

# Ordering Interruptions in a Tertiary Care Center: A Prospective Observational Study

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**OBJECTIVES:** By self-report, interruptions may contribute to up to 80% of ordering errors. A greater understanding of the frequency and context of interruptions during ordering is needed to identify targets for intervention. We sought to characterize the epidemiology of interruptions during order placement in the pediatric inpatient setting.

**METHODS:** This prospective observational study conducted 1-hour-long structured observations on morning rounds and afternoons and evenings in the resident workroom. The primary outcome was the number of interruptions per 100 orders placed by residents and physician assistants. We assessed the role of ordering provider, number, type and urgency of interruptions and person initiating interruption. Descriptive statistics,  $\chi^2$ , and run charts were used.

**RESULTS:** Sixty-nine structured observations were conducted with a total of 414 orders included. The interruption rate was 65 interruptions per 100 orders during rounds, 55 per 100 orders in the afternoons and 56 per 100 orders in the evenings. The majority of interruptions were in-person ( $n = 144$ , 61%). Interruptions from overhead announcements occurred most often in the mornings, and phone interruptions occurred most often in the evenings ( $P = .002$ ). Nurses initiated interruptions most frequently. Attending physicians and fellows were more likely to interrupt during rounds, and coresidents were more likely to interrupt in the evenings ( $P = .002$ ).

**CONCLUSIONS:** Residents and physician assistants are interrupted at a rate of 57 interruptions per 100 orders placed. This may contribute to ordering errors and worsen patient safety. Efforts should be made to decrease interruptions during the ordering process and track their effects on medication errors.

## ABSTRACT

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Preventable medical errors lead to >400 000 deaths annually.<sup>1</sup> Pediatric patients are twice as likely to experience harm or death from medication errors compared with adults and are almost 3 times more likely to have a potential adverse drug event.<sup>2-4</sup> Because of the significant morbidity of medication errors in the pediatric population, the American Academy of Pediatrics has identified the prevention of medication errors as a key priority to ensure safe care for children.<sup>3,5</sup> Twenty-seven percent of all pediatric medication orders lead to errors and up to 80% of pediatric potential adverse drug events occur at the drug ordering stage.<sup>4,6,7</sup> Ordering errors while placing orders for radiologic and laboratory tests are also concerning and less well characterized in the literature. One study of errors during the testing process in outpatient family practice clinics found a rate of 3.9 voluntary error reports per week occurring at the test ordering stage and reported that adverse outcomes from errors during the testing process occur in 18% to 58% of events.<sup>8</sup>

A key contributor to harmful ordering errors may be interruptions. Studies examining the etiology of wrong-patient ordering errors suggest that interruptions during computerized order entry may contribute to 80% of identified errors.<sup>9,10</sup> Interruptions during tasks that require high working memory loads, such as ordering complex medications, were associated with decreased accuracy.<sup>11,12</sup> Interruptions during medication ordering in pediatrics may be particularly dangerous due to the need to calculate doses by weight.<sup>3,5,13</sup> Observational studies of physician and nurse workflow disruption in the emergency department and on inpatient units have shown that providers are interrupted as often as 5 to 7 times per hour.<sup>14-17</sup> These studies have focused on interruptions as barriers to efficiency and sources of frustration for providers, however, no adult or pediatric studies to date investigated interruptions during the critical act of medication, radiologic study, and laboratory test ordering in the inpatient or outpatient setting.

A greater understanding of the frequency and context of interruptions during order placement is necessary to identify the scope of this problem and targets for future intervention. We sought to characterize the epidemiology of these interruptions during resident and physician assistant order entry.

## METHODS

### Setting

The study was conducted at an urban tertiary care academic children's hospital on 3, non-intensive care inpatient units. All 3 units are medical-surgical floors, consisting of a mix of general pediatric, subspecialty, and surgical patients. Inpatient orders for all patients are primarily placed by pediatric interns, residents, and physician assistants. There are 29 pediatric interns, 46 pediatric residents, and 10 physician assistants annually, with 25 rotating residents from other departments or outside hospitals. All orders are placed using computerized physician order entry. Orders are placed during family centered patient-care rounds using mobile computer workstations, or during the remainder of the day in resident workrooms.

### Measures

The primary study measure of interest was the proportion of orders placed that were interrupted. Secondary measures included types of interruptions, individuals initiating interruptions and urgency of interruptions.

### Study Procedures

Members of the study team conducted 1-hour structured observation sessions of ordering providers on each inpatient unit over a 1-year period from March 2015 to February 2016. Providers were told that these observers were "observing the work environment." Study team members conducting observations included a pediatric hospital medicine fellow, a pediatric hospital medicine attending, and resident physicians. Study team members were trained in data collection methodology by the principal investigator, and a standardized data collection tool was used. After first observations were completed, data were reviewed with the study principal

investigator to ensure accuracy. During all observation sessions, study team members identified a provider placing an order by watching the large computer screens that are easily readable across the workroom or by standing in a position on rounds to observe the computer screen. Team members then recorded the number of orders placed and the number of interruptions that occurred during the ordering process. All orders placed were included, such as medications, laboratory orders, and radiology orders. If a single order was interrupted more than once before completion, all interruptions were counted. When that provider finished writing orders, as identified by watching the provider's computer screen and seeing them submit an order, the observer then shifted to a new ordering provider. Therefore, multiple providers were observed per observation session; however, the observer focused on 1 provider at a time if providers were placing orders concurrently. Orders could encompass admission orders or orders on existing patients, and every individual order in an order set was treated separately. An interruption was defined for study team members as an external factor, which caused an individual to cease their current task to attend to that stimulus (eg page, phone call, person approaches them to start conversation). Self-interruptions, defined as when an individual, independent of another person, suspends an activity to perform another activity, were excluded, based on previous research methodology.<sup>16,18</sup> Only interruptions that occurred during the time that a provider was placing an order were counted.

For the first 6 months of the study, monthly 1-hour observation sessions took place between 1 PM and 4 PM on each floor in the resident workrooms. For the second 6 months of the study, additional 1-hour observations sessions were added during morning patient-care rounds and in the evenings between 7 PM and 11 PM in the resident workroom. These additional observation sessions were added to capture potential differences in interruptions throughout the day when workflow and number of health care personnel present

differed. A total of 3 hours of observations were conducted on each floor monthly in the second 6 months of the study.

Observations took place in the context of an initial quality improvement project to decrease medication ordering errors by decreasing interruptions on only 1 of 3 inpatient units. However, after multiple Plan-Do-Study-Act cycles in 6 months, there was no difference in the interruption rate on the intervention unit when compared with the control units and the quality improvement project was stopped. Because there was no significant difference in the rate of interruptions on the intervention unit when compared with each control unit (unpublished data; available on request), data were analyzed in aggregate for the current study. This study was approved by the institutional review board at our institution.

### Data Collected

The role of ordering provider (intern, resident, physician assistant), number of providers observed, number of orders placed and number of interruptions were collected. To characterize types of interruptions, team members also recorded whether the interruption was in-person or by phone, text page, or overhead page. For the second 6 months of the study, observers also recorded who initiated the in-person and phone interruptions (coresident, attending, fellow, nurse, social worker, consult, or other) and whether the interruption was urgent or nonurgent. Urgent interruptions were defined as issues for which the ordering provider had to stop his or her current task to address immediately (eg, acute change in patient's clinical status, which required evaluation at the bedside).

### Statistical Analysis

Descriptive statistics were used to assess observation characteristics. Data on individuals initiating interruptions were categorized as nurse, resident, attending or fellow, and consult or other. The proportion of orders that were interrupted, interruption type, and role of individuals initiating interruptions were compared across ordering time periods using

Fischer's exact test ( $\chi^2$ ). The association between afternoon interruption rates and census in patient days over a 1-year time period was assessed with spearman's correlation and data were displayed on a run chart. All analyses were performed using Stata 13.0 (College Station, TX).

## RESULTS

Sixty-nine observation sessions were included in the analysis. Of these, 18 were performed on morning rounds, 34 were performed in the afternoon, and 17 were performed in the evenings (Table 1). The median number of ordering providers observed per observation session was 3 (interquartile range 2–4) with 46 observation sessions capturing interns, 56 observation sessions capturing residents, and 22 observation sessions capturing physician assistants. A total of 414 orders were placed.

On average, 65 orders were interrupted per 100 orders placed (95% CI: 53–75) during morning rounds, compared with 55 per 100 orders placed (95% CI: 48–61) during afternoon observation sessions and 56 per 100 orders placed (95% CI: 44–67) during evening observation sessions ( $P = .32$ ). Monthly afternoon interruption rate was not related to census in patient days ( $\rho = 0.2$ ,  $P = .52$ , run chart displayed in Fig 1). The run chart shows a mean interruption rate of 55 interruptions per 100 orders placed with a minimum of 21 interruptions per 100 orders placed and a maximum of 123 interruptions per 100 orders placed (rate  $>100$  indicating interruptions occurred more than once per order). The majority of interruptions were in person ( $n = 144$ , 61%), followed by phone interruptions ( $n = 59$ , 25%) (Fig 2). Type of interruption differed by time of day

( $P = .002$ ): in-person interruptions occurred most frequently during morning rounds and in the afternoon, phone interruptions occurred most frequently in the afternoons and evening, and overhead page interruptions occurred most frequently during morning rounds. Overall, nurses were the most common initiators of interruptions. The individuals initiating the interruption differed by time of day ( $P = .002$ ): the majority of interruptions during rounds were initiated by nurses and attending physicians/fellows and the majority of interruptions in the afternoons and evenings were initiated by nurses and co-residents (Fig 3). The majority of the interruptions were classified as nonurgent ( $n = 124$ , 94%).

## DISCUSSION

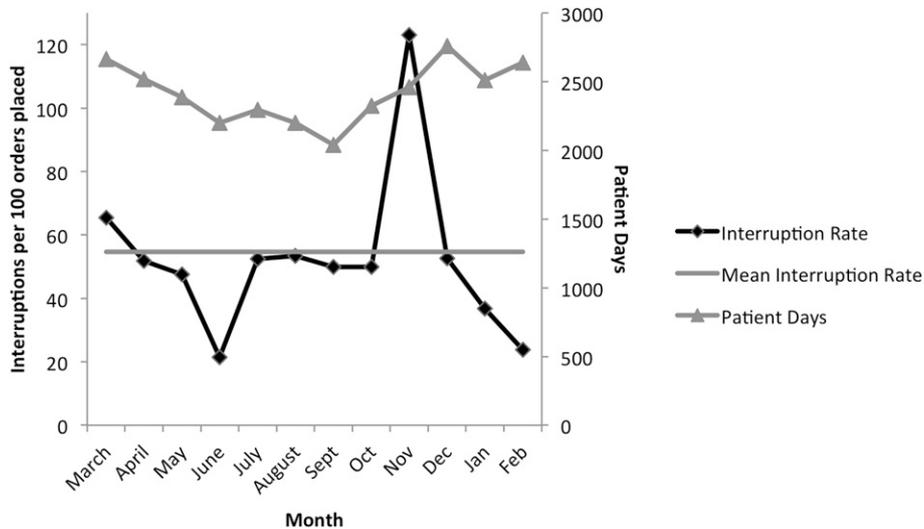
In one of the first studies to assess the frequency and context of interruptions during order placement in a pediatric inpatient facility, we found that residents and physician assistants were interrupted at a rate of 57 interruptions per 100 orders placed and that this did not vary with changes in patient census or time of day. The majority of interruptions were in person or by phone and overall the individuals initiating the interruption most commonly were nurses. The vast majority of these interruptions were non-urgent. These data are concerning for patient safety since ordering interruptions have been linked to medication errors.<sup>10</sup> While direct harm to patients was not evaluated in this study, the risk of harm from interrupting this mission critical task for medical care is high enough that future work should focus on reducing these ordering interruptions.

To date, much of the literature on interruptions focuses on interruptions

**TABLE 1** Characteristics of Structured Observations

	Morning Rounds	Afternoon	Night	Total
Number of observations	18	34	17	69
Providers <sup>a</sup>	22	127	39	188
Orders	79	260	75	414
Number of interruptions	51	143	42	236
Interruptions per 100 orders	64.6	55.0	56.0	57.0

<sup>a</sup> Providers may be counted more than once if observed on multiple occasions.

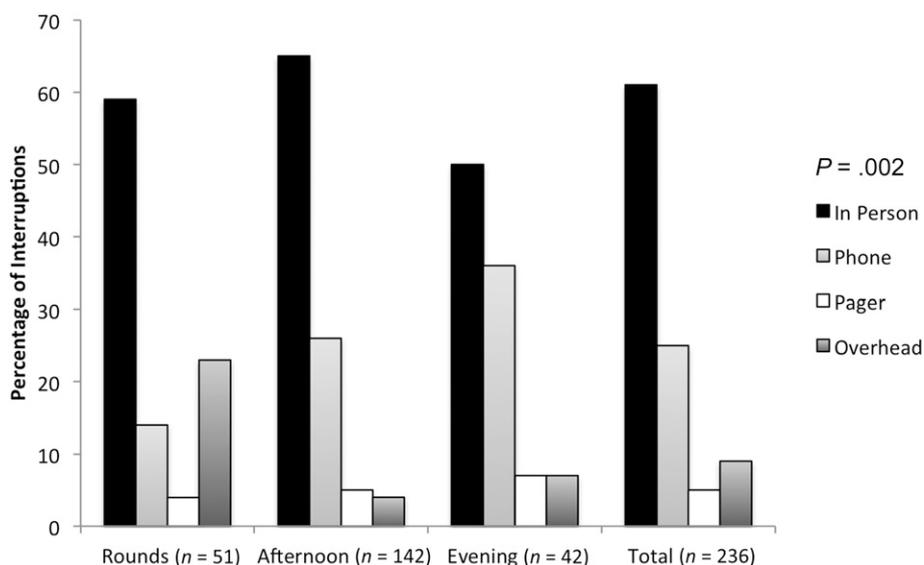


**FIGURE 1** Interruptions per 100 afternoon orders placed by month. (Interruption rate may exceed 100 if multiple interruptions occurred per order.)

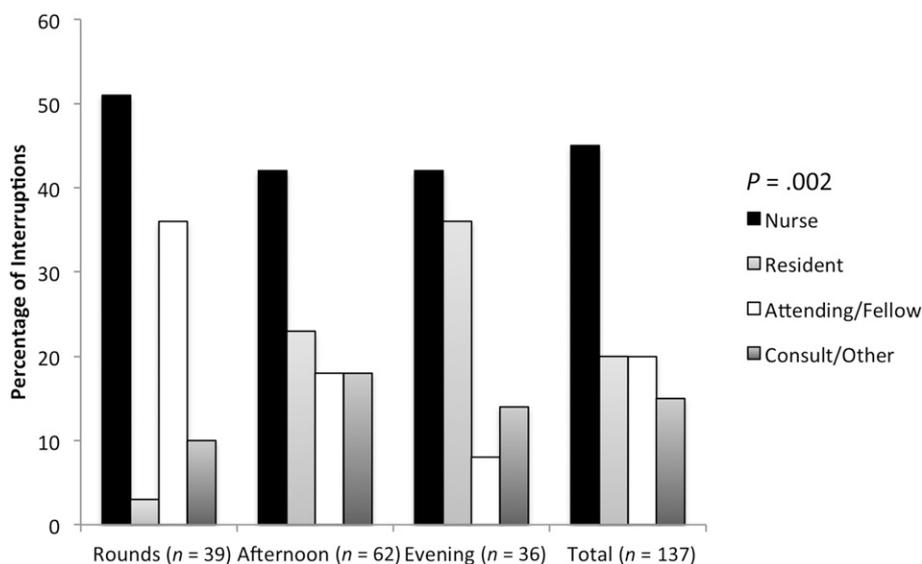
during medication preparation and administration. Up to 53.1% of medication administrations are interrupted.<sup>19</sup> Our data suggest that interruptions during ordering occur as frequently as interruptions during medication administration. Interventions to decrease interruptions during medication administration have reduced the number of interruptions by 43% to 75%.<sup>18,20,21</sup> Interventions have included marked

no-interruption zones in medication preparation areas, having nurses wear a visible symbol to indicate the process of medication administration time, designation of specific protected medication rounding time, and scripting for nurses to defer interruptions.<sup>18,20-22</sup> Lessons learned from these studies may help guide quality improvement and patient safety interventions to decrease interruptions during the ordering process.

Our data also suggest that the majority of interruptions occur in person, which allows for the opportunity for the individual initiating the interruption to recognize that his or her colleague is placing an order. Although communication among members of the medical team is a key component of safe and effective patient care, we found that the majority of interruptions in our study were nonurgent.<sup>23,24</sup> These data suggest that educating staff and other



**FIGURE 2** Type of interruptions by time of day. *P* value compares proportion of interruptions across each time period, which were in person, by phone, pager, or overhead via Fischer's exact test.



**FIGURE 3** Individuals initiating interruptions by time of day. *P* value compares proportion of interruptions across each time period initiated by each group of providers.

physicians that medication ordering is a critical time for patient safety similar to the act of preparing or administering a medication may be important. Additionally, we appreciate that some interruptions may actually be clarifying a previous order and increase patient safety. Although these potentially “beneficial” interruptions should not be eliminated, it is likely that providers and hospitals can find systems to better integrate needed but nonurgent interruptions. The second most common form of interruptions was phone calls. Future studies are needed to determine whether empowering providers to defer nonurgent phone calls and promoting team-based medical care in which nonordering providers are encouraged to triage nonurgent phone calls can create a safer environment for patients in the hospital.

Our study has several limitations. We were unable to directly correlate interruptions with medical errors because we did not collect patient identifiers. However, previous studies have suggested an association between interruptions and wrong patient ordering errors in computerized physician ordering systems and analysis of a national database shows that interruptions contribute to as many as 80% of ordering errors.<sup>10,25</sup> A simulation study testing the effect of interruptions on creating and

updating electronic medication charts was not able to detect an association between interruptions and errors.<sup>26</sup> However, this study was admittedly underpowered to detect such an association, and a 1-hour simulation in a laboratory setting with 4 case scenarios may not be reflective of the environment on a busy clinical floor. Further observational studies are needed in the clinical environment with patient-level data to fully assess the association of interruptions with errors.

Additionally, due to the observational nature of our study, our data are subject to reactivity bias because providers may have changed their behavior with the observer in the room. However, the interruption rate was quite high despite this, and we would anticipate that the reactivity effect would have biased the results toward a lower interruption rate. In addition, reactivity bias may have been mitigated by providers not knowing intent of the study. We also did not formally assess reliability between study team members with a statistical test such as a  $\kappa$  coefficient. Observation of a portion of orders was missed because 1 provider was observed at a time if multiple providers were placing orders. Additionally, our observations were performed during specific times, and we were not able to cover the full spectrum of when providers

place orders. It should be noted that because measurement occurred in the context of a QI project designed to decrease interruptions, the current study may underestimate the rate of interruptions. We did not study the specific type of order being interrupted, which would be an interesting area of future study. In addition, we report that there is no association between monthly interruption rate and monthly census in patient days; however, our ability to assess this association is limited because we were not able to account for the patient census at the time observations were completed. There may also be unaccounted for correlation between observation sessions as some of the ordering providers between overlap multiple observation sessions, but the study team does not anticipate that there is anything inherent about the ordering provider that would cause them to be interrupted more frequently than their peers. Finally, this is a single institution study performed at a tertiary teaching hospital, and our findings may not be generalizable to other inpatient settings.

## CONCLUSIONS

Interruptions occur at a rate of 57 per 100 order entries performed by residents and physician assistants on the pediatric

inpatient units. These interruptions likely contribute to ordering errors and are a concern for patient safety. Efforts should be made to rigorously decrease interruptions during the ordering process.

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