Medication Errors

Why they happen, and how they can be prevented.

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Medication errors are the most common type of medical error.[1] One of every three adverse drug events (ADEs) precipitated by a medication error occurs when a nurse administers medications to a patient.[2, 3] The number would be greater if nurses did not intercept 86% of all potential errors.[4]

Preventable ADEs causing injury or death have significant economic consequences.[5-7] The annual cost of drug-related morbidity and mortality in the United States has been estimated to be between $1.56 billion and $5.6 billion; most of the costs are related to hospital admissions caused by the use of inappropriate drug therapy or the absence of appropriate drug therapy.[8-11] Inappropriate prescribing and patient noncompliance resulting in ADEs contribute to 3% to 28% of all hospitalizations, the rate varying by the age and morbidity of patients.[12-14] Patients injured by ADEs have their hospital stays extended by an average of two days, at an additional cost of $2,000 to $2,500 per patient.[7, 9]

This article is not an exhaustive review of the literature on medication errors. Instead, it provides an overview of what is known about errors in medication administration, barriers to implementing safer practices, and current and potential mechanisms to improve medication administration.

DEFINITIONS

Medication errors are defined as the preventable inappropriate use of medications. These errors can occur at any point in the process: ordering, transcribing, dispensing, administering, or monitoring medications. Some errors result from what psychologist James Reason would term an *unsafe act*[15]—an action that violates a policy or procedure but may be done to save time.

Medication errors may or may not have serious consequences. Some medication errors change a patient's outcome, but the change does not result in any harm. Other medication errors have the potential to cause harm, but they do not actually cause harm. Serious medication errors that are not intercepted, however, will actually harm the patient.[2, 16] One study estimated that 30% of patients with drug-related injuries died or were disabled for more than six months.[17] Like medication errors, ADEs can occur at any step in the medication process.[4, 7, 18, 19]

Theoretically, all medication errors are preventable. The same does not hold true for ADEs. *Preventable* ADEs could have been avoided if appropriate and reasonable steps had been taken. For example, an anaphylactic reaction to penicillin is a *preventable* ADE if the patient's allergy to penicillin was noted in the chart or if the patient knew of a past penicillin reaction and was capable of communicating it to the clinician. But an allergic reaction to penicillin in a patient who was not aware of an allergy to penicillin would be a *nonpreventable* ADE.

There are approximately 100 medication errors for every preventable ADE and seven potential ADEs (or near misses) for every preventable ADE. Because they are not intercepted before harming a patient, 1% of medication errors lead to ADEs.[2, 10]

Not all ADEs result in clinically important negative outcomes. For example, an ADE may simply manifest as a minor rash that does not cause any discomfort and resolves spontaneously within 24 hours.

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Table 1. Types of Medication Errors by Clinician, Pharmacist, or Patient

	When an Error Occurs			
	PRESCRIBING	DISPENSING*	ADMINISTERING	TAKING†
ERRORS OF OMISSION				
• Drug not prescribed	X			
• Drug not dispensed		X		
• Drug not administered			X	
• Drug not taken				X
ERRORS OF COMMISSION				
• Wrong drug	X	X	X	X
• Wrong dose	X	X	X	X
• Wrong substitution for a drug	X			
• Wrong patient	X	X	X	X
• Wrong regimen				
•Frequency of administration	X	X	X	X
•Timing of administration	X	X	X	X
•Duration	X	X	X	X
• Wrong route of administration	X	X	X	
• Allergic reaction	X	X	X	
• Drug interaction				
•With another drug	X		X	X
•With food	X		X	X
•With other therapies	X		X	X
• Communication failure				
•Illegible handwriting	X	X	X	
•Incomplete prescribing order	X			
•Vague instructions	X	X	X	
•Prescription not recognized		X		
•Unknown prescriber or illegible prescriber identification	X			
• Failure to follow appropriate policies	X	X	X	
• Failure to follow drug-specific instructions	X	X	X	X
• Overuse of a drug without therapeutic benefit	X			X

* Includes transcribing, verifying, and dispensing medications. Generally involves nurses and pharmacists.
† Includes patient compliance.

Bates DW, et al. *J Am Med Inform Assoc* 1999;6(4):313-21; Rupp MT, et al. *Med Care* 1992;30(10):926-40.

Table 2. Examples of Situations Requiring Hypervigilance to Avoid Medication Errors

INADEQUATE PATIENT INFORMATION
- Clinical team unaware of known allergies or all current medications taken by the patient

INABILITY TO MONITOR
- Vital signs or laboratory values not checked before calculating dose or administering medication

COMPROMISED HEALTH STATUS (INCLUDING MULTIPLE CHRONIC CONDITIONS)
- Failure to recognize abnormal laboratory results

NUMBER OF MEDICATIONS
- Patient taking multiple medications misses or doubles a dose

UNFAMILIARITY WITH MEDICATION
- Not knowing dosing procedures or drug–drug interactions

MONITORING EFFECT OF TREATMENT
- Not doing required follow-up laboratory testing, such as with anticoagulants or antiseizure medications

ADMINISTERING IV MEDICATIONS (INCLUDING INFUSION PUMPS AND PARENTERAL DELIVERY)
- Administering IV push medications too rapidly

SWITCHING ROUTE OF ADMINISTRATION
- Not having a therapeutic dose when switching from IV to PO

DRUG REQUIRING MANIPULATION FOR ADMINISTRATION
- Inaccurate dosing when splitting, crushing, or suspending a medication

DRUG DOSING REQUIRES CALCULATIONS
- Miscalculation of drug dose for age or weight, especially when weight and age are discordant
- Mistaking teaspoons for tablespoons and vice versa

HANDWRITTEN PRESCRIPTION
- Incomplete information
- Written for an incorrect dosage form or strength
- Illegible order or signature
- Decimals leading to mistaken dosing
- Nonstandard terminology

CHILDREN
- Wrong dose, route, or frequency
- Calculation of drug dose depending on weight
- Administration of medications to neonates in intensive care
- Dosing errors, especially for IV administration

ELDERLY
- Patients taking multiple drugs, having depressive symptoms or poor health status, being female, or making several outpatient visits in the past year are at greater risk for medication errors
- Patient does not understand and follow the prescribed regimen
- Elderly are more sensitive to effects of medication, and adjustments in dose may be necessary

WOMEN
- Women who are pregnant or lactating given medications not approved for them

Bates DW, et al. *J Gen Intern Med* 1993;8(6):289-94; Gurwitz JH, Avorn J. *Ann Intern Med* 1991;114(11):956-66; Hanlon JT, et al. *J Am Geriatr Soc* 1997;45(8):945-8; Hutchinson TA, et al. *J Chronic Dis* 1986;39(7):533-42; Chrischilles EA, et al. *Ann Intern Med* 1992;117(8):634-40; Rupp MT, et al. *Med Care* 1992;30(10):926-40; Zhan C, et al. *JAMA* 2001;286(22):2823-9; Hanlon JT, et al. *Pharmacotherapy* 2000;20(5):575-82; Aparasu RR, Fliginger SE. *Ann Pharmacother* 1997;31(7-8):823-9; Phillips J, et al. *Am J Health Syst Pharm* 2001;58(19):1835-41; Lesar TS, et al. *JAMA* 1990;263(17):2329-34.

PREVALENCE

Medication errors have been estimated to occur at a rate of five per 100 medication administrations, but only seven in 100 medication errors have the potential to cause patient injury, and only one in 100 actually results in injury.[2, 10] In hospital settings, the number of ADEs has been reported to vary from about one error per patient per day[20] to about 6.5 events per 100 nonobstetric admissions.[2] One study found that inpatient ADEs are more common in teaching hospitals than in community hospitals, but this was most likely because ADEs are more commonly detected and reported in teaching hospitals.[17] Within the hospital, ADEs occur more frequently in the ICU.[2]

The true number of medication errors and ADEs is difficult to assess for several reasons. First, only a small percentage of medication errors and ADEs are detected, and an even smaller number are reported. Second, there are inconsistencies in the way that errors are reported and counted. For example, if a nurse inadvertently switches medications for two patients, how should it be reported? It could be reported in several ways: as one error because the medications were switched once; as two errors, because two patients were involved, and each potentially received the wrong medication; as the total number of wrong medications that were given to both patients; as one error for each adverse patient outcome; as no error if no adverse events actually occurred; or as one error for each near miss and potential adverse event.[21]

Third, most studies have looked at medication errors only in the inpatient hospital setting. Little is known about medication errors that occur in other settings, such as outpatient clinics, nursing homes, ambulatory surgical centers, and home health care. Reports of ADEs in the outpatient setting range from three to 50 ADEs per 1,000 adult patients.[22-24]

Fourth, most studies on medication errors have focused on errors of commission, when a patient is erroneously given a medication or an incorrect dose that could potentially result in harm. This fails to consider errors of omission, which occur when a patient is not given a medication that is indicated and recommended. For example, if a patient presents to the ED with an acute myocardial infarction and is not given a medication demonstrated to reduce morbidity and mortality, such as aspirin or a thrombolytic agent, an error of omission has occurred. When errors of omission are considered, the estimated number of patients injured or killed each year by medication errors easily exceeds 1 million.[25]

Medication errors should be seen as opportunities to assess practice, find out what went wrong, learn from mistakes, and make changes.

TYPES AND CAUSES OF MEDICATION ERRORS

From a systems perspective, the occurrence of medication errors reflects the quality of the medication ordering and administration processes (see Table 1, page 15). Large studies have found that the majority of ADEs—49% to 56%—originate when physicians prescribe or order medications. Nurses and pharmacists are responsible for medication errors involving administration (26% to 34%), dispensing (14%), and transcription (11%).[2, 26, 27] Patients themselves are sometimes the cause of a medication error—for example, when they fail to take a medication as prescribed or when they take too much or too little medication.

Traditionally, medication errors have been attributed to mistakes by individual clinicians (physicians, nurses, pharmacists) or by patients. Even though individuals are often responsible for making these errors, this "blame-seeking" approach does not consider the chain of events that may have led to the error, and it fails to address the root cause and most important reason for most medication errors—systems failures.[1, 4]

Examples of systems and organizational failures that can lead to medication errors and ADEs include the following:

- inaccessibility of patient information, such as information about the patient's health status, illnesses, laboratory test results, current medications, or known drug allergies
- insufficient knowledge about a drug, such as proper dosing or drug–drug interactions
- handwritten orders that are illegible, misspelled, abbreviated, incorrect, or incomplete
- failures in the administration of a drug, such as giving drugs at the incorrect time or by an incorrect route, giving drugs other than those prescribed, or giving drugs to the wrong patient[4, 27, 28]

Much of the research on medication errors has focused on misuse. Two other important problems need to be recognized: overuse of inappropriate or ineffective medications and underuse of beneficial medications, both of which may harm the patient.[29]

Table 3. Drugs Commonly Associated with Medication Errors

DRUG TYPE	EXAMPLES OF COMMON ERRORS
Analgesics	• Oversedation • Wrong route of administration • Failure to monitor heart rate, respiration, and blood pressure • Allergic reactions in patients with documented allergy
Antibiotics	• Overuse when symptoms do not warrant use • Wrong antibiotic or dose or both
Anticoagulants	• Inadequate therapeutic dosing • No evaluation of findings from laboratory testing of blood values, such as international normalized ratio
Cardiovascular agents	• Overdose
Chemotherapeutic agents	• Overdose • Wrong route of administration • Lack of monitoring lab values and side effects
Diuretics	• Overdose • Lack of monitoring electrolytes
Psychotropic medications	• Oversedation
Diabetic medications	• Use in people without diabetes • Overdose of intravenous or injectable medications, including duplicate dosing • Drug substitution or wrong type of insulin • Mistaking heparin for insulin
Nonsteroidal antiinflammatory drugs (NSAIDs)	• Extended use, leading to serious gastrointestinal complications such as bleeding and perforation • Overdose because NSAIDs are contained in many over-the-counter products • Taking excessive amounts, leading to hepatotoxicity, acute renal failure, or death
Total parenteral nutrition solutions	• Given peripherally, not through a central line • Wrong amount of components

Leape LL, et al. *JAMA* 1995;274(1):35-43; Bates DW, et al. *J Gen Intern Med* 1993;8(6):289-94; Bates DW, et al. *JAMA* 1998;280 (15):1311-6; Evans RS, et al. A decision support tool for antibiotic therapy. In: Gardner R, editor. *Proceedings from the Nineteenth Anuual Symposium on Computer Applications in Medical Care*. Philadelphia: Hanley and Belfus; 1995. p. 651-5; Gurwitz JH, et al. *JAMA* 2003;289(9): 1107-16; Chiquette E, et al. *Arch Intern Med* 1998;158(15):1641-7; Shumak SL, et al. *Arch Intern Med* 1991; 151(9):1877-8; Gurwitz JH, et al. *Am J Med* 2000;109(2):87-94; Cohen MR, et al. *J Healthc Risk Manag* 1998;18(1):16-27; Wolfe MM, et al. *N Engl J Med* 1999;340(24):1888-99; U.S. Pharmacopeia. Assessing the safety of parenteral nutrition. *USP Patient Safety CAPSLINK* 2004. http://www.usp.org/pdf/ patientSafety/ capsLink2004-02-01.pdf; Freedman JE, et al. *Circulation* 2002;106(20):2623-9.

For example, underusing β-blockers and aspirin in patients with ischemic heart disease can increase the likelihood of death from cardiovascular disease, inadequate use of inhaled steroids can increase morbidity and mortality in patients with asthma, and overusing antibiotics can lead to antibiotic-resistant infections.

HIGH-RISK SITUATIONS

Some situations require extra vigilance if medication errors are to be avoided (see Table 2, page 16). Medication errors are more common among certain types of patients, including those who are very ill, have multiple concurrent diagnoses, and are taking certain types of medications or multiple medications. Patients receiving aggressive treatments (for example, in critical care units) also are at high risk and require extra vigilance, as do children and women, especially pregnant or lactating women.[2, 30] The elderly are also at higher risk, in part because the number of medications they take generally increases with age.[31] In addition, metabolism changes with age, and older people are more likely to have multiple medical problems or other comorbidities.[32]

Medication errors can occur with virtually any type of drug. But errors are more common with certain classes of medication (see Table 3, page 18). The pharmacologic properties of some medications may result in more side effects, toxicities, or drug–drug interactions. Other drugs are often implicated in medication errors because of their narrow therapeutic indices, which make it difficult to maintain and monitor therapeutic levels. And some drugs are associated with medication errors mainly because they are prescribed so frequently. Analgesics and antibiotics, two of the most commonly used drugs, were found to be responsible for a majority of medication errors in one study.[33]

PREVENTING ERRORS

The first line of defense against medication errors should be the prescribing clinician, who should have all the information needed to make the best possible prescribing decisions for each patient. Among the necessary information are evidence-based recommendations on medications for different illnesses or conditions, including correct dosing, benefits, and potential risks. Accurate and complete information is also needed about the patient's current medications, illnesses and comorbid conditions, and known allergies or adverse reactions to medications. Comprehensive and current information on appropriate medication choices, including emerging drugs, is also important.[4, 34]

The second line of defense is the personnel responsible for dispensing the medications, usually the nurse or pharmacist. Persons involved with dispensing medication have important roles in reviewing prescriptions and assessing their appropriateness in view of factors such as allergies, diagnoses, symptoms, and test results. It's up to these professionals to make sure the right drug is dispensed in the right dose, the right form, and at the right frequency. Dispensers must ensure that the medication being administered is the one that was prescribed, unless they discover a potential problem that necessitates a change or cancellation of the original order. Proof of the importance of this role comes from a study in which pharmacists reduced ADEs in patients in the ICU by seeking clarification of drug orders and providing feedback to the prescribers.[35]

The third line of defense is the individuals responsible for actually administering the medications to the patient, most often nurses. Their responsibilities overlap with those of the people dispensing the medications, but they occur at a different stage in the process. In some cases, the same person (often the nurse) dispenses and administers the medications. Before giving medications, these clinicians help ensure safety by checking that the drug is the one that was ordered and dispensed. They also provide a final check to make sure the patient is given the right drug, for the right reason, in the right dose, at the right time, and through the right route.[36] (See Table 4, page 20.)

The fourth line of defense is the patient, who can question why he is receiving a medication; verify that it is the proper medication, dose, and route; and alert the prescribing, dispensing, or administering clinician to potential problems such as allergies or past drug–drug interactions. Yet despite the important role that all patients can play in safe medication administration, they are often not actively engaged. A potentially valuable resource to reduce medication errors remains largely untapped.

PATIENT-CENTERED MEDICATION SAFETY

Little research on safe medication administration has focused on patient noncompliance and its impact on ADEs.[37] In one study, noncompliance was found in 20% to 59% of elderly patients.[22] Patients who are noncompliant tend to have multiple chronic conditions, be forgetful, and experience adverse effects from their medications.[12] Patient noncompliance may result in medication errors that can precipitate hospitalization or serious injury.[5, 12, 14]

A patient-centered approach to safe medication administration depends on the thoughtful use of the

Table 4. Questions and Steps to Ensure the Correct Administration of Medications

QUESTIONS TO ASK		ACTIONS TO TAKE
When preparing to give medication:		
Right drug	• Has the patient been given this medication before? • Given the patient's symptoms and diagnosis, does it make sense for the patient to have this medication?	• Determine if the patient has any known drug allergies or sensitivities. • Assess the patient's other medications to detect possible contraindications. • Make sure it is the right medication; packaging, labeling, and spelling of some drugs look alike. • Have another person double check all medications.
Right reason	• Do the patient's condition, symptoms, and health status warrant receiving this medication?	• Determine if the patient has the condition the medication is used for.
Right dose and preparation	• Is the correct dose being administered? • How is the medication administered?	• Ensure labeling is legible and clearly understood.
Immediately before administering the medication:		
Right patient	• Is this the right patient to receive this medication?	• Verify the identity of the patient using at least two identifiers (check wristband, ask patient his name).
Right time	• Is this the correct time for the medication to be administered?	• Check when the medication was last administered. If the drug is new, document when it is first given.
Right route	• Is it appropriate to administer the medication orally, intravenously, or by injection?	• Check the original orders to verify the route of administration.
After the medication has been administered:		

Right drug, right dose, and right rate	• How is the patient responding to the medication?	• Monitor the patient to
		  • determine the efficacy of the drug.
		  • detect and prevent complication.
		  • evaluate and document changes in health status.
		• When applicable, assess the patient's laboratory values to detect changes.
		• Provide patient education, when possible, so patient is alert to adverse effects and changes in how he feels.

Institute for Safe Medication Practice. 2003. http://www.ismp.org; Pape TM. *Medsurg Nurs* 2003;12(2):77-93; quiz 4; Allan EL, Barker KN. *Am J Hosp Pharm* 1990;47(3): 555-71.

best available evidence, honest communication, and shared decision making with clinicians. Patients become comanagers in their care in an effort to yield better outcomes. Patients who are involved in their own management have better outcomes than those who are not.[38, 39]

Yet a patient-centered approach is seldom seen in clinical practice.[40] Patient-centered care establishes a partnership between clinicians and patients. Providers make joint decisions with patients, incorporating patients' wants, needs, and preferences. The result should create better decision making and active participation by patients in their own care.[41]

THE 'NOT ME' SYNDROME: GOOD CLINICIANS DON'T MAKE ERRORS

"Bad" clinicians are not the only ones making errors. Most errors are made by well-meaning clinicians who are trying to provide good care. Leape and colleagues evaluated more than 250 serious errors in two tertiary care hospitals and did not find any individuals responsible for a recurring pattern of errors.[4]

Although clinicians recognize that patient safety is a serious issue, some have preconceived notions that inhibit a shift to a culture of safety. A large proportion of medication errors are not reported, for many reasons. A major reason is embarrassment or fear of punishment from colleagues, employers, regulatory agencies, or patients and their families. Because of this fear, only about 5% of potentially life-threatening errors are reported.[4, 42] Other errors are not reported because they seem unimportant or inconsequential or because they were intercepted before the patient was harmed—an attitude of "no harm, no foul."[4, 43, 44] When an error is discovered by the person who committed it, the typical action is to ignore it and not report it. When an error is discovered by someone else, it often goes unreported because of fear of retribution from the person who committed the error, especially when that person is a physician or someone in authority. Even when the mistake can be traced to the person prescribing the medication, an error not intercepted by a nurse may end up being blamed on the nurse who administered the medication.[45]

Clinicians have conflicting emotions when they commit medication errors. They may be self-critical, feel guilty, and want support from peers and managers.[46] When an error is reported by an outside party, the typical response from the individual committing the error is defensive: denial, anger, and abusive behavior toward the person reporting the error. This type of reaction results from fear of being blamed for the mistake, which may result in litigation or other serious consequences to the clinician's reputation or career. Fear of litigation is understandable, as monetary awards for medical malpractice average $668,000 per case in instances involving unsafe medication administration that resulted in injury and death.[47]

In this culture of blame and litigation, underreporting and cover-up of errors, even serious ones, is common. As a result, nothing is learned from the errors, and actions cannot be instituted to prevent similar mistakes.

The majority of medication errors reflect systems failures, not individual ones. To create a true culture of patient safety, medication errors should be seen as opportunities to assess the processes of care, to find out what went wrong, to learn from mistakes, and to make changes to prevent similar errors. Through such lessons, safety and quality of care can be improved.[1, 48, 49]

This is not an easy task. It will require a significant change in the attitudes of both health care and legal professionals. Instead of focusing on blame and punishment or worrying about egos, everyone needs to concentrate on learning from mistakes to make the health care system as safe as possible. Systems failures—such as inadequate staffing, overwhelming workloads, and the complexity of clinical decision making—must be addressed, as they can lead to medication errors.

Occasionally, a clinician will exhibit repeated patterns of poor performance that result in actual or potential errors or harm. This is not a systems error. In such cases, appropriate action directed at the clinician is warranted.

USING HEALTH INFORMATION TECHNOLOGY

Health information technologies—such as electronic prescribing, electronic health records, computerized provider order entry (CPOE), bar coding, automated drug-dispensing systems, and unit dosing—can potentially reduce medication errors. The most extensively studied of these technologies is CPOE, which has been shown in many studies to reduce medication errors.[33, 50-54] However, most of these studies have been done in the inpatient setting in academic medical centers using homegrown clinical information systems, which makes their applicability to other settings questionable. In addition, although a large number of studies have demonstrated the effects of CPOE in reducing medication errors, there are few data that show these systems reduce actual adverse events, and no data that demonstrate improvements in important clinical outcomes (for example, reduced mortality rates). Beyond CPOE, many of the other health information technologies have not been sufficiently

Table 5. Benefits of and Barriers to Using Information Technology to Improve Medication Administration

INFORMATION TECHNOLOGY	BENEFITS	BARRIERS
Medication prescribing		
Computerized or electronic medical record	• Provides patient information to guide drug selection and regimen • Reduces errors related to order transcription • Reduces errors related to use of abbreviations and name confusion	• Not widely available or used • Systems may be incompatible outside an organization or institution
Computerized provider order entry	• Legible prescription • Integrates drug formularies • Provides clinical decision-making support with alerts and reminders as prescriber enters an order • Requires verification of drugs that may be confused with similar sounding or potentially misspelled medications • Double checks an order before it goes forward • Assists with converting oral to IV doses	• Patient data not up to date • High cost of implementation • Not widely available
Automated prospective drug utilization review systems	• Gives alerts to ensure accurate prescription	• Alerts can be overridden • Too many alerts cause frustration • False-positive alerts
Medication dispensing		
Automated dispensing devices	• Holds medications at a specific location and allows dispensing only to a specific patient • Helps assess the full range of medications a patient is receiving • Assesses drug allergies • Identifies inappropriate drug therapies, averting hospitalizations resulting from adverse drug events	• Not linked with bar coding and electronic information systems • No communication with the prescriber • Doesn't fully assess potential interactions because of limited data
Medication administration		
Physical packaging changes	• Changes appearance of medications to avoid errors associated with similar looking or similarly spelled drugs • Uses only one name and one look for each drug, or uses standardized labels	• Cost of repackaging • New packaging may not be in stock • Is not mandated
Bar coding	• Verifies medications and patients • Automated record of medication administration to specific patients • Used in dispensing and verification process • Counters the misreading of drug names and dosages	• Has not been widely used, but is now required by the U.S. Food and Drug Administration on most drugs • Cost of scanners • Can introduce human error by requiring manual loading of equipment and bar-code verification • Limited number of portable scanners • Complex bar-coding systems lead to errors • Lack of universal bar codes • Packaging changes needed for bar codes on unit doses • Problematic for doses such as half a tablet • Requires costly relabeling using a standard that needs to be defined

Bates DW, et al. *J Am Med Inform Assoc* 1999;6(4):313-21; Institute of Medicine. *Description and analysis of the VA National Formulary.* Washington, DC: National Academies Press; 2000; Meyer GE, et al. *Am J Hosp Pharm* 1991;48(5): 953-66; Gebhart F. *Drug Topics* 1999;143:44; Puckett F. *Am J Health Syst Pharm* 1995;52(12):1305-9; Barker KN, et al. *Am J Hosp Pharm* 1984;41(7):1352-8; Barker KN, Allan EL. *Am J Health Syst Pharm* 1995;52(4):400-3; Davis NM. *Am J Health Syst Pharm* 2000;57(16):1487-92; Monane M, et al. *JAMA* 1998;280(14):1249-52; McDonald CJ. *N Engl J Med* 1976;295(24): 1351-5.

evaluated for valid conclusions to be drawn about their impact on safe medication administration.

As described in Table 5 (page 22), CPOE and other health information technologies provide solutions to well-known causes of medication errors. For example, illegible handwriting is a common problem that can be eliminated almost entirely by CPOE. The use of abbreviations and trailing zeros (that is, zeros to the right of a decimal point) can also lead to inappropriate and potentially dangerous medication prescribing. Again, CPOE can virtually eliminate these problems by not allowing prescriptions to violate computerized rules on abbreviations or trailing zeros.

RESEARCH PRIORITIES

More studies are needed to evaluate the impact of health information technologies on improving rates of medication-related adverse events. Rigorous studies should assess the different types of technology and their impact on the various steps in the medication process—from prescribing to ordering to delivering to administering. Studies are needed in a variety of health care settings.

The Agency for Healthcare Research and Quality (AHRQ) is working to address some of these issues. During the past three years, the AHRQ has spent more than $50 million and supported more than 100 patient safety projects, many of which involve health information technology. Recently, the AHRQ announced the availability of $41 million in research grants to study the use of health information technology to improve patient safety and quality of care.

Many providers are reluctant to change current practices or to use new safety interventions without strong evidence from rigorous scientific investigations. Some scientific evidence on medication errors exists, including the causes of such errors and approaches to improving medication safety, but the field of patient safety research is relatively new.[55] An evidence-based approach to improving medication safety, which includes systems changes and considers the impact and costs of such interventions, has begun, but much more work is needed.[37]

CHANGING THE CULTURE

Methods for detecting, reporting, preventing, and mitigating medication errors and ADEs may be thwarted unless widespread systematic changes are made. A culture of safety encourages nonpunitive reporting of medication errors and near misses; it also addresses systems factors that contribute to medication errors.[56] More complete, accurate, and timely surveillance of medication errors and ADEs will lead to better understanding of the risks and benefits of medication therapies.

A procedural change that will improve medication safety is to increase the role of pharmacists in medication prescribing and monitoring. Providers and patients need to be continually educated on the risks and benefits of various drug therapies.

Medication safety can be improved by assessing current practices, developing interventions to improve such practices, evaluating the impact of these interventions, providing feedback to clinicians and patients, and revising efforts to ensure continuous improvements in patient safety and quality of care. In their important role as guardians of the second and third lines of defense against medication errors and ADEs, nurses must continue to maintain vigilance with every medication that is prescribed, dispensed, and administered. As awareness about safe medication administration continues to grow and as systemwide changes are implemented to address medication errors, most preventable errors and ADEs should become a thing of the past. ▼

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