

REVIEWS

Medication errors: scope and prevention strategies

Luigi Brunetti¹, Dong-Churl Suh²

1. Rutgers, The State University of New Jersey, USA. 2. College of Pharmacy, Chung-Ang University, Republic of Korea

Correspondence: Dong-Churl Suh. Address: College of Pharmacy, Chung-Ang University, 221 Heukseok-dong, Dongjak-gu, Seoul, Republic of Korea. E-mail: dongsuh75@gmail.com

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Abstract

Background: Medication errors are a significant public health concern. Although significant advances have been made, errors are still relatively common and represent an opportunity for healthcare improvement.

Methodology/Principal findings: Since the publication of *To Err is Human*, medication errors have been under tremendous scrutiny. Organizations have moved towards a non-punitive approach to evaluating errors. This approach to medication errors has aided in identifying common pathways to medication errors and improving understanding regarding the anatomy of a medication error. As a result, prevention strategies have been developed to target common themes contributing to errors. Error prevention strategies may target common contributors of medication errors, broadly grouped as performance lapses, lack of knowledge, and lack or failure of safety systems. Strategies to thwart medication errors range from process improvement to integration of technology in the health care environment.

Conclusions/Significance: Organizations should devote resources to address medication error prevention strategies in an effort to improve patient outcomes and decrease morbidity and mortality associated with medication errors.

Key words

Medication error, Computerized physician order entry, Bar code medication administration, Adverse drug event

1 Introduction

It is estimated that an error occurs at some point in the medication use process in 5 to 14% of medication doses dispensed^[1-4]. Medication errors and preventable adverse drug events have a variety of public health implications ranging from increased hospital length of stay, detrimental effects on quality of life, and death. Approximately 1 to 10% of medication errors are associated with patient harm^[4-7]. Prevention of medication errors continues to be an important public health concern.

In order to reduce the incidence of medication errors and provide patients with safe and effective care, practitioners should be familiar with the literature and strategies to prevent medication errors. The objectives of this review are to highlight common contributors to medication errors and to present possible prevention strategies-enhancing communication, technology, education, and encouraging voluntary reporting.

2 Literature retrieval

Literature retrieval was accessed through MEDLINE/PubMed (1950-June 2012), Web of Science (1980-June 2012), and Google Scholar using the terms medication error, computerized physician order entry, bar coded medication administration, medication reconciliation, and medication management. References from publications identified were reviewed for additional resources. Only articles in English were reviewed and articles that represented controlled clinical evaluations were given priority for inclusion in the review.

3 Background/Epidemiology

There are a multitude of terms used to describe and define medication errors in the literature. As a result, epidemiological studies evaluating medication errors are difficult to compare given the differences in identifying the outcome. The National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP) created an international definition in an effort to standardize medication error definition. NCC MERP has defined a medication error as “any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the healthcare professional, patient, or consumer. Such events may be related to professional practice, healthcare products, procedures, and systems, including prescribing, order communication, product labeling, packaging, and nomenclature, compounding, dispensing, distribution, administration, education, monitoring, and use”^[8]. NCC MERP has also proposed a medication error index intended to categorize errors based on severity or outcome of the medication error. The index is divided into four main categories and nine subcategories (Figure 1)^[8]. As evident in this definition, the medication use process is complex, hence the susceptibility to error. Although the NCC MERP definition is commonly used to categorize medication errors in studies, it was originally developed for medication error reporting rather than detection. The Institute of Medicine (IOM) has provided a broader definition for medication errors to include errors of omission. IOM defines a medication error “as the failure of a planned action to be completed as intended (i.e., error of execution), or the use of a wrong plan to achieve an aim (i.e., error of planning). An error may be an act of commission or an act of omission”^[9]. NCC MERP also incorporates “near misses” into their schema (i.e., NCC MERP category A). A “near miss” may be defined as circumstances or occurrences that presented a risk but did not cause patient harm^[8]. The reporting of these “near misses” or potential medication errors are critical and a necessity in order to improve patient safety. Learning from these potential errors is an opportunity to identify circumstances that are prone to errors and develop mechanisms to thwart the occurrence of a medication error. Overall, there is ambiguity in the definition in medication errors that contributes to variation in study results. Future studies are needed to develop a standard definition for medication errors^[10].

NCC MERP Index for Categorizing Medication Errors

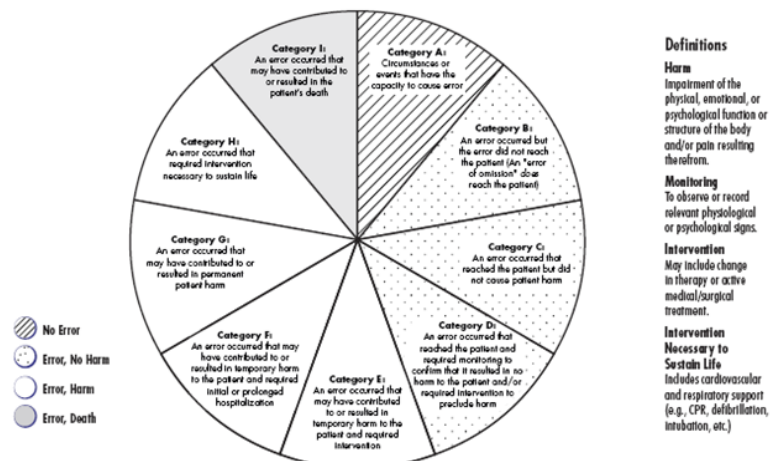


Figure 1. NCC MERP index for categorizing medication errors.

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Some populations may be particularly vulnerable to harm resultant to medication errors. The elderly have the highest rate of death from medication errors ^[11]. Several factors present in the elderly population contribute to this increased risk including, polypharmacy, increased drug sensitivity, drug-disease interactions, and unnecessary drug utilization ^[12]. Likewise, the pediatric population is also at an increased risk for medication errors. It has been reported that a medication error impacts 1 in 10 pediatric hospital admissions and injures thousands of children annually ^[3, 13].

Each year medication errors are thought to account for 7000 deaths ^[9]. There are a wide variety of error rates reported in the literature. In one study of 36 facilities, the medication error rate was reported as 14.6% ^[14]. Another study of 1116 hospitals reported that approximately 5% of all admitted patients experienced a medication error during their hospital stay ^[15]. Reported medication error rates in the prescribing stage of the medication use process in the hospital setting ranged from 0.61 to 53 per 1000 orders ^[9]. Medication error rates are higher in the pediatric population with 4.2% to 24% of pediatric prescriptions containing an error ^[3, 16]. The disparity in reported error rates is likely related to the voluntary nature of reporting as well as definitions used in identifying medication errors. It is likely that actual medication error rates are higher than those reported.

In terms of financial impact on the healthcare system, drug related morbidity and mortality costs the United States between \$76.6 to \$136 billion annually ^[17]. Further, the negative consequences of medication errors in terms of reputation, psyche, and loss of life are immeasurable. It has been estimated that 2 out of every 100 hospital admissions will experience a preventable adverse drug event and the occurrence of a preventable adverse drug event increases hospitalization costs by \$4,700 per event. Application of these figures to a 700-bed hospital yields an increased cost of approximately \$2.8 million annually ^[18]. In the ambulatory setting, adverse drug events cost the healthcare system an approximate \$8 billion annually ^[19]. Overall, the cost of medication errors has not been clearly defined and data in the pediatric and psychiatric population are scarce ^[9]. Most of the available data are from the hospital setting and related to additional costs incurred.

Mitigating factors in medication errors

There have been a variety of models used to categorize the causes of medication errors. One such categorization scheme suggests categorizing the causes of errors into three silos; 1) performance lapses; 2) lack of knowledge; and 3) lack or failure of safety systems ^[9]. Many medication errors fall into the category of lack or failure of safety systems. Healthcare professionals do not intentionally commit errors; however, inadequate systems predispose individuals to committing errors. In one analysis, 78% of errors were caused by seven system failures, with the leading problem (28%) attributed to failure to disseminate drug information ^[20]. Systems failure is further substantiated by the United States Pharmacopeia's MEDMARX experience. Reviews of these data suggest that there are a multitude of causes for medication errors further substantiating the need for a systems approach ^[21, 22].

In each of the medication use phases (prescribing, ordering/transcribing, dispensing, and administration), there is a potential for a medication error to occur. Elements such as missing patient information, patient education, inadequate drug information, impaired communication, staffing inadequacies, product labeling and nomenclature, staff education, and competency may interrupt the medication use process and contribute to a medication error (IOM). Often, medication errors are a result of multiple failures rather than a single deviation.

A common theme in medication errors is lack of communication ^[23]. Communication was the leading cause of sentinel events in 2010 and among the top 3 causes over the past several years according to the Joint Commission. Approximately 60% of sentinel events list communication as a root cause. In terms of medication errors, communication was listed as one of the root causes in approximately 70% of sentinel events reported between 2004 through third quarter 2010 ^[24].

Although all medications have error potential, agents with narrow therapeutic indices are more likely to cause patient harm. The Institute for Safe Medication Practices (ISMP) has published a list of high-alert medications. The use of medications on this list requires additional safeguards to ensure patient safety. Many high-alert medications highlighted by ISMP are administered by the intravenous route (i.e., heparin, insulin, electrolytes). The use of parenteral medications is associated with the highest risk of harm; therefore, the prevention of errors with medications administered by the parenteral route should be of high priority ^[25].

4 General recommendations to prevent medication errors (Table 1)

4.1 Communication

The healthcare environment is fast-paced and pressure ridden. It is well established that poor communication can have devastating consequences in the healthcare environment. It has been estimated that 75% of transcription errors are a result of distractions ^[26]. One analysis quantifying the impact of interruptions on patient safety found that interruptions were associated with a 12.1% increase in procedural failures and a 12.7% increase in clinical errors ^[27]. In the same analysis, the authors found that nurse experience was not protective against making clinical errors in the presence of interruptions. These data highlight the importance of designing effective work environments in order to minimize error risk potential. Abbreviations also have a negative impact on communication and have been linked to medication errors. In one analysis of a total of 643,151 medication errors reported to the MEDMARX program 29,974 (4.7%) were attributed to abbreviation use ^[28]. In order to minimize error potential, distractions should be kept to a minimum, especially in areas where medication orders are processed. Furthermore, abbreviation use should be discouraged especially those appearing on the Joint Commission “Do-not use list”. Open dialogue should be encouraged between disciplines in order to minimize miscommunication.

Table 1. Medication errors: contributing factors and strategies to mitigate

Contributing factor to error	Strategy to mitigate
Performance lapse	<ul style="list-style-type: none"> • Use a peer review process to dissect medication errors and address performance issues.
Lack of knowledge	<ul style="list-style-type: none"> • Review health records to identify and address performance lapses. • Clinician and patient education are critical. Ensure methods are tailored for the specific population. • Use various methods to relay information throughout the facility. • Incorporate pharmacists into patient care teams.
Lack or failure of safety systems	<ul style="list-style-type: none"> • Computerized physician order entry (with decision support) • Bar-code medication administration • Identification of high risk medications and populations • Formulary management • Review health records to identify system failures. • Reporting is critical in order to identify areas for improvement.

It is also essential for practitioners to communicate with patients. A recent analysis demonstrated that one-third of 651 hospital inpatients had a medication error present on admission ^[29]. Eighty-five percent of these errors originated from poor medication histories. These data suggest that by communicating with patients and reconciling medication histories, a significant number of medication errors can be averted. The Joint Commission designated medication reconciliation as a national patient safety goal in 2005 ^[30]. Organizations should develop a process to accurately reconcile patient

medications. An electronic medication reconciliation tool and process improvement has demonstrated a reduction in potential adverse drug events related to medication discrepancies by 28% (RR 0.72; 95% CI, 0.52 – 0.99) ^[31].

4.2 Computerized physician order entry

Computerized physician order entry (CPOE) with decision support has the potential to reduce medication errors. The majority of studies have demonstrated a reduction of medication errors in the adult population by 13% to 86% (IOM 2006). In the pediatric population the reduction in medication errors has not been as great, ranging from 7% to 41% ^[32-37]. While the evidence supporting CPOE is overwhelming, there are data in the pediatric population demonstrating approximately a threefold increase in mortality after implementation ^[36]. More recent data in the pediatric population, however, have demonstrated a significant decrease in mortality by 20% ^[38]. Ultimately, institutions implementing CPOE should monitor the performance of their systems to ensure optimal outcomes. Despite evidence that CPOE significantly reduces medication errors, poor design, implementation, planning and lack of decision support may introduce new errors ^[39]. Also a concern are the unintended consequences when using some features of CPOE. For example, the uses of “hard-stop” alerts are extremely effective in preventing drug interactions; however, may cause delays in time sensitive medications leading to negative outcomes ^[40]. Using CPOE with decision support and pharmacist monitoring is another strategy to aid in the realization of this technology. One analysis of antibiotic orders found the incidence of inappropriate dosing was decreased by approximately 80% using the aforementioned strategy ^[41]. While decision support is beneficial, judicious use of alerts is a necessity. Override rates of decision support functions may be increased as a result of clinician alert fatigue ^[42]. Design and appropriate execution of CPOE is essential for it to deliver its promises in error reduction. Institutions should be prepared to customize the features of their CPOE systems in order to accommodate the unique populations that they may serve ^[43].

Institutions should also be cognizant that although CPOE is an important component of a closed loop medication management system integration with other technologies (i.e., bar coded medication administration (BCMA), electronic medication administration record, and automated medication dispensing devices) and clinical processes are necessary for optimal success ^[44, 45]. Closed loop systems help ensure clinicians have access to all of the information collected from the technologies throughout the institution.

4.3 Bar-code medication administration

Bar-code medication administration (BCMA) systems are one technology that addresses medication errors occurring at the administration phase of the medication process ^[46]. While CPOE may intercept errors committed during medication prescribing, BCMA may be more effective in intercepting errors committed during medication administration. Errors occurring at the administration node are less likely to be intercepted prior to reaching patients. Leape and colleagues reported that of the medication errors occurring at the administration phase in their study cohort (38%) only 2% were intercepted before reaching the patient. These data highlight the need to improve the administration process and the importance of a closed loop medication management system ^[47, 48]. BCMA has demonstrated the ability to reduce medication errors by 65% to 86% ^[49, 50]. Although BCMA has the ability to improve the medication use process, particularly at the administration phase, it may also introduce new types of errors. For example, mislabeling medications that are repackaged to accommodate bar-coding is a common err. These errors occur because not all medications are commercially available in bar-code ready packaging; therefore, pharmacies must repackage medications in order to be compatible with BCMA. It is also critical that the technology is used appropriately and optimized to ensure the greatest benefit. If fired alerts are ignored or overridden, the purpose of the system is defeated. Likewise, if bar code scanning is bypassed or a work-around is used, potential administration errors will not be intercepted. Consequences of workarounds include wrong administration of medications, wrong dosage, wrong times, and incorrect formulations ^[51]. Audits of overrides and bypassed alerts are necessary to optimize the BCMA process. Flawed BCMA design, poor implementation, and lack of consideration to workflow discourage use of BCMA ^[51]. In order to realize the benefits of BCMA, the integration of this technology must be facilitated with the understanding of the institution specific workflow.

4.4 Clinician education

Drug information should be readily accessible to clinicians. In an analysis of medication errors, Leape et al. identified dissemination of drug knowledge as the most common cause of error accounting for 29% of the 334 errors^[47]. Availability of information is especially important for infrequently used medications or non-formulary medications since practitioners may be unfamiliar with their use. Sources of information include, but are not limited to, tertiary references, online sources of information, newsletters, and/or inclusion of pharmacists on patient care rounds.

4.5 Patient education

It is estimated that 9 out of 10 adults lack the skills needed to manage their health and prevent disease^[52]. In a study of 659 public hospital patients, patients with poor health literacy skills were five times more likely to misinterpret their prescriptions than those with adequate skills^[53]. In another analysis, parents with low health literacy were more 1.7 times likely to give their children the wrong medication dosage^[54]. It has been established that counseling patients on their medications facilitates the detection of preventable adverse drug events^[31]. Additionally, patient attitudes and beliefs toward medications impacts medication adherence^[55,56]. Organizations must bridge the gap in health literacy and improve communication^[57]. Potential areas for development include the implementation of adherence programs, empowering patients with innovative programs, ensuring education materials are written in the 5th grade reading level, and field-testing educational materials using patient focus groups^[58].

4.6 High-risk medications and vulnerable populations

Organizations should identify a list of “high-alert” medications because the propensity for harm as a result of a medication error is increased with the use of these agents. ISMP and the Joint Commission have developed a list of “high-alert” medications. Particular attention should be placed on those medications that are administered via the parenteral route. Policies should be created to address the medication use process associated with the use of these medications and provide the necessary drug information to appropriately use the medications. The use of medication in vulnerable populations should also be addressed. Creating standard concentrations and limiting formulary is prudent for all populations, but particularly important in the pediatric population to decrease the likelihood of harm resulting from medication errors. Likewise, identification of potentially inappropriate medication use in the elderly can minimize potential unwanted drug toxicity. The use of the Beers’ criteria or the Screening Tool of Older Persons’ Prescriptions (STOPP) and Screening Tool to Alert doctors to Right Treatment (START) may help practitioners identify and correct prescribing errors^[59-61].

4.7 Formulary management

Formulary management should also be considered a tool in the armamentarium against medication errors^[62]. Medications that are obsolete or confer a greater potential for harm versus benefit compared to similar/alternative medications should be re-evaluated for formulary inclusion. Many preventable adverse drug events are dosage related; therefore, consideration should be placed on formulary dosage restrictions (recommendations).

4.8 The use of electronic health records

Health care organizations have large databases available for identifying patients who are not compliant with medications or for the identification of unsafe medication practices^[58]. In either case, the organization may bring these issues to the attention of the responsible health care provider using traditional (i.e., letters) or electronic approaches (i.e., computer alerts). One important consideration is minimization of unintended “noise” caused by alerts generated by the later method. In a study of 233,537 medication safety alerts generated by an electronic prescribing system over a 9-month period, clinicians accepted only 9.4% of medication alerts^[63]. These data highlight the importance of limiting alerts to the most clinically relevant and the most severe so that preventing errors most likely to cause harm is not compromised. Data generated by these methods may also be used to target provider education initiatives (i.e., if there are recurrent themes in the alerts generated)^[58].

4.9 Reporting system

Non-punitive reporting is critical in order to identify system failures. Building safer systems requires learning from previous errors^[64]. In order to foster an environment that learns from its mistakes, it is paramount to move beyond placing blame on an individual^[65]. This concept should not replace professional accountability; however, it should be noted that the overwhelming majority of medication errors are a result of system failure^[47]. Organizations should develop processes to encourage non-punitive reporting. It is essential to report medication errors, “near misses”, and other problems in order for the medication management system to evolve. Reporting alone is not sufficient and caution should be exercised when acting on the incident without dissecting the anatomy of the error. Systematic evaluation of the incidents and subsequent enhancements in the system processes ensure meaningful corrections. To achieve this level of learning, organizations should ensure psychological safety^[66]. Psychological safety is defined as “a team climate characterized by interpersonal trust and mutual respect in which people are comfortable being themselves”^[67]. By fostering this type of environment, individuals are more compelled to inquire, seek feedback, identify system failure, and provide feedback.

The data obtained through these reports should be critically evaluated in order to identify and correct error-prone processes. Nonetheless, voluntary reporting is plagued with under reporting; therefore, organizations should consider other tools to identify areas for improvement. Other approaches include chart review, claims data, incident reporting, administrative database examination, computer monitoring, direct care observation, and/or patient monitoring^[64].

5 Conclusion

The medication use process is complex. Various strategies may be utilized to safeguard against medication errors such as improving communication, the use of technology, education, and development of policies for high-risk medications. Optimization of this process involves learning from past events-medication errors. Organizations must foster a non-punitive reporting environment in order for the medication use process to evolve into a safer process.

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