainable in EHR log files.[38]

In a prior study assessing interprofessional TMS data across multiple clinical practice settings,[23] we discovered that task-switching may serve as a measure of CIS-related documentation burden. Kannampallil and colleagues[39] describe clinician cognitive burden as "sensory, task-based, and psychological factors" which can be quantified through EHR-

C

Multitasked	CIS-related task	Task To which Switch Occurred (Following Task)*										
		Entering Data	Viewing Data	Viewing Patient List/Schedule	Documenting Handoff/Sign-out	Log into EHR	Log out of EHR	Medication Administration	Medication Reconciliation	Smartphone Clinical Messaging App	Entering Orders	Transcribing
	Entering Data	**45.4%**	8.6%	11.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.0%	0.0%
	Viewing Data	5.9%	**24.8%**	38.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	8.1%	0.0%
	Viewing Patient List/Schedule	3.1%	31.2%	**30.6%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	7.5%	0.3%
	Documenting Handoff/Sign-out	0.0%	0.0%	0.0%	**83.3%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Log into EHR	0.0%	0.0%	45.5%	0.0%	**9.1%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Log out of EHR	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**	0.0%	0.0%	0.0%	0.0%	0.0%
	Medication Administration	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**	0.0%	0.0%	0.0%	0.0%
	Medication Reconciliation	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**100.0%**	0.0%	0.0%	0.0%
	Smartphone Clinical Messaging App	2.6%	2.6%	10.5%	0.0%	0.0%	0.0%	0.0%	0.0%	**26.3%**	0.0%	0.0%
	Entering Orders	0.7%	9.0%	20.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	**47.8%**	0.0%
	Transcribing	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**100.0%**

D

Not Multitasked	CIS-related task	Task To which Switch Occurred (Following Task)*										
		Entering Data	Viewing Data	Viewing Patient List/Schedule	Documenting Handoff/Sign-out	Log into EHR	Log out of EHR	Medication Administration	Medication Reconciliation	Smartphone Clinical Messaging App	Entering Orders	Transcribing
	Entering Data	**29.1%**	17.2%	21.9%	0.3%	0.3%	0.0%	0.0%	1.0%	2.0%	5.3%	0.0%
	Viewing Data	9.9%	**11.9%**	47.5%	0.1%	0.0%	0.0%	0.0%	0.0%	1.9%	11.0%	0.4%
	Viewing Patient List/Schedule	6.9%	45.5%	**10.3%**	0.4%	0.1%	0.0%	0.0%	0.0%	3.0%	11.5%	0.3%
	Documenting Handoff/Sign-out	12.5%	0.0%	18.8%	**43.8%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Log into EHR	5.0%	0.0%	50.0%	0.0%	**30.0%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Log out of EHR	0.0%	0.0%	50.0%	0.0%	0.0%	**0.0%**	0.0%	0.0%	0.0%	0.0%	0.0%
	Medication Administration	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**	0.0%	0.0%	0.0%	0.0%
	Medication Reconciliation	25.0%	0.0%	25.0%	0.0%	0.0%	0.0%	0.0%	**12.5%**	0.0%	0.0%	0.0%
	Smartphone Clinical Messaging App	4.4%	6.6%	33.0%	1.1%	0.0%	0.0%	0.0%	0.0%	**14.3%**	6.6%	0.0%
	Entering Orders	4.2%	13.0%	40.3%	0.3%	0.0%	0.0%	0.0%	0.6%	3.9%	**18.2%**	0.0%
	Transcribing	10.0%	40.0%	30.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**

*Includes CIS-related tasks and row percentages only.

Fig. 5 (Continued)

Table 3 Communication tasks by average duration and overall proportion of CIS-related task time multitasked

Communication task	Average duration per multitask		Proportion multitasked
	Seconds	SD	(%)
Verbal care-related with staff	18.9	25.5	14.6
Phone talking	26.5	44.6	4.6
Verbal with patient or family	18.9	31.9	1.3
Handoff/sign-out	25.8	42.3	0.8
Rounding and meetings	56.8	37.9	0.5
Code/RRT[a]	–	–	–
Overall average per task	20.7	30.8	3.6

[a]No data available as the task was not observed during the observation periods.

mediated task-switching within and between patient charts. Our analysis revealed that ED clinicians experienced 1.4 ± 0.6 task switches/min,[23] which intensified by 33.0% when multitasking. According to Kannampallil et al,[39] greater task-switching is associated with increased cognitive resource expenditure; therefore, tasks that are performed frequently but exhibit short *average duration*, such as *viewing patient list/schedule* or *viewing data,* may indicate excessive task-switching and documentation burden (►Table 2). Interestingly, these short duration tasks pertain to data retrieval and patient selection,[40,41] which are high-risk areas for medical errors especially if poor EHR design and usability are present.[42,43]

Lastly, task sequence may also indicate CIS-related documentation burden.[39] In this analysis, clinicians were more likely to switch *from* and *to* the same task at higher proportions compared with a different task following multitasking, with the exception of *transcribing* and *log into EHR*. While observed at lower frequencies, multitasking of *medication*

reconciliation and *transcribing* was always succeeded by the same task. Conversely, when *medication reconciliation* and *transcribing* were not multitasked, they were succeeded by a different task 94.4% of the time, suggesting the importance of completing these tasks at one point in time in the ED setting. In fact, prior research indicates that medication errors are the most common threat to patient safety—most of which are avertable through adequate medication reconciliation protocols. Similarly, one-third of serious medication errors in hospitals are attributed to transcription errors.[44]

Limitations

As we did not collect data on workflow interruptions and their clinical value (i.e., beneficial or detrimental to care quality), we cannot ascertain whether frequent task-switching among ED clinicians suggests the presence of excessive or unneeded interruptions in the ED workflow. These data were captured anonymously; therefore, we were unable to match observations with their corresponding EHR log files to perform more granular analyses on the type and nature of CIS-related tasks performed. Akin to all TMSs, these results are subject to the Hawthorne effect,[45] and may not be generalizable to other institutions, settings, and health professionals. However, we adapted our interprofessional taxonomy from existing taxonomies to improve generalizability and facilitate research across roles and settings. Finally, while we conducted observations that were representative across weekdays and start times, our study relied on convenience sampling of a small subset of prescribing providers (i.e., residents and physician assistants). However, our sample size is within range of similar studies applying direct observation methods.

Future Directions

Uncovering objective measures of EHR documentation burden may facilitate the restructuring of EHR workflows to reduce interruptions and disruptions, and the elimination of EHR documentation and actions (e.g., clicks) that have no clinical benefit and/or come at an additional cost to patient safety or care quality. We plan to triangulate our TMS findings with EHR log file data to assess whether multitasking and fragmentation can be extended to more robust and scalable measures of EHR documentation burden that do not require direct observation techniques and are generalizable to varied settings and institutions.[7,24] Specifically, we will examine EHR-mediated within and between task-switching (e.g., alerts) in the ED workflow as a proxy measure of burden using EHR log files. Finally, it is important to note that organizational factors, such as team structure, play a role in self-reported burnout in the ED.[46] Given the team-based nature of the ED environment,[47] future studies should examine universal measures of burden that are extensible to all health professional roles, such as registered nurses and ancillary staff. Holistic monitoring of burden among team members will ensure that fundamental sources of burden are acutely addressed and not simply offloaded onto other roles.[48]

Conclusion

Monitoring CIS-related workflows in the ED is a valuable method to identify tasks that not only occupy clinician time, but also contribute to fragmentation in the workflow. In this study, *data-viewing* and *data-entering* tasks accounted for 94.7% of CIS-related tasks captured among ED clinicians. Forty-four percent of the total observation time was spent multitasking with communication tasks, which intensified task-switching in the workflow by 33.3%. In nearly all instances of CIS-related task switches, clinicians were more likely to return to the same CIS-related task at higher proportions when comparing multitasked to non-multitasked tasks. While results demonstrate that multitasking and task-switching continue to pose challenges to the ED workflow,[11,12,22] they also suggest that EHR documentation burden and workflow fragmentation may be quantifiable through more robust and scalable measures developed using EHR log files.

Clinical Relevance Statement

In the last decade, the implementation of electronic health records (EHRs), combined with an expanding health care regulatory environment, has led to a subsequent growth of EHR documentation burden among health care providers. EHR documentation burden has been implicated as a potential source of medical errors and patient safety concerns, which is particularly critical to address in the ED, a dynamic and fast-paced setting that is highly sensitive to workflow changes. Research on multitasking and workflow fragmentation in the ED may provide further insights on the fundamental sources of EHR documentation burden and how to best measure burden in the EHR.

Multiple Choice Questions

1. All of the following have been shown to increase multitasking and fragmentation in the clinical workflow except:
   a. Limited EHR usability.
   b. Limited integration of EHRs in the clinical workflow.
   c. Increased stationary work.
   d. Streamlined ED faculty evaluation and management coding.

   Correct Answer: The correct answer is option d. Increases in multitasking and fragmentation in the workflow have been attributed to limited usability and integration of EHRs into the clinical workflow coupled with more stationary work.[6,19]

2. Multitasking and interruptions may be beneficial for patients and providers in the ED for the following reason:
   a. Facilitates the passage of information in a timely fashion.
   b. Reduces cognitive burden of documentation among providers.

c. Decreases the likelihood that medical errors will occur.
d. Impedes communication between ED team members.

Correct Answer: The correct answer is option a. Because the ED is a highly dynamic environment, there exists a unique tension between efficiency and safety in the ED. Therefore, multitasking and interruptions may be beneficial for patients and team members by expediting the passage of essential information in a timely fashion.[13]

Author Contributions

S.C.R. conceptualized the TMS. S.C.R. and A.J.M. defined the scope of the analysis. A.J.M. performed the analysis and wrote the manuscript. L.A. was involved in data collection. J.M.S. and J.E. trained the observers. L.A., K.D. C., R.T., and S.C.R. provided revisions and feedback, and approved the final manuscript.

Protection of Human and Animal Subjects

The study was performed in compliance with the World Medical Association Declaration of Helsinki on Ethical Principles for Medical Research Involving Human Subjects, and was reviewed by the Columbia University Irving Medical Center Institutional Review Board.

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Conflict of Interest

None declared.

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