MEDINFO 2007
K. Kuhn et al. (Eds)
IOS Press, 2007

Multitasking by Clinicians in the Context of CPOE and CIS Use

[a]Sarah Collins, [a,b,c] Leanne Currie, [c]Vimla Patel,
[a,c]Suzanne Bakken, [c]James J. Cimino

[a] *Columbia University School of Nursing, New York, New York, USA*
[b] *New York Presbyterian Hospital, New York, New York, USA*
[c] *Department of Biomedical Informatics, Columbia University, New York, New York, USA*

Abstract

Interest in studying distractions and interruptions in the context of clinician workflow has increased in light of evidence that these events may negatively impact patient safety. Additionally, many recent informatics-based studies analyze computer provider order entry (CPOE) and clinical information system (CIS) implementation and its effects on clinician workflow. This study expands the development and use of a taxonomy to characterize distractions to clinicians and their subsequent actions in the context of CPOE/CIS use. We found a total of 75 distracting events in 406 minutes of observational data of which 32 led to interruptions and 30 led to continued multitasking. The above primary actions led to 5 tasks not completed and 4 episodes of clinician's lack of recall. Differences in the distribution of the source of distractions and primary action of the distracted clinicians may be a function of clinical setting and clinician type using the CPOE/CIS. Nine secondary actions, potentially resulting in a slip or a mistake, suggest that CPOE may necessitate different forms of safety nets than traditional clinician communication.

Keywords:

communication, distraction, interruption, computer provider order entry, clinical information system

Introduction

Multitasking is a valued skill in the clinical setting allowing for the efficient execution of daily activities, yet, may fail to be an effective mechanism in clinical practice when it leads to cognitive overload [1]. Clark and Brennan [2] noted that the properties of a communication medium impose constraints on the communication process; therefore, the design of communication modalities should account for these constraints [3].

During coordinated activities, such as communication amongst the health care team, responsible clinicians must establish common ground. Common ground is defined as similar experiences, beliefs, and knowledge and is necessary to ensure that clinicians' mental models reflect each others' needs within the context of the task and current situation [4]. Coordinated communication may serve as a "rescue" to account for the fact that the introduction of each new interaction can detract from the clinician's finite cognitive resources [4]. When cognitive resources are exhausted, the average amount of attentional resources, also known as working memory, available to any single interaction may be reduced [5].

Computerized Provider Order Entry (CPOE) systems attempt to alleviate clinician cognitive overload through providing an organized electronic format for work activities. CPOE systems can have several types of decision support functions such as automated alerts and reminders; however, excessive alerts have been shown to cause cognitive overload and alert fatigue [6]. Alert fatigue occurs when the number of reminders and alerts are perceived too be excessive. This number often varies from clinician to clinician and may cause clinicians to override both critical and non-critical alerts, compromising the desired safety effect of integrating decision support into CPOE [6].

The benefits of CPOE implementation likely outweigh the unintended consequences [7]. However, due to the asynchronous channel's inability to form a mental model of the cognitive needs of the clinician, new ways to detect distractions, interruptions and multitasking in the setting of CPOE and general clinical information system (CIS) usage are needed. Furthermore, other clinicians within the same workspace may be equally vulnerable to similarly reduced attentional resources. This study describes the use of a taxonomy to characterize and analyze distractions and subsequent actions in the setting of CPOE/CIS usage.

Background

Studies characterizing interruptions and distractions during clinician workflow continue to demonstrate their prevalence and significance to the health care work environment's culture [8,9]. Interruption rates consistently approach 30% of all clinical communication, in many settings. On the other hand, interruptions serve as the most frequently used method of communication in the health care environment and are thus considered a beneficial activity [8]. Of great concern however, up to 43% of medication errors have been attributed to distractions such as interruptions [10]. CPOE systems show great promise in their potential to increase patient safety and have been

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shown to reduce medication errors up to 81% [11]. However, unexpected "silent errors", i.e., latent errors resulting from mismatches between clinician workflow and CPOE or CIS development and deployment, have emerged as potentially contributing to medical errors [7].

Table 1 – Taxonomy of distractions during CPOE use

Distraction with multitasking (Event): Period when a distraction causes a subject to interact in two or more concurrent communication events [9].

Primary Actions	Definition	Examples				
		User	**Source**	**Original Task**	**Distraction Quote or Episode**	Secondary **Action**
Interruption (I)	Cessation of productive activity before the current task was completed for an externally imposed reason [13].	MD	*C*	Ordering urine electrolytes	Difficulty navigating CPOE order process; sought assistance from second clinician but was unsuccessful	*IT*: User stopped after 1 minute and 5 seconds of unsuccessful attempts.
Continued Multitasking (CM)	Continued interaction in two or more concurrent communication events or tasks.	MD	*SC*	Ordering Mucomyst medication	"Is that the patient's chart you have?"	*LR*: Difficulty recalling Mucomyst dose previously stated by another clinician.
Deferred Task (DT)	Acknowledged distraction stimulus from external source that was not followed by cessation of original task or continued multitasking.	MD	*SC*	Ordering patient laboratory draws	"Did patient X ever get the CT and biopsy?" (different patient than active patient record on CPOE screen)	*IT*: User acknowledged distraction with indication to follow-up, yet follow-up was not observed.

Secondary Actions	**Definition**
Lack of Recall (LR)	Inability to quickly recall previously verbalized information about the task (could result in slip or mistake [16]).
Incomplete Task (IT)	Either original task and/or interruption task not completed during the observed session (could result in slip or mistake [16]).
Change in Plan of Care (CPC)	Information of a new plan interrupts a task and causes the interrupted task to be irrelevant and discarded (could result in slip or mistake [16]).
Source of Distraction Event	**Definition**
Information Need (IN)	Required data to answer a question is not known.
Synchronous Communication (SC)	Two parties exchange messages across a communication channel at the same time (e.g. face-to-face, telephone) [17].
Computer (C)	Distraction caused by technical problems (e.g. frozen user interface) or CPOE/CIS usability difficulties.

In an earlier study, we developed a taxonomy to characterize distractions and interruptions during the use of CPOE in a medical intensive care unit (MICU) [12]. The taxonomy extended the work of Coiera et al.'s definition of distraction with multitasking [9] and Flynn et al.'s definition of an interruption [13]. Our previous study found that information needs accounted for 55% of the distraction events detected and clinical communication accounted for 40% [12]. Distraction events may be attributed to more than one source. For example, a clinical communication may be related to an information need. Additionally, 14% of distractions were attributed to computer problems. For example, while the observed MICU resident was changing a CPOE oxygen order, another clinician distracted him with an information need. In this instance, the second clinician asked for information that the first clinician needed to obtain from the CIS. The distraction interrupted the resident, the resident answered the question, and then lack of recall of the original intended oxygen order occurred for 1 minute and 6 seconds [12].

In a second study, as part of the Infobuttons project at Columbia University, 51% of clinician information needs went unmet [14]. Consistent with Coiera et al.'s findings that clinicians use synchronous channels of communication more frequently, Currie and colleagues found that for

76% of information needs concerning domain-related questions, the individual in need of the information utilized a person to answer the question (rather than a paper or computer-based resource) [14]. The health care setting, rich with information needs and with an apparent preference for face-to-face communication sets up an interrupt-driven environment [15] which has previously been shown to both compromise patient safety [10] and to provide an opportunity for coordinated activity "rescues" [4]. However, to date, these phenomena have been studied in the absence of CPOE/CIS, therefore this study characterizes and analyzes interruptions and distractions to clinicians in the context of CPOE/CIS use.

Methods

Morae ™ software served as the portable usability lab to collect all observational data during randomly selected periods of time [14]. We used a Taxonomy of Distractions During CPOE use which was developed for earlier work on this topic to characterize distraction and interruption events during observational data of medical resident rounds in the MICU (See Table 1) [12]. We developed the taxonomy by iteratively using deductive and inductive methods to characterize our observational data. This was congruent with the hybrid method to categorize interruptions and activities as described by Brixey et al. in the HyMCIA study [18]. For this study, we used the taxonomy and extended our sample to residents and other clinician's who were using CPOE/CIS on inpatient medical/surgical floors collected for the Infobuttons project at Columbia University Medical Center (CUMC).

Table 2 – Time and events by type of clinician for combined rounds and non-rounds data

Clinician	Minutes (%)	#Distraction	Events/Hr	Interruption (%)	Continued	Multitask-Deferred Task (%)
MD MICU Rounds	93 (23)	22 (29)	8	10 (31)	3 (10)	9 (69)
MD Non-rounds	158 (39)	41 (55)	28	13 (41)	25 (83)	3 (23)
RN Non-Rounds	94 (23)	8 (11)	5	5 (16)	2 (7)	1 (8)
PT/OT Non-Rounds	45 (11)	2 (2.5)	2.5	2 (6)	0	0
Student Non-Rounds	16 (4)	2 (2.5)	7.5	2 (6)	0	0
Total	406	75	Avg 10	32	30	13

The coding schema, as shown in Table 1, which was used to characterize distraction events, includes the initial event of Distraction with Multitasking when the clinician engages in another interaction in addition to the current use of CPOE. The initial event is followed by a primary action of the distracted clinician: an Interruption, a Deferred Task, or Continued Multitasking. The primary action may or may not be followed by a secondary action: Lack of Recall, Incomplete Task, or Change in Plan of Care.

Results

We observed 38 clinicians from a combined data set of MICU rounds and CPOE/CIS use on a medical/surgical unit at the Columbia-Presbyterian campus of New York Presbyterian Hospital. A total of 75 Distraction with Multitasking events were detected in 406 minutes of observational data. Table 2 shows the breakdown of total minutes and events per type of clinician observed.

Distractions during MICU rounds

During 93 minutes of MICU rounds, observational data of a medical resident using CPOE found that a total of 22 distractions occurred, with one distraction occurring on average every 4.2 minutes. Ten of the events were categorized as Interruptions, three as Continued Multitasking, and nine as a Deferred Task. An Interruption preceded one Incomplete Task and two Lack of Recall episodes and one Change in Plan of Care. One Deferred Task preceded one Incomplete Task. Three sources of distraction were identified. It is important to note that these sources are not mutually exclusive; therefore, the sum of the percentages does not equal 100 percent. These sources were as follows: information need events [14] accounted for 12 out of 22 events (55%), clinician communication accounted for 9 out of 22 events (40%), and frozen CPOE user interface screens accounted for 3 out of 22 events (14%).

Distraction during MedSurg non-rounds

The second observational data set consisted of clinicians (physicians, nurses, physical therapists, occupational therapists, and medical students) while using a CPOE/CIS system. The observational data ranged in length of time from one minute to 37 minutes. The recording time represents time when the user was actively using the CPOE/CIS system.

The analysis of 313 minutes of data that was collected identified a total of 53 Distraction with Multitasking events. When examining overall data, on average a distraction event occurred every six minutes. Of these 53 events: 27 events were characterized as a Continued Multitasking primary action with two secondary actions of Lack of Recall; 22 events were characterized as an Interruption primary action with two secondary actions of Incomplete Tasks; four events were characterized as a Deferred Task primary action with one secondary action of Incomplete Task.

Distractions by user type

Sixteen physicians were observed using CPOE/CIS for a total of 158 minutes with 41 identified Distraction with Multitasking events. Of the 41 events, 25 (60%) resulted in a Continued Multitasking primary action and two of those primary actions led to a Lack of Recall secondary action. Thirteen of the 41 events, or 31%, produced an Interruption primary action with one of those actions leading to an Incomplete Task secondary action. Of the remaining three

Deferred Task primary actions, only one led to an Incomplete Task secondary action. An event occurred every 3.8 minutes while a physician was using CPOE/CIS.

Observational data of 13 nurses using CPOE/CIS totaled 94 minutes and identified 8 Distraction with Multitasking events. 62%, or 5 of the 8 events, were followed by an Interruption primary action, with one of those actions leading to an Incomplete Task secondary event. In contrast, 2 (25%) of the 8 events led to Continued Multitasking primary actions. The remaining event was identified as a Deferred Task primary action. An event occurred every 11.75 minutes while a nurse was using CPOE/CIS.

Four physical therapists were observed using CPOE/CIS for a total of 31 minutes and encountered one Distraction with Multitasking event. Observational data collected on one occupational therapist using CPOE/CIS for a total of 14 minutes identified one Distraction with Multitasking event. The two events that occurred during physical therapist and occupational therapist CPOE/CIS use both resulted in an Interruption primary action with no occurrence of a secondary action. On average a physical therapist or occupational therapist encountered an event every 22.5 minutes.

Three medical students were observed using CPOE/CIS for 16 minutes with two Distraction with Multitasking events identified. Each of the two events encountered by medical students was followed by an Interruption primary action and no secondary action. The medical students, on average, experienced an event every eight minutes.

Of the 75 events in the combined data set, 10 resulted in a secondary action (See Table 3).

Table 3 – Total count of primary and secondary actions

Primary Actions		Secondary Actions		
		Lack of Recall	Incomplete Task	Change in Plan of Care
Interruption	N = 32	2	3	1
Deferred Task	N = 13	0	2	N/A
Continued Multitasking	N = 30	2	0	N/A
Total	N =75	4	5	1

An information need [14] accounted for 21 of the 53 non-rounds events (40%). In these cases, 13 of the 22 information needs caused an Interruption, two of which the information need failed to be met and an Incomplete Task resulted. Six of the 22 information needs caused Continued Multitasking, two of which caused Lack of Recall episodes. Two Deferred Tasks resulted from an information need, one of which the information need was deferred and resulted in an Incomplete Task. Of note, 17 of the 21 events resulting from information needs utilized a human resource [14].

Discussion

We observed 6 hours and 46 minutes of clinicians using a CPOE/CIS system in the MICU and in MedSurg. Distractions occurred 75 times during this time period. The MICU rounds data resulted in a greater proportion of Deferred Tasks while the medical/surgical unit non-rounds data resulted in a greater proportion of Continued Multitasking. However, Interruptions as a primary action from a distraction event were found to have high proportions in both the rounds and the non-rounds data. Possibly the nature of the structure, pace and coordinated activity [4] of MICU rounds leads the resident using CPOE/CIS to be less likely to engage in Continued Multitasking. The less structured work of non-rounds CPOE/CIS use may increase the likelihood of engaging in conversation with a colleague while using the CPOE/CIS system, a form of Continued Multitasking.

The emergent phenomenon that physicians opted for the primary action Continued Multitasking 60% of the time versus nurses who opted for the primary action Interruption 62% of the time possibly relates to the type of distractions encountered by each type of clinician or the nature of the CPOE/CIS tasks required by the two types of clinicians. Though data samples were small, physical therapists, occupational therapists, and medical students followed a distraction with an Interruption primary action in all cases. This phenomenon may influence the design of clinician tailored interfaces of CPOE/CIS systems. Further investigation is necessary to determine if the nature of the informatics task, CPOE specific versus CIS specific, influences the secondary action of the clinician and if the type of clinician plays a role in determining the chosen secondary action when encountered with a distracting event.

The taxonomy was able to characterize a consistent rate of Distraction with Multitasking events for physicians using CPOE/CIS during MICU rounds and during non-rounds usage. The nature of the events appeared to differ; yet the frequency of events did not. Analysis of the content of distraction events shows that the rounds events were more structured and clinically focused. The events during non-rounds, in addition to clinically focused communication events, included “casual, polite and social” conversation.

The combined average event rate for the physician observational periods was one event every 3.98 minutes. This event rate shows more frequent occurrence of distraction events than compared to the non-CPOE/CIS specific Coiera et al.’s 2002 study of physicians in an emergency department that detected a distraction event every 11.1 minutes [9].

A similar comparison is shown for the distraction events experienced by nurses in this study to interruptive events experienced by nurses in a level one trauma center in 2005 [19]. Brixey et al.’s definition of an interruption included distracting events and recipient blocked tasks [19] (deferred tasks), allowing for comparison of total events between the studies [12]. In the context of nurse CPOE/CIS use, our study detected an event every 11.75 minutes

compared to the non-CPOE/CIS specific Brixey et al.'s detection of an event every 15 to 24 minutes [19].

The above comparisons to other studies show that general workflow distraction events rates may vary from distraction event rates in the context of CPOE/CIS use. One previous study of distractions in general clinician workflow did detect distraction event rates at 1 every 4 minutes [20], comparable to the CPOE/CIS distraction event rate. However, the internally consistent rates among rounds and non-rounds physician data shows a possible trend of increased distraction event rates in the context of CPOE/CIS use. Our small sample size, yet rich data set, indicates that CPOE/CIS use lends a clinician vulnerable to at least a similar rate and possibly a higher rate of distraction events than are found in general clinician workflow.

Due to the nature of some clinical tasks (i.e. looking up laboratory orders) there exists some difficulty determining the end point of an intended task. Additionally, a secondary action might result in a slip or mistake [16], but we were unable to ascertain if a slip or mistake occurred because we did not have follow-up data [12]. However, the detection of secondary actions, such as Lack of Recall, though a small count, is concerning if the context of CPOE/CIS use does not allow for the recognition and "rescue" of cognitive overload by colleagues at the same level seen in coordinated activity amongst clinicians [4].

Conclusions

Distractions per hour of CPOE/CIS use are as prevalent, and possibly more prevalent, than distractions per hour in general clinician workflow. Evidence of the existence of secondary actions indicates an opportunity for a slip or mistake to occur [17]. The taxonomy is comprehensive enough to capture the distraction events, primary actions and secondary actions that occur in the context of clinicians' use of CPOE/CIS systems.

The interrupt-driven nature of the clinical work environment impacts the cognition of a clinician while using CPOE/CIS. Health care providers rarely work at private workstations in secluded areas; clinical information needs, as well as social engagement, both addressed through clinician communication, contribute to distraction events and possible slips or mistakes [17] in patient care. Given the prevalence of distraction events in the context of CPOE/CIS use, and previous work indicating the relationship between distractions and potential for patient harm, the results of this study indicate an area ripe for further analysis.

Acknowledgments

This research is sponsored by a grant from the National Institute for Nursing Research (T32NR007969) and a grant from the National Library of Medicine (1R01LM07593).

References

[1] Laxmisan A, Hakimzada F, Sayan O, Green R, Zhang J, Patel V. The Multitasking clinician: Decision-making and cognitive demand during and after team handoffs in emergency care. International Journal of Medical Informatics. (in press, 2006.)

[2] Clark H, Brennan S. Grounding in communication. Perspectives on Socially Shared Cognition, Resnick L, Levine JM, Teasley SD, Eds. Washington, DC: Amer. Psychol. Asssoc., 1991, 127-149.

[3] Patterson ES, Cook RI, Woods DD, Render ML. Examining the complexity behind a medication error: generic patterns in communication. IEEE SMC 2004; Part A, 34(6):749 – 756.

[4] Klein G, Woods D, Bradshaw J, Hoffman R, Feltovich P. Ten Challenges for Making Automation a "Team Player" in Joint Human-Agent Activity. IEEE Intelligent Systems. 2004; 19(6):91-95.

[5] Coiera E. Interaction Design Theory. International Journal of Medical Informatics 2003; 69: 205-222.

[6] Van der Sijs H, Aarts J, Vulto A, Berg M. Overriding of drug safety alerts in computerized physician order entry. J Am Med Inform Assoc. 2006; 13(2):138-47.

[7] Ash JS, Berg M, Coiera E. Some unintended consequences of information technology in health care: the nature of patient care information system-related errors. JAMIA 2004; 11:104-112.

[8] Alvarez G, Coiera E. Interruptive communication patterns in the intensive care unit ward round. International Journal of Medical Informatics 2005; 74: 791-796.

[9] Coiera E, Jayasuria R, Hardy J, Bannan A, Thorpe M. Communication loads on clinical staff in the emergency department. MJA 2002; 176(9): 415-418.

[10] MEDMARX Data Report 2002.

[11] Bates DW, Teich JM, Lee J, Seger D, Kuperman GJ, Ma'Luf N, Boyle D, Leape L. The impact of computerized physician order entry on medication error prevention. J Am Med Inform Assoc. 1999 Jul-Aug;6(4):313-21.

[12] Collins S, Currie LM, Bakken S, Cimino JJ. Interruptions During the Use of a CPOE System for MICU Rounds. AMIA Symp Proc. 2006.

[13] Flynn EA, Barker KN, Gibson JT, Pearson RE, Berger BA, Smith LA. Impact of interruptions and distractions in dispensing errors in an ambulatory care pharmacy. American Journal of Health-System Pharmacy. 1999; 56(13):1319-25.

[14] Currie LM, Graham M, Allen M, Bakken S, Patel V, Cimino JJ. Clinical information needs in context: an observational study of clinicians while using a clinical information system. AMIA Symp Proc. 2003;190-194.

[15] Chisholm CD, Collison EK, Nelson DR, Cordell WH. Emergency department workplace interruptions: are emergency physicians "interrupt-driven" and "multitasking"? Acad Emerg Med. 2000; 7(11):1239-43.

[16] Zhang J, Patel V, Johnson TR, Shortliffe EH. A cognitive taxonomy of medical errors. Journal of Biomedical Informatics 2004; 37:193–204.

[17] Coiera, E. Communication Systems in Healthcare. Clinical Biochem Review. 2006; 27:89-98.

[18] Brixey J, Robinson D, Johnson C, Johnson T, Turley J, Patel V, Zhang J. Towards a hybrid method to categorize interruptions and activities in healthcare. International Journal of Medical Informatics (in press 2006.)

[19] Brixey J, Robinson D, Tang Z, Johnson T, Zhang J, Turley J. Interruptions in Workflow for RNs in a Level One Trauma Center. AMIA Symp Proc. 2005;86-90.

[20] Spencer R, Logan P. Role-based communication patterns within an emergency department setting. In: Proceedings HIC 2002; 2002; Melbourne; 2002.

Address for correspondence

Sarah A. Collins, RN, BSN
Mail Code 6, 630 West 168th Street, New York, NY 10032
Telephone: 1-781-801-9211, e-mail sac2125@columbia.edu