

Medication Error Prevention: Where are we now and What are the Strategies for the Future?

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Abstract

Medication errors represent the seventh most common cause of adverse reactions in the healthcare industry [1]. Despite this prevalence, little change has occurred over the last 60 years in the approach to administration. There are multiple causes, patient and medication related, as well as a number of mechanisms through which incorrect drug or incorrect doses are given. Research shows that while individuals are associated with these adverse events, the larger issue is ultimately a system and process failure. Technological advancements are catching up in the safety arena, but the most important determinant will ultimately be the adoption by healthcare institutions of a culture of safety. That will entail a combination of training and education plus creating an anonymous reporting of errors in order to avoid fear of blame for individuals. This system change will enable healthcare institutions to track trends, analyze errors and make progress in decreasing medication errors, particularly as financial pressures mount.

Keywords: Medication Error; Adverse Reaction; Sentinel events; High risk medication; Strategies for prevention; Future Technology

Introduction

Potentially preventable complications are estimated to add 9.4% - 9.7% to hospital inpatient costs annually in the United States. With national estimates of inpatient hospital care costs totaling \$940 billion in 2006, the 9.4% estimate is indicative of an \$88 billion issue for the nation [2]. Out of those, medication error represents a sizable portion that is mostly preventable. Stelfox and Palmisani mention medication error as the seventh most common cause of death in healthcare, with antibiotics and neuromuscular relaxants leading such events [1]. With a record of 7,000 deaths and billions of USD in costs annually, the reviews and analyses of causes has increased over the last few years as the Centers for Medicare and Medicaid Services (CMS) is steadily pursuing the financial incentives related to better quality of care and reduced costs, especially in the readmission area, where medication errors hold a large portion of accountability [3]. Medication error prevention has been an elusive goal since while some progress has been made; the numbers remain below the goal that the Institute for Healthcare Improvement (IHI) had set.

Bates et al. found that about two out of every 100 in-patients experience a preventable adverse drug event, resulting in an average increase of hospital costs by \$4700 per admission or about \$2.8 million annually for a 700 bed hospital. By now, most statistics have placed medication errors as among the top causes of death [4].

Medication errors are happening throughout patients' episodes of care in the hospital, with reportedly one third of the patients taking five or more prescriptions, making polypharmacy one of the top reasons for the errors [5]. The more pharmacological advances translate into newer drugs and more choices, so too do the risks associated with taking them. There are specific risk (patient and medication related) factors that make certain populations more susceptible to medication errors. The group that carries the most risk as a result of medication errors is the elderly, in particular, due to a combination of a large amount of medications they take, and age related physiologic changes. Adverse drug effects can occur in any patient, but certain characteristics of the elderly make them more susceptible. An example is the decrease in renal function in elderly people, thereby directly affecting renal clearance of drugs as well as drug interactions. The Agency for Healthcare Research Quality (AHRQ) has pointed to the fact that patients 65 and older encountered the most adverse reactions [6].

At any age, adverse drug effects may occur even when drugs are prescribed and taken appropriately, i.e., new-onset allergic reactions are not predictable or preventable. However, adverse effects are thought to be preventable in almost 90% of cases in the elderly (compared with only 24% in younger patients). Certain drug classes are commonly involved including antipsychotics, warfarin, antiplatelet agents, hypoglycemic drugs, antidepressants, and sedative-hypnotics [7].

Another susceptible population is the pediatric one, mainly due to the fact that drugs need to be prescribed based on body weight. Other well documented patient-specific reasons include limited patient literacy and numeracy. Medication-specific causes include a list of high alert medications that are known harmful if taken in error. The Agency for Healthcare Research Quality

has made information available on both drugs that have caused harm if taken in error as well as drugs that could potentially be harmful if they reached the patient. The top 10 such drugs include hypoglycemic agents, oral anticoagulants and antiplatelet agents, antibiotics, opiates and sedatives and potassium chloride. These medications also top the list for readmission causes for patients discharged after hospital stays. A recent study by Budnitz et al. identified the nature of the drugs involved in 88.3% of emergency hospital admissions of older adults as hematologic, endocrine, cardiovascular, central nervous system, and antibiotics. Nearly two-thirds of the hospitalizations were due to unintentional drug overdoses. Just four types of medications – warfarin, insulins, oral antiplatelet agents, and oral hypoglycemic agents – together accounted for 7 in 10 of the emergency hospitalizations [8].

Medication Errors and Anesthesia

Another source of medication-specific risk is represented by look alike, sound alike medications, with similar physical appearance or labeling, but different pharmacological properties. In this category, a particular place is held by anesthesia specific drugs that often have similar color-coded labels for a drug class that have different pharmacodynamics. For example, similar labeling of the neuromuscular blocking drugs cisatracurium and rocuronium, both are neuromuscular blocking drugs but with different properties onset and duration. An Australian analyzed over 2000 incident reports in the anesthesia-related practice. The analysis showed that the most common errors involved administration of the incorrect drug, but in 144 cases the wrong drug in a correctly labeled syringe was the culprit that resulted from miscommunication during a provider change 61% of adverse events occurred during the administering phase, making the ordering and administering phase of the medication error cycle the top one for medication error probability [9].

For anesthesiologists, estimated to provide over one million IV anesthetics in their professional lifetimes, the problem of medication error is further compounded by working in a rapidly changing and critical environment, devoid of extra layers of redundancy for checks and double checks, and the necessity to prepare their own drug dilution or drip. An added risk factor is the need to make assessments, in urgent situations, the medications a patient is already taking and reconcile them. That all without even taking into consideration the added risk of having a large number of elderly patients, the most common segment presenting for high risk surgery.

Similar figures have been reported by other countries, clearly underlining the importance of medication error prevention. In New Zealand, for example, while prospectively collecting data for a research study from over 10,000 anesthetics administered, approximately one error was shown to occur for every 130 administrations. A very similar rate was found in Seattle, using the same study method. Interestingly, while respondents in New Zealand viewed medication error as a problem, they saw it as pertinent not to their own practice but to other anesthesiologists' practices, a phenomenon known as optimism bias [10]. Canada had an even more proactive approach to determining the extent of the

problem by sending an anonymous survey to all members of the Canadian Society of Anesthesiologists in which they asked how often a medication error was encountered during their practice. The majority of respondents acknowledged that they had had more than one error in their professional lifetimes, with syringe swap being the most common error. The study found that 1.4% of the errors resulted in major morbidity, including four deaths. Having a root cause analysis of causes provided information about sources of error. Despite the fact that the majority of respondents agreed that labeling syringes appropriately was best practice, only about 70% of them adhered to those standards. Even fewer of the anesthesiologists read the label of the drug they would give, although they agreed it is best practice to read it before any drug administration [11].

Injecting a drug safely is not in itself the problem. The challenge the anesthesia professional faces is the sheer volume of drug administrations in a professional lifetime. Doing this 100% accurately is very difficult. Many of our patients have diminished physiologic reserve to tolerate drug error, whether from age, emergency conditions of surgery or the severity of their injuries. The outcome of any drug administration is largely determined by chance, therefore the harmful potential should be judged rather than the true outcome. Research has shown that no one person is to blame, as errors are mainly a process and systems failure of the pathway at one point or another. Most frequently cited causes for medication error in anesthesiology are syringe swap, overdose (due to pump malfunction, misunderstanding of the dose, incorrect route, omission or wrongly calculated dose), but those are the readily apparent causes only. Hughes reviews insightful system causes that she divides into latent causes (staff shortage and lack of medication administration protocols), error producing causes (distractions/interruptions/fatigue) and active failure (failure of memory and attention, incorrect choice of an objective or pathway of attaining it) [12]. The ASA has developed and published statements on both distractions and fatigue.

Among the drugs used in anesthesia, the most frequently implicated in errors were opioids, cardiostimulants and vasopressors [13]. Inexperience was cited as a contributor to error in the Sakaguchi study, however not considered a factor in Llwellyn's South Africa based study, rather the study found that the mislabeling of drugs was the most prominent cause of error [13,14].

When comparing academic and community healthcare organizations, academic institutions experience the added risk of trainee mistakes. The Phillips study found a statistical significant correlation between an increase in medication errors and the new medical residents academic year start in July [15].

Aside from the wrong drug, the drug route of administration factors into causality of medication errors. Horror stories of accidental injection of a powerful local anesthetic such as bupivacaine intravenous rather than intrathecal are by now well-known and have been reviewed. The Philips study also found that while the most implicated in the most severe drug reactions and sentinel events (medication error associated with high risk

medications, known to cause harm when given in error) were central nervous system and cardiovascular drugs, the breakdown of how the errors happened was: incorrect dose (40.9%), wrong drug (16%) and wrong route (9.5%) [15].

Incorrect medication was found to be the most common type of drug error (48%) occurring perioperatively, followed by overdose (38%), incorrect administration route (8%), under dosing (4%) and omission (2%) as cited in the Journal of Patient Safety [16]. Opioids, cardiac stimulants, and vasopressors were the most common culprits in that report. 42% percent of incorrect medication administration occurred following syringe swap, drug ampules swap occurred in 33% of cases, and the wrong choice of drug was made in 17%. The first, second, and third most frequent causes of overdose involved a misunderstanding or preconception of the dose (53%), pump misuse (21%), and dilution error (5%).

Employers, consumers and taxpayers are increasingly demanding that providers of medical care be held more accountable, particularly as the costs of health insurance continue to rise. Several organizations have been developed and are devoted exclusively to patient safety enhancements. This adds to the pressure of financial penalties already in place for consequences of medication errors such as readmission and increased length of stay. It is worth of mentioning that preventable medical errors as a whole with medication error close behind represent the third largest cause of death in the U.S. – preceded only by heart disease and cancer – claiming the lives of some 400,000 people each year.

Culture of Safety

With that in mind it is of little wonder that medication errors are the focus of hospitals, employers, patients and regulatory agencies alike for both quality of care improvement as well as cost decrease. By definition a medication error is, “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, while a near miss is a medication error that did not translate into harm to the patient [17]”. In their article Cooper et al. published a classification of medication errors most encountered in anesthesia that is depicted in the table 1 below [17].

Cooper and colleagues have also identified several risk factors in their critical incident analysis of preventable mistakes. Maximum errors were determined to be due to either inadequate experience (16%) or inadequate familiarity with equipment or device (9.3%), whereas haste and inattention or carelessness each amounted to 5.6% of errors during anesthesia [17]. Of note, while there are no perioperative studies that examine the impact of distractions on medication error, there have been such studies done in the pharmaceutical world.

Flynn and colleagues analyzed the impact of distractions in an ambulatory pharmacy on prescription errors rates. Out of 5072 prescriptions to be filled, 3% were erroneous due to interruptions (i.e. telephone calls) and almost 7% due to distractions. The most

Table 1: ¹⁷Practical classifications of medication errors during anesthesia.

Drawing up drugs and labeling phase	Similar looking vials
	Unlabeled syringes
	Not checking the label (including expiry date) prior to administration
	Different concentration in the syringe and incorrect label. (Incorrect dilutions esp. relevant in pediatric patients).
Drug administration phase	Near misses.
	Incorrect dose (inadequate or in excess) esp. in pediatric patients.
	Syringe swap.
	Wrong route of administration.
	Incorrect timing of administration.
	Omission, repetition or substitution of drug.
Documentation errors	Adverse event not recognized or not documented
	Reluctance amongst doctors to admit the error.
	Failure to report an error during medication.

significant correlation was found to be workload. Similar studies, although much needed, are lacking in the perioperative arena [18].

Aside from certain steps specifically aimed the administering process, the concept of culture of safety was developed. Again, championing it in the setting of pharmacies, Ashcroft and colleagues looked at safety culture assessment in community pharmacies in the United Kingdom. They describe different levels within the culture of safety, ranging from a lack of understanding of the need for risk management to integrating risk management into all processes. Level 1 is called “pathological,” and in this instance subjects do not value risk management and view safety issues as a waste of time. Level 2 is “reactive,” in which every incident is considered to be very serious and an action is taken every time. Level 3 is “calculative,” and aims to anticipate every possible scenario and plan for it in advance. Level 4 is “proactive,” and subjects are on the alert and anticipating that risks will emerge. Finally, Level 5 is “generative,” and risk management is a priority and a part of all processes [19].

Much work has been concentrated on prevention strategies that includes proper labeling and even larger labels for high risk drugs, electronic medical record reconciliation and bar coding of medication. A modest decrease in errors was achieved, thereby underscoring the importance of finding new avenues in that direction. One such novel concept applied to healthcare are the

six sigma methodologies. Imported from Toyota and Motorola manufacturing industries, the combination of lean (decrease waste) and six sigma (decrease variance), are applicable to the healthcare industry with medication error. Virginia Mason hospital, a pioneer in these methodologies, has completely reengineered their approach to medication administration [20].

Freedtert Hospital Systems in Milwaukee has completed two successful projects with such methodologies applied. Their project focused on IV drip medication error improvement. Lack of standardization was considered the most important cause of medical errors associated with IV drips. Even more interesting, while applying the methodology a number of hidden causes were uncovered, that were not readily apparent, including lack of oversight, defective faxes (orders not received), administering drugs based on habit and not body weight, or not stopping a medication in a timely manner, thereby underscoring the importance of viewing any strategic approach as a system and process and not individual approach. Redesigned IV pumps with up to date information in their libraries as well as standardizing and preparing up to 36 drugs were also the result of the systematic Lean Six Sigma (LSS) approach for Freedtert [21].

While the LSS methodologies offer insights into process and system failures, technology is advancing rapidly and catching up in the medication safety arena as well, though it continues to remain cost prohibitive at this stage. Below is a review of a few future trends that will shape the prevention of errors.

VEINROM

Conceptually developed as a manifold for multiple IV ports, V(asoconstrictors)E(mergency drugs)N(euromuscular blockers) I(nduction drugs)R(eversal agents)O(piods) M(iscellaneous drugs) represents a novel design for intraoperative drug administration. It requires an interlocking mechanism that can only do so with a predisposition syringe. Ports and syringes are color and texture coded and have both scan bar abilities and can be readily connected to electronic medical records for updating the medication record in real time [22].

VALIMED

Medication validation systems is based on another novel concept of using photoelectron spectroscopy in order to validate that the correct substance is being administered, may that be in individual syringes or infusions. The table top device is comparing a control substance sample to the drug to be administered. The physical principle is based on measuring the energy of electrons binding on a substance that were accelerated by ionization through UV light exposure [23].

Important as a patient safety tool, it can also serve for identification of controlled medication waste in the hospitals. As an article in Health System has emphasized, the technology is promising. More importantly, it has been tested by Michigan Health System successfully, with no medication error reported during the trial period. It has the disadvantage of being time consuming (approximately one minute for the test), but if used only for high risk drug administration, can prove an invaluable

tool in medication error prevention [23].

ROBOT ASSISTED MEDICATION PREPARATION

In an era of automation and many surgical suites with access to robots, it is not unexpected that new technology will influence medication error prevention in particular. While still cost prohibitive, the technology has already started to make progress, for now in the preparation of chemotherapeutic drugs. The University of Ancona, Italy, is reporting that 95% of their chemotherapeutic drugs are prepared by two robots. So far 19,000 medications have been prepared with robotic arm aid and no medications errors were reported [24].

PREFILLED SYRINGES OUTSOURCED

Prefilled syringes from an outside location is another avenue in the prevention of medication errors strategies. It is estimated that the prefilled syringes market will grow by 2019 to a 4.98 billion USD industry [25].

Medication error continues to remain a quality problem while still representing a large cost concern for hospitals and employers. Many statistics do not even count in their cost analysis the loss of productivity or days missed at work. This waste represents an opportunity that can lend itself well to the LSS methodologies. While a number of strategies have already been implemented, some of them are still cost prohibitive for smaller or low volume hospitals, such as bar coding beds. Emerging, are hidden causes that will need to be addressed by the leaders in healthcare through championing and implementing a culture of safety. Technological advances are catching up quickly with special design administration devices as well as robotization, which are all efforts to advance patient safety and quality of care.

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