A Prospective Observational Study of Medication Errors in a Tertiary Care Emergency Department

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Study objective: We determine the rate and severity of medication errors, as well as factors associated with error occurrence in the emergency department (ED).

Methods: This was a prospective observational study conducted between May 1, 2008, and February 1, 2009. The pharmacist observer was present in the ED for 28 shifts (12 hours each). Information was collected on the medication use process by observing the activities of nurses caring for the patients. Errors were categorized by severity. Logistic regression was used to analyze factors associated with a risk of medication error.

Results: The observer identified 178 medication errors in 192 patients during the data collection period. At least 1 error occurred in 59.4% of patients, and 37% of patients overall had an error that reached them. No errors in the study resulted in permanent harm to the patient or contributed to initial or prolonged hospitalization; however, interventions were performed to prevent patient harm that likely influenced the severity of error. Errors categorized according to stage were prescribing (53.9%), transcribing (10.7%), dispensing (0.6%), and administering (34.8%). Variables predictive of medication errors were boarded patient status (odds ratio [OR] 2.15; 95% confidence interval [CI] 1.03 to 4.5), number of medication orders (OR 1.25; 95% CI 1.12 to 1.39), number of medications administered (OR 1.22; 95% CI 1.07 to 1.38), and nursing employment status (less error if full time) (OR 0.37; 95% CI 0.16 to 0.86).

Conclusion: Medication errors in the ED are common, and most errors occur in the prescribing and administering phases. Boarded patient status, increasing number of medications orders, increasing number of medications administered, and part-time nursing status are associated with an increased risk of medication error. [Ann Emerg Med. 2009;xx:xxx.]

Please see page XX for the Editor's Capsule Summary of this article.

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INTRODUCTION

Background

In the emergency department (ED), the lack of continuity with patients, coupled with an inadequate information infrastructure for care across the continuum, often forces emergency providers to see patients without all the information needed to make well-informed decisions.[1,2] Therefore, it has been speculated that the environment in the ED may be more conducive to medication errors than other areas of the hospital.[1,3,4] Current sources of data about medication errors in the ED are from voluntary reporting databases.[5] However, the errors reported through these voluntary systems may be a gross underestimation of the actual number of errors because the error rate calculated from passive reporting systems may be erroneously low compared with that of more active methods such as direct observational techniques.

Importance

Direct observation of the medication use process has been shown to increase the number and types of medication errors detected compared with traditional voluntary reporting techniques.[6,7] To our knowledge, this is the first study to use this approach to evaluate medication errors in the ED. The results of this study provide information about medication errors in this setting that can be compared with those of previous reports using other detection methods. At our institution, and for others considering a direct observation approach to error detection, the baseline information is crucial to assess the effect of future system changes to enhance medication safety in the ED.

Editor's Capsule Summary

What is already known on this topic

Medication errors are common in clinical work, and emergency department (ED) work is thought to be especially conducive to these problems.

What question this study addressed

The frequency of medication errors as measured by direct observation of a single ED.

What this study adds to our knowledge

At least 1 error was noted in more than half of the 192 patients observed, and more than one third of these reached the patient. None, however, resulted in direct harm. The number of medications, boarding status, and part-time nursing status were associated with greater frequency of errors.

How this might change clinical practice

These results are consonant with those of other studies suggesting that medication errors are common but only occasionally harmful; they support improvements in working conditions to increase medication safety.

Goals of This Investigation

The primary purpose of this investigation was to determine the rate and severity of medication errors as categorized according to the National Coordinating Council for Medication Error Reporting and Prevention system.[8] Additionally, factors associated with an increased risk of medication errors were identified.

MATERIALS AND METHODS

Study Design

This was a prospective observational study conducted in a tertiary care ED between May 1, 2008, and February 1, 2009. Institutional review board approval was obtained from the human subjects committee before this study was conducted.

Setting

The study was performed in a 40-bed, academic, tertiary ED with an annual census of approximately 70,000 patients. The ED is designated as a Level I trauma center. The ED was divided into 2 treatment areas: a 6-bed trauma resuscitation area and the general ED. The ED did not use computerized physician order entry or have a dedicated emergency pharmacist.

Selection of Participants

All ED nurses were eligible to participate in the study, without any inclusion or exclusion criteria. Nurses were initially contacted by the nurse manager about the availability to be a study subject. Interested nurses then gave consent to the principal investigator before their participation in the study. Information provided during the consenting process included the fact that this was a study on medication errors. Nurses were informed that all data collected would be anonymous.

Methods of Measurement

The study involved 28 observational shifts by 1 clinical pharmacist with expertise in emergency pharmacotherapy and training in observational methods by investigators experienced with this approach to event detection. The shifts were each 12 hours long and mirrored the nursing shifts at the study site. They were equally divided between day and night. Also, 25% of the shifts were conducted on the weekend. During each shift, the observer followed only the one nurse who had given consent for that shift and collected information on patients covered by that nurse only. The observations were performed in both the main ED and the trauma resuscitation area. The number of observational periods was based on previous studies conducted in ICUs that used a similar methodology.[6,7] We estimated that there would be sufficient data for descriptive analyses after 28 12-hour shifts (336 hours) of observational time.

Data Collection and Processing

Data were collected prospectively by the observer for the entire nursing shift and recorded on a paper data collection form. The observer recorded information pertinent to the nurse who was being observed. This included employment status (part time or full time), years of experience, observation time (night or day), day of the week, and boarding status of patients cared for by the nurse. Boarded patients were defined as patients in the ED who were admitted to the hospital but awaiting inpatient beds because of hospital crowding.[9] The medication use process (prescribing, transcribing, dispensing, administering, and monitoring) was observed and recorded for each patient who was covered by the nurse during the 12-hour shift. Specific medication-related documentation collected included drug name, dose, route, and frequency. Also, specific times when drugs were ordered and administered were recorded. A brief description of all events suspected or known to be medication errors and associated harm were documented during the observation period. Because the study was designed only to observe the medication use process, there were no planned interventions. However, if a medication error had the potential to cause patient harm, the observer would intervene as needed. This was planned a priori and was required for institutional review board approval.

Outcome Measures

Our primary outcome was to evaluate the rate and severity of medication errors in the ED, as well as potential factors leading to the errors. The error rate was expressed in terms of the proportion of patients who had an error and the number of

doses of medications administered. Medication errors were categorized according to the definitions of the National Coordinating Council for Medication Error Reporting and Prevention.

Primary Data Analysis

Error categorization was performed independently by a pharmacist and a physician not involved in the data collection process. Interrater reliability of the categorizations was performed with the κ measure coefficient of agreement. If there were discrepancies in categorization between the 2 evaluators, it was resolved by a discussion involving the observer. Descriptive analyses were performed to evaluate error rates and severity according to National Coordinating Council for Medication Error Reporting and Prevention. Univariate logistic regression analyses were performed to evaluate factors associated with the occurrence of 1 or more medication errors for a patient (including all National Coordinating Council for Medication Error Reporting and Prevention categories). Significance for all analyses was defined as $P<.05$. Analyses were performed with Intercooled Stata 7.0 (StataCorp, College Station, TX).

RESULTS

A total of 18 nurses gave consent for participation in the study. Eleven nurses completed 2 shifts each and 6 nurses completed 1 shift each, for a total of 28 shifts. One nurse who gave consent was unable to participate because of scheduling issues. Each nurse cared for a median of 7 patients (interquartile range 6 to 8) during a 12-hour shift. The observer identified 178 medication errors in 192 patients who were treated during the observation periods. A total of 123 of these medication errors reached the patient (category C or higher). There were 953 medication orders written and 629 medications administered during the study. Therefore, there was approximately 1 medication error for every 5 medication orders written and 4 doses administered. There was approximately 1 error that reached the patient (category C or higher) for every 8 medication orders written and 5 doses administered. Overall, 59.4% of patients had 1 or more errors and 37% of patients had 1 or more errors that reached them (category C or higher).

Percentage distribution of error categories by severity according to the National Coordinating Council for Medication Error Reporting and Prevention are listed in Table 1. There was a high rate of agreement between the 2 independent coinvestigators with regard to error categorization (percentage agreement=96%; κ=0.91). There were no errors in the study that resulted in permanent harm to the patient or contributed to initial or prolonged hospitalization. The observer intervened on 52 occasions to prevent potential patient harm resulting from medication errors. Only 1 error in the study may have contributed to or resulted in temporary harm to the patient.

Errors categorized according to stage of occurrence were as follows: prescribing (53.9%), transcribing (10.7%), dispensing (0.6%), and administering (34.8%). Of the 52 errors that required observer intervention, 39 were prescribing errors, 9 were administering errors, 3 were transcribing errors, and 1 was a dispensing error. The following variables were positively or negatively predictive of patients with 1 or more medication errors: boarded patient status, number of medication orders, number of medications administered, and nurse employment status (Table 2).

Table 1. Categorization of medication errors by severity (n=178 errors).

Category	Definition*	No.	%
A	Circumstances or events that have the capacity to cause error	34	19.1
B	An error occurred but the error did not reach the patient	21	11.8
C	An error occurred that reached the patient but did not cause patient harm	71	39.9
D	An error occurred that reached the patient and required monitoring to confirm that it resulted in no harm to the patient or required intervention to preclude harm	51	28.7
E	An error occurred that may have contributed to or resulted in temporary harm to the patient and required intervention	1	0.5
F	An error occurred that may have contributed to or resulted in temporary harm to the patient and required initial or prolonged hospitalization	0	0
G	An error occurred that may have contributed to or resulted in permanent patient harm	0	0
H	An error occurred that required intervention necessary to sustain life	0	0
I	An error occurred that may have contributed to or resulted in patient's death	0	0

*According to the National Coordinating Council for Medication Error Reporting and Prevention.

Table 2. Univariate regression analysis of patients at risk for errors.

Variable	Odds Ratio (95% CI)
Boarded status	2.15 (1.03-4.5)
Number of medication orders	1.25 (1.12-1.39)
Number of medications administered	1.22 (1.07-1.38)
Observation time (night)	1.21 (0.68-2.15)
Patient age	1 (0.99-1.02)
Patient sex (male)	0.63 (0.35-1.14)
Nurse employment status (full time)	0.37 (0.16-0.86)
Nursing experience, y*	
<1	1.08 (0.47-2.48)
6-10	0.62 (0.29-1.35)
>10	0.8 (0.28-2.31)

*Compared with nurses with 1 to 5 years' experience.

LIMITATIONS

An unanticipated problem was the degree to which the observer had to intervene to prevent potential patient harm. The decision to intervene was based on the professional judgment of the observer who was a pharmacist with specialized

training in emergency medicine. Although we cannot be certain that a lack of intervention would have definitely resulted in patient harm, it is highly likely that the final categorization of these medication errors at intervention would underestimate their true severity. To account for this, all errors that required observer intervention were considered to be category D or higher, according to definitions from the National Coordinating Council for Medication Error Reporting and Prevention. Also, we had originally planned that the observer would not answer any drug therapy questions during the observation shift, but instead the questions would be referred to the central pharmacy or on-call pharmacist. These resources are available 24 hours a day at our institution. The observer noted that when questions were referred, they were often not answered promptly because of time constraints (eg, nurse calls pharmacy but does not wait to speak to a pharmacist when put on hold). Because of a concern for patient safety, the observer was compelled to answer drug therapy questions in these situations. It is possible that answering some questions may have led to an underestimation of the severity of medication errors observed.

Medication errors in this study were recorded by using a prospective observational approach by following one nurse at a time. However, the observer still found it difficult to observe the medication administration process in the ED environment. Other aspects of the medication use system (eg, prescribing, transcribing) were easier to observe and detect errors. To observe medication administration thoroughly, the observer would have had to interrupt the nurse, which could have affected patient care. Similar difficulties by the observer have also been reported in studies in the ICU.[6,7] Therefore, if anything, this study underestimates the true incidence and severity of medication errors in the ED. The results of this study cannot be generalized to all EDs because medication use systems, technology, and other resources can differ between institutions. Finally, we could not exclude potential clustering of the data for nursing status (full versus part time) because errors were not linked to specific nurses during the data analysis process because of institutional review board requirements.

DISCUSSION

One key finding of this study is that close to 60% of patients whose medication process was observed in the ED during this study had 1 or more medication errors. However, 37% of patients overall had an error that reached them and only 1 error resulted in patient harm. Previous studies have shown approximately 1 error for every 5 doses of a medication administered in the ICU setting.[7] This rate is similar to the rate that we found in the ED. However, comparisons involving different patient care settings are difficult, even when the same method of error detection is used. Regardless, to our knowledge, this is the first study to use direct observation for medication error detection in the ED. Also, this is the first study to show a direct relationship between patient boarding and an increased risk for medication errors, which provides additional evidence for the need to reduce patient boarding in the ED.

During the study, the observer intervened several times to intercept medication errors that may have resulted in patient harm. According to this finding, the potential benefits, and the success of other decentralized pharmacists at our hospital, we now employ a full-time pharmacist in our ED. According to a recent national survey, 6.8% of EDs have this additional resource.[10] The pharmacist in the ED has been a liaison between the central pharmacy of the hospital and emergency providers, which has led to process changes with regard to medication distribution and optimization in the use of control access cabinets in the ED. Also, regular educational sessions provided by the emergency pharmacist have likely influenced prescribing and medication use in the ED.

We conclude that medication errors are common in the ED but seldom result in adverse events. Most medication errors occur during the prescribing and administering phase of the medication use process. Boarded patient status, an increasing number of medications ordered or administered, and part-time nursing status are associated with an increased risk of medication error.

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REFERENCES

1. Burstin H. "Crossing the quality chasm" in emergency medicine. *Acad Emerg Med*. 2002;9:1074-1077.
2. Peth HA Jr. Medication errors in the emergency department: a systems approach to minimizing risk. *Emerg Med Clin North Am*. 2003;21:141-158.
3. Brown M. Medication safety issues in the emergency department. *Crit Care Nurs Clin North Am*. 2005;17:65-69, xi.
4. Cobaugh DJ, Schneider SM. Medication use in the emergency department: why are we placing patients at risk? *Am J Health Syst Pharm*. 2005;62:1832-1833.

5. Hicks RW, Camp S. United States Pharmacopeia. Medication errors in emergency department settings. Available at: http://www.usp.org/hqi/patientSafety/resources/posters/posterEmergencyDept.html. Accessed July 10, 2009.
6. Buckley MS, Erstad BL, Kopp BJ, et al. Direct observation approach for detecting medication errors and adverse drug events in a pediatric intensive care unit. *Pediatr Crit Care Med*. 2007;8:145-152.
7. Kopp BJ, Erstad BL, Allen ME, et al. Medication errors and adverse drug events in an intensive care unit: direct observation approach for detection. *Crit Care Med*. 2006;34:415-425.
8. National Coordinating Council for Medication Error Reporting and Prevention. Medication error index. Available at: http://www.nccmerp.org/medErrorCatIndex.html. Accessed May 4, 2007.
9. American College of Emergency Physicians. Emergency department crowding: high-impact solutions. ACEP Taskforce report on boarding. Available at: http://www.acep.org/workarea/downloadasset.aspx?id=37960. Accessed April 15, 2008.
10. Pedersen CA, Schneider PJ, Scheckelhoff DJ. ASHP national survey of pharmacy practice in hospital settings: dispensing and administration—2008. *Am J Health Syst Pharm*. 2009;66:926-946.

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