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Research Paper

Severity and probability of harm of medication errors intercepted by an emergency department pharmacist

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Abstract

Objectives The objective of this study was to evaluate the severity and probability of harm of medication errors (MEs) intercepted by an emergency department pharmacist. The phases of the medication-use process where MEs were most likely to be intercepted were determined.

Methods The emergency department was staffed with a full-time pharmacist during the 7-month study period. The MEs that were intercepted by the pharmacist were recorded in a database. Each ME in the database was independently scored for severity and probability of harm by two pharmacists and one physician investigator who were not involved in the data collection process.

Key findings There were 237 ME interceptions by the pharmacist during the study period. The final classification of MEs by severity was as follows: minor ($n = 42$; 18%), significant ($n = 160$; 67%) and serious ($n = 35$; 15%). The final classification of MEs by probability of harm was as follows: none ($n = 13$; 6%), very low ($n = 96$; 41%), low ($n = 84$; 35%), medium ($n = 41$; 17%) and high ($n = 3$; 1%). Inter-rater reliability for classification was as follows: error severity (agreement = 75.5%, kappa = 0.35) and probability of harm (agreement = 76.8%, kappa = 0.42). The MEs were most likely to be intercepted during the prescribing phase of the medication-use process ($n = 236$; 90.1%).

Conclusions A high proportion of MEs intercepted by the emergency department pharmacist are considered to be significant or serious. However, a smaller percentage of these errors are likely to result in patient harm.

Introduction

It has been speculated that the emergency department (ED) of a medical facility is particularly prone to medication errors (MEs) since providers are frequently interrupted and have to make quick decisions with little or no clinical information.[1–3] Up to 60% of patients in the ED may experience a ME during their stay.[4] Also, since 'high-risk' medications such as opioids are commonly used in the ED, errors in this setting may also result in greater patient harm.[5] One option to improve patient safety is to utilize pharmacists in the ED to intercept MEs. In fact, the number of EDs in the USA that have implemented ED pharmacists as a patient safety measure has increased from 6.8% to 28.6% in a 1-year time frame between 2008 and 2009.[6,7] Although small retrospective studies have shown a benefit in terms of ME reduction and cost avoidance with the use of ED pharmacists, no prospective comparative studies have evaluated outcomes such as patient harm avoided.[5,8] Patient harm due to a ME is known as an adverse drug event (ADE). In a recent multicentre study, 84% of MEs intercepted by ED pharmacists were considered to be serious or significant.[9] However, there is little information regarding the estimated probability of harm or ADEs if these MEs had not been intercepted. This is an important consideration in terms of patient outcomes and the design of future prospective comparative studies.

The objective of this study was to evaluate the severity and probability of harm of MEs intercepted by an ED pharmacist. The phases of the medication-use process where MEs are most likely to be intercepted were also determined.

Methods

Study design

This is a retrospective evaluation of a quality improvement database. The database contained information regarding MEs intercepted by the ED pharmacist between 17 December 2008 and 16 July 2009. The project was determined exempt from Human Subjects Committee review by the Department Review Process using guidelines issued by the Institutional Review Board of the University of Arizona, USA.

Study setting and population

The study was performed in a 61-bed, academic tertiary ED with an annual census of approximately 65 000 patients. The ED is designated as a level 1 trauma centre (highest acuity trauma designation in the USA). The ED also utilizes computerized physician order entry, smart pump technology and automatic dispensing cabinets. Bar-coding for medication administration is not implemented in the ED.

During the study, the ED was staffed with one full-time ED pharmacist with approximately 10 years of experience working in this setting. He was present in the ED for 40 hours per week (1200–2200 for 4 days per week, excluding weekends). The ED pharmacist performed a variety of activities such as prospectively reviewing medication orders, participation in drug therapy consultations, obtaining and preparing medications for administration, performing medication reconciliation and participating in resuscitations. The ED pharmacist was able to intercept suspected MEs while being involved in any of these activities.

Study measurements

An ME was defined as any error in the medication-use process. An ME was considered to be intercepted if the ED pharmacist (DPH) intervened to prevent possible patient harm. Interventions by the ED pharmacist were entered into a quality improvement database. Data recorded for each suspected ME intercepted included a brief description of the error and the process phase during which the error occurred (prescribing, dispensing, transcribing (transcribing occurs when the nurse rewrites a medication order from the computer system to a paper medication administration record; this only occurs for those patients who are admitted but remain in the ED for an extended period of time), administering or monitoring). Each suspected ME intercepted was independently evaluated by two pharmacists (AEP and BLE) and one emergency physician (ABS) who were not involved in the data collection process. All case reviewers have experience in patient safety investigations and have performed error categorizations in previous studies.[4,10,11] Suspected MEs that were judged not to be MEs by any of the case reviewers were excluded from the analysis. The remainder were considered to be confirmed ME interceptions. Note that events such as name misspellings or other inconsequential events were not recorded in this database.

The primary outcome measures were the severity of error and probability of ADE associated with each confirmed ME intercepted. Each confirmed ME interception was independently scored for severity of error and probability of ADE by the two pharmacist investigators (AEP and BLE) to provide a single severity and probability score for each case. When there were disagreements in scoring between the investigators, the most conservative value was selected (least severity or probability of harm). Cases were also independently reviewed by an emergency medicine physician (ABS) for severity of error and probability of ADE. Severity of each confirmed ME interception was classified similarly to previous investigations.[9,12] The severity categories from lowest to highest severity are: minor (patient harm is likely to be minor), significant (could result in a moderate level of patient harm), serious (severe harm could occur but not life-threatening), and potentially lethal (could result in life-threatening consequences) (Table 1). Note that MEs with a high severity may have a low probability of an associated ADE and MEs with a low severity may have a high probability of an ADE. Therefore, MEs were also categorized based on probability of ADE occurrence. These probabilities were as follows: 0 (none), 0.01 (very low), 0.1 (low), 0.4 (medium) and 0.6 (high). This classification system is based on previous studies that have evaluated probability of ADEs.[13] The maximum probability value was set at 0.6 to maintain a conservative bias.

Table 1 Severity of error categorization* in an emergency department of a US medical facility

Potentially lethal (could result in life-threatening consequences)
Examples:
Potentially lifesaving drug at a dosage too low for the disease being treated
High dosage (>10 times normal) of drug with low therapeutic index
Serious (severe harm could occur but not life-threatening)
Examples:
Low dosage of drug for serious disease in patient with acute distress
High dosage (4–10 times normal) of drug with low therapeutic index
High dosage (10 times normal) of drug without low therapeutic index
Significant (could result in a moderate level of patient harm)
Examples:
Drug dosage too low for patient's condition
High dosage (1.5–4 times normal) of drug with low therapeutic index
High dosage (1.5–10 times normal) of drug without low therapeutic index
Minor (patient harm is likely to be minor)
Examples:
Unavailable or inappropriate dosage form
Incomplete information in medication order

*Scoring system adapted from References 9 and 12.

Data analysis

Interceptions of MEs were categorized based on severity of ME and probability of an ADE as described above. Scores that were more than two values different on the Likert scales for severity or probability were evaluated as a group by the investigators and reconciled. If scores were one value different, then the lower score was used in the final analysis. This was done to provide conservative estimates of potential patient harm for each ME intercepted. Inter-rater reliability of the categorizations between the combined pharmacist scores and the physician scores were performed using the kappa measure coefficient of agreement. For inter-rater reliability testing, the severity scale was dichotomized into errors that had serious or higher severity versus those that were less severe. The probability scale was dichotomized into errors that had a medium or high probability of harm versus those with a lower probability. A power analysis was not performed since this was a descriptive study. Analyses were performed using Stata 11.0 (College Station, Texas, USA).

Results

There were 262 suspected MEs intercepted during the study period that were recorded in the database. Of these, 25 were not considered to be MEs, resulting in 237 confirmed ME interceptions. During this study period there were 36 747 medication orders prescribed when the pharmacist was present yielding a rate of ME interception of approximately 0.6 per 100 medication orders. The final classification of MEs by severity was as follows: minor ($n = 42$; 18%), significant ($n = 160$; 67%) serious ($n = 35$; 15%). None were considered to be potentially lethal (Table 2). There was 75.5% agreement for severity classification between the investigators with a kappa of 0.35 (fair agreement). The final classification of MEs by probability of ADE occurrence was as follows: none (0) ($n = 13$; 6%), very low (0.01) ($n = 96$; 41%), low (0.1) ($n = 84$; 35%), medium (0.4) ($n = 41$; 17%) and high (0.6) ($n = 3$; 1%) (Table 3). There was 76.8% agreement for probability classification between the investigators with a kappa of 0.42 (moderate agreement). The relationship between severity of error and probability of harm is reported in Table 4.

Any MEs were most likely to be intercepted when they originated during the prescribing phase of the medication-use process ($n = 211$; 89%), followed by administering ($n = 17$; 7%), dispensing ($n = 8$; 3%) and monitoring ($n = 1$; < 1%). No errors were intercepted during the transcribing phase.

Table 2 Relationship between severity of error and probability of harm ($n = 327$) of intercepted medications

	Severity		
Probability	Minor	Significant	Serious
None	10	3	0
Very low	27	69	0
Low	5	74	5
Medium	0	14	27
High	0	0	3

Table 3 Selected medication error interceptions by severity

Potentially lethal
None reported in study
Serious
Patient with a myocardial infarction was prescribed a heparin infusion. Patient also had concurrent active gastrointestinal bleeding. This was intercepted and heparin order was discontinued.
Significant
Patient (weight = 100 kg) with head trauma is prescribed mannitol 10 g IV for reduction of intracranial pressure. Pharmacist recommended an increase in dose. Note that typical dose recommended for this indication is 0.25–1 g/kg.
Minor
A 14-year-old trauma patient was ordered a tetanus vaccine. This was not needed since the patient was up to date with this vaccine and therefore it was discontinued by the pharmacist.

Table 4 Selected medication error interceptions by probability of harm

High (0.6)
Patient with a hypertensive emergency was prescribed nitroprusside 0.5 μg/kg/min IV. Nurse almost administered 5 μg/kg/min (10 times the prescribed dose). This was intercepted by the pharmacist as he was present at the bedside. Possibility for rapid drop in blood pressure was avoided.
Medium (0.4)
Patient (weight = 80 kg) with chronic kidney disease (creatinine clearance = 20 ml/min) was prescribed enoxaparin 80 mg subcutaneously every12 h. This dose was reduced by the pharmacist to 80 mg subcutaneously every 24 h due to renal dysfunction. Potential for bleeding complications was avoided.
Low (0.1)
Patient prescribed prothrombin complex concentrate 100 units/kg for INR reversal. Typical recommended dose is 25–50 units/kg. Pharmacist intervened to decrease dose to 25 units/kg. There is the potential to increase risk for thromboembolic complications with higher doses.
Very Low (0.01)
Patient with bacterial meningitis is empirically prescribed vancomycin 1 g IV and ceftriaxone 1 g IV. Typical recommended dose of ceftriaxone for meningitis is 2 g IV in adults. Dose was increased as per pharmacist's recommendation.
No harm expected (0)
Patient with ethanol intoxication is not ordered a banana bag (magnesium 1 g, folic acid 1 mg, thiamin 100 mg and multivitamin 10 ml – all mixed in 1 l normal saline). This was recommended by the pharmacist and subsequently ordered by the physician.

IV, intravenous; INR, international normalized ratio.

Discussion

One of the key findings of this study is that 82% of the MEs intercepted were considered to be significant or serious, based on severity. This confirms findings in a recent multicentre study which showed a similar rate of significant or serious errors.[9] However, when categorized by probability of ADE, only 18% were considered to be of medium or high probability (≥0.4 overall). The mode probability of harm of the MEs intercepted was low (0.01). These results indicate that ED pharmacists are able to intercept a substantial number of potentially serious MEs in the ED; fortunately, the overall probability of associated ADEs was judged to be low. This is an important consideration for future comparative studies evaluating the impact of the ED pharmacist on patient outcomes. It is likely that future studies evaluating differences in the occurrence of patient harm would require a larger study sample compared to estimates solely based on error severity.

The determination of probability of ADE for each ME intercepted was sometimes difficult to estimate despite the use of a validated scale that has been used in other investigations. This is primarily because such probabilities are rarely available in the literature and can vary based on patient risk, co-morbidities or other factors. Therefore, this was somewhat of a subjective determination by the investigators. We did not record information related to the activities of the ED pharmacist that led to ME interception, but this could be the focus of future investigations. Finally, the results should be extrapolated with caution to other institutions since this is a single centre study and factors such as the training and experience of ED pharmacists may differ.

We found that the ED pharmacist was most likely to intercept MEs during the prescribing phase (89%). This finding has been noted in other studies conducted in the ED setting.[9] This does not necessarily mean that there are more MEs that occur during this phase, since the attributable phase is a function of the method of ME detection. For example, national databases compiled from voluntary reporting systems in EDs have shown a greater number of MEs during the administration phase.[14] However, administration MEs occur in the final phase of the medication-use process so are less amenable to pharmacist interception and may not be adequately represented in our data. The utilization of other technologies such as bar-coding may be more effective at prevention of MEs during this phase. Interestingly, the ED pharmacist was able to intercept dispensing errors, some of which were made by other pharmacists in the inpatient pharmacy. Also, there were some interceptions made by the ED pharmacist that were not considered to be MEs (25 of 262 suspected ME interceptions) when subsequently evaluated by the pharmacists and physician investigators. There are a number of potential explanations for this finding including the retrospective analysis of the events with the potential for incomplete or missing information in the database that might provide more details on the interventions.

Our rate of ME interception of 0.6 errors per 100 medication orders was lower than that found by Rothschild *et al.*[9] The rate of recovery in their study was 2.9 errors per 100 medication orders. This is likely attributed to the manner in which we obtained our denominator. We included all medication orders prescribed when the pharmacist was present in the ED regardless of whether or not they were reviewed by the pharmacist. In Rothschild *et al.*,[9] they only included medication orders that were reviewed by the pharmacist. Using a denominator of all medication orders is more realistic because, given the various functions performed by an ED pharmacist, it may not be possible to review all orders by a single pharmacist during a shift. Review of all orders in most EDs would restrict the pharmacist to a computer terminal for order review, potentially at the expense of other more important clinical services. When other clinical services are deemed of higher priority, orders could either be reviewed later, if non-emergent, or by another pharmacist.

Conclusion

A high proportion of MEs intercepted by the ED pharmacist are considered to be significant or serious. However, a smaller percentage of these errors are likely to result in patient harm or ADE. The ED pharmacist is most likely to intercept MEs that occur during the prescribing phase of the medication-use process.

Declarations

Conflict of interest

The Author(s) declare(s) that they have no conflicts of interest to disclose.

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