WHEN A GOOD CARE PLAN GOES WRONG

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A hospitalized 8-month-old child with heart failure secondary to arrhythmia is prescribed digoxin. The dose based on weight is calculated to be 90 micrograms. The resident incorrectly converts the dose from micrograms to milligrams, resulting in a written order for "0.90 milligrams." The non-STAT order is then faxed to the pharmacy, where the pharmacist notes the dose to be excessive. The ordering physician is not immediately available, as the residents had changed shift, so the fax order is temporarily put aside. A hard copy of the order subsequently arrives to the pharmacy, and a pharmacy technician unaware of the noted discrepancy fills the order.

The drug is dispensed to the bedside. Prior to administration of the medication, the nurse notes the dose to appear to be excessive and attempts to confirm the order with the covering resident. The resident recalls checkout to mention that the child should receive "90 of digoxin," but did not notice the unit conversion error that had occurred. The nurse matches the verbal confirmation from the resident with the order and administers the medication. The patient subsequently develops arrhythmias and dies [1].

This devastating error in patient care occurred at one of the hospitals where the author practices. The author can attest that the patient's family members were not the only ones affected by this tragic loss. The residents, nurses, and attending physicians involved in this case were distraught that an error, which could have been prevented at so many levels, resulted in the death of one of their patients. Residents in particular found the incident difficult to handle emotionally. With little experience with patient deaths in general, residents found themselves questioning their choice of a career in medicine after the loss of a patient due to a medical error.

Accidents happen. Unfortunately, accidents that happen in the course of patient care can have significant consequences for all involved, including bodily harm or even death for the patient and lost consumer trust for the health system. The providers involved in accidents like the one described in the opening scenario often must deal with their emotional reactions virtually in isolation, because the ensuing legal process requires their silence. However, such physicians are not alone in their isolation, as accidents and mistakes in health care delivery are not infrequent occurrences [2].

The 1999 Institute of Medicine (IOM) report, *To Err is Human*, states that "at least 44,000, and perhaps as many as 98,000, Americans die in hospitals each year as a result of medical errors" [2]. Others have extrapolated the statistics from this report to suggest that the number of patient deaths due to medical errors in American hospitals exceeds the annual number of deaths from motor vehicle accidents, from breast cancer, or from AIDS [3], or the entire loss of U.S. service members over a decade of war in Vietnam [4]. The exact number of patients who die in American hospitals as a result of medical errors is controversial [5–7], but it is clear that medical errors occur more commonly than they should [5]. What is most important at this time is to seek answers to the questions of why medical errors occur and what can and should be done to address the threat they pose to quality patient care.

The IOM has classified health care quality problems in the United States into three categories: "underuse," "overuse," and "misuse" [8]. Definitions and examples of these three types of quality problems are provided in **Table 1**. Increasing pressure to demonstrate improved quality is being felt at many levels within the health care system and is coming from several sources, both internal and external (**Figure**) to the medical profession. Initiatives to improve the quality of health care delivery range from federal legislation setting minimum quality of care and safety standards to local quality improvement projects at the provider level, such as providing residents with palm pilots to assist in correct drug choice and dose calculations. Employer purchasing power and consumer advocacy groups are increasingly attempting to hold health care providers and systems accountable for improving health care quality, and the IOM report has sparked great interest among these groups in the need to report and reduce the incidence of medical errors.

The attention that patient safety and medical errors have received since the IOM report was published has

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Table 1. Glossary of Terms

Term	Definition	Example
Patient safety	Freedom from accidental injury	A full-term infant is born via normal vaginal delivery without complications to the infant or mother.
Error	Failure of a planned action to be completed as intended (ie, error of execution)	Immunizations are ordered for a child, but the mother is discharged from the clinic before they are administered.
	Use of the wrong plan to achieve an aim (ie, error of planning)	An antibiotic is ordered to treat a urinary tract infection when the causative organism is known to be resistant to that antibiotic.
Adverse event	An injury caused by a medical intervention and not due to the underlying condition of the patient*	A 60-year-old man requiring an appendectomy undergoes surgery and postoperatively develops superficial cellulitis at the incision site.
Adverse drug event	An injury related to medication administration and not due to the underlying condition of the patient*	A patient with no known allergies has an allergic reaction to the antibiotic prescribed for an otitis media. (Note that a *preventable adverse drug event* would be an allergic reaction that occurs in the same patient 2 months later, when the same antibiotic is prescribed by mistake.)
Near miss	A preventable adverse event identified prior to impacting a patient	In the above case, the pharmacist notices the patient's history of allergy to the antibiotic prescribed and calls the physician's office rather than dispensing the medication.
Misuse	An appropriate service is selected, but a preventable complication occurs and the patient does not receive the full potential benefit of the service	An error occurs in the calculation of a dose of digoxin, which results in an overdose and subsequent death of the patient.
Overuse	Providing a health care service under circumstances in which its potential for harm exceeds its potential benefit	Antibiotics are prescribed for an otherwise healthy 30-year-old woman with a simple (viral) upper respiratory tract infection.
Underuse	Failure to provide a health care service when it would have produced a favorable patient outcome	A patient develops measles at 26 months of age because the vaccine was missed at 12 months of age.

Data from Kohn LT, Corrigan JM, Donaldson MS, editors. To err is human: building a safer health system. Washington (DC): National Academy Press; 2000; Chassin MR, Galvin RW. The urgent need to improve health care quality. Institute of Medicine National Roundtable on Health Care Quality. JAMA 1998;280:1000–5; Chassin MR. Is health care ready for Six Sigma quality? Milbank Q 1998;76:565–91, 510; *and* Chassin MR. Assessing strategies for quality improvement. Health Aff (Millwood) 1997;16:151–61.

*Not all adverse events or adverse drug events are preventable.

caused a flurry of subsequent published reports and commentaries. As a result, the medical literature is full of various terms describing "mistakes" in medicine. Many of these terms are imprecise and are used interchangeably, creating confusion [9]. This article defines some of the key terms used in discussions of misuse, patient safety, and medical errors and discusses sources of these problems and possible remedies to reduce their occurrence. In addition, the article provides a framework for understanding where the health care industry is in its effort to address these quality problems.

What is a Misuse Quality Problem?

As defined by the IOM, a *misuse quality problem* occurs "when an appropriate service has been selected but a preventable complication occurs and the patient does not receive the full potential benefit of the service" [8]. The case described in the opening scenario is an example of misuse. In this case, the patient was prescribed an appropriate service (digoxin) for the medical condition, but a preventable complication (overdose of digoxin) occurred when a series of errors allowed the patient to receive the wrong amount of medication. Thus, the full potential

benefit of the service was not realized—the patient subsequently died. This incident might also be referred to as a *medical error*, an *adverse event* (AE), or an *adverse drug event* (ADE). Other examples of misuse quality problems include administration of a medication to a patient with known allergy (an ADE) or the development of an avoidable complication during surgery (an AE).

Examples of misuse abound in the medical literature, particularly misuse involving medication-related errors. ADEs have been studied extensively for several reasons: they represent one of the most common types of medical errors [10], they account for significant increases in hospital costs [11], and they are more readily studied because of ease in identifying study subjects and in accessing data related to drug prescribing [2]. In one study, Bates and colleagues [11] reported that about 30% of patient injuries occurring in a teaching hospital resulted from preventable ADEs. The authors estimated the excess hospital costs attributable to a preventable ADE to be $4700; based on that rate, they estimated the costs related to preventable ADEs to be about $2.8 million per year for a 700-bed hospital. Classen [12] reported that 2.43 ADEs occurred for every 100 hospital admissions and estimated that about 50% of these events were preventable. Lesar [13] determined that 3.99 prescribing errors occur per 1000 medication orders. The most common reasons for a medication error in this study were unappreciated reduced renal or hepatic function requiring a change in dosage (13.9%); history of allergy to the same medication class (12.1%); wrong drug name, dosage form, or abbreviation (11.4%); and incorrect dosage calculation (11.1%).

Some spectacular examples of misuse have been reported in the general media, bringing the problem to the forefront of public attention. The amputation of the wrong extremity of a patient (an AE) in Florida and a chemotherapy overdose (an ADE) in New York were headline stories in several daily newspapers [14]. In the former case, the correct surgical procedure (amputation) was chosen for the patient's condition, but an error occurred in the execution of that procedure (the wrong extremity was amputated). In the latter case, the correct therapy (chemotherapy) was chosen for the patient's cancer, but preventable errors occurred during their use (a variety of misadministrations), resulting in the patient's death. The growing number of reports about the magnitude and sometimes horrific nature of medical errors has made patient safety a key issue for health care leaders, health care purchasers, the government, and the public at large.

This attention is warranted, if for no other reason than for the cost exacted by medical errors. For example, if the findings by Bates and colleagues [11] were generalizable, the increased cost of preventable ADEs across the nation's hospitals would be about $2 billion [2]. Also, money spent to counteract AEs or to redirect care (eg, retesting, retreatment) could be spent providing appropriate care that results in favorable patient outcomes. But perhaps most importantly, errors in patient care threaten to diminish trust in the health care system and to decrease both patient and provider satisfaction.

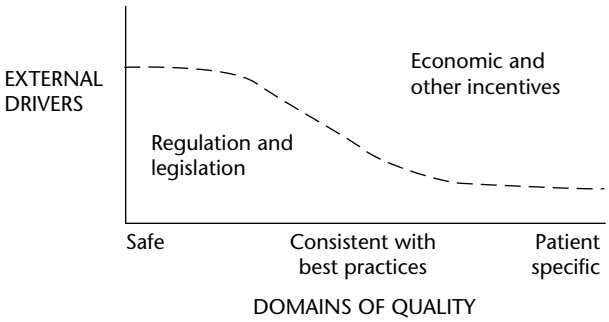

Figure. Two-dimensional model illustrating how external drivers of health care quality improvement (ie, legislation and regulation; economic and other incentives) influence specific domains of quality (ie, safe care; care that is consistent with current, evidence-based best practices; care that meets patient-specific needs, values, and expectations). Regulatory and legislative efforts to reduce quality problems have more influence in the creation of minimal standards of patient safety, and economic and other incentives have more influence in the customization of medical care specific to patient circumstances. (Adapted with permission from Kohn LT, Corrigan JM, Donaldson MS, editors. To err is human: building a safer health system. Washington (DC): National Academy Press; 2000:18.)

Why Do These Events Occur?

Much has been written about why errors and accidents occur in medicine, some of which draws from theory and experience unrelated to the practice of medicine (eg, systems theory, error reduction strategies within the airline industry). The complexity of this subject makes a brief review impossible and is beyond the scope of this article. A recent commentary by Bates and Gawande [15] provides a useful overview of some of the theoretical underpinnings of the study of medical errors as well as thoughts about how these problems should be addressed across the health care industry.

As pointed out in the IOM report [2] as well as by Bates and Gawande [15], a common reaction when a medical error occurs is to seek someone to blame. Fear of blame or damage to one's reputation or the reputation of one's institution has been a major deterrent to bringing mistakes or *near misses* (see Table 1) to the surface so they

Table 2. Sources of Medication Errors and Possible Solutions

	Source of Error	Possible Solution
Health care systems	Unappreciated renal or hepatic dysfunction requiring change in medication dosage	Computerized order-entry technology allowing quantifiable patient factors (eg, age, serum creatinine, blood urea nitrogen) to be considered
	Incorrect medication dosage calculations	Standardized drug preparations and dosing, computerized order entry
	Avoidable allergic or drug-drug reactions	Improved information systems and technology (eg, electronic medical records, computerized order entry)
	Lack of knowledge or appreciation of drugs prescribed	Computerized order-entry technology to help guide prescribers while also screening for drug-related problems
	Illegible orders	Computerized order entry
Individual health care providers	Incorrect medication dosage calculations	Handheld electronic prescription pads, double checking calculations by another individual
	Illegible order	Attention to improved penmanship, avoidance of abbreviations
	Lack of knowledge about drugs being prescribed	Self-directed learning about commonly used medications, consultation with clinical pharmacists

Data from Classen DC, Pestotnik SL, Evans RS, et al. Adverse drug events in hospitalized patients. Excess length of stay, extra costs, and attributable mortality. JAMA 1997;277:301–6; Lesar TS, Briceland L, Stein DS. Factors related to errors in medication prescribing. JAMA 1997;277:312–7; Reducing and preventing adverse drug events to decrease hospital costs. Res Action [serial on-line] 2001. AHRQ Publication Number 01-0020. Rockville (MD): Agency for Healthcare Research and Quality. Available at http://www.ahrq.gov/qual/aderia/aderia.htm. Accessed 3 May 2001; *and* Evans RS, Pestotnik SL, Classen DC, et al. Preventing adverse drug events in hospitalized patients. Ann Pharmacother 1994;28:523–7.

can be examined for causative factors that might be addressed to avoid a potential recurrence. Unfortunately, some quality assurance programs in medicine tend to try to assign blame for errors rather than using the incidents as opportunities to evaluate the medical delivery system [16]. James [16] described this as asking "who" in an attempt to identify providers involved with an adverse outcome. In this scheme, outcomes are tracked without a focus on the systems that produced the quality problem. This punitive process can jeopardize individuals and systems financially through levying of fines, or professionally through regulatory disincentives (eg, withholding of accreditation) [16]. In the "point-the-finger" environment of classic quality assurance programs, health care providers and organizations tend to obscure rather than report incidents of misuse [1]. In the digoxin overdose case, a "point-the finger" quality assurance program would have stopped after laying blame solely at the resident, the pharmacy, or the nurse rather than exploring the complex system of problems that contributed to the error.

The increased attention on medical errors has lead to the examination of how human factors and the systems and processes of health care delivery might come together to cause errors. It has thus been shown that many factors can contribute to medical errors, including increasingly complex medical science, poorly designed delivery systems, and human imperfection (**Table 2**). The current medical system often requires physicians, nurses, and pharmacists to perform tasks at levels of perfection not achievable by human beings [8]. Patients with increasingly complex problems are being managed with a wider variety of tools and techniques, yet data and systems that will help providers to remain current and to prevent errors and misuse problems have not kept pace. Rarely does the typical paper (or electronic) medical record have readily accessible, foolproof systems to prevent, for instance, a drug interaction in a patient seeing several subspecialists.

Because of the complex nature of errors, it is imperative that health care providers lead efforts to identify the sources of medical errors and to establish nonblame systems that encourage physicians to take responsibility for reporting errors and for working to help prevent them. New tools for dissecting and learning from individual errors, such as root cause analysis, are becoming available and should help in this overall effort [17]. In addition, lessons learned from within the health care field and from other industries should not be

overlooked, such as efforts to systemically address errors in anesthesia [18,19] and systems developed to prevent or anticipate and then compensate for expected human errors in the airline industry [8].

Should Every Occurrence Be Investigated?

The notion that all instances of misuse require correction has been disputed [4]. Some misuse incidents result in no harm to a patient. Others extend a patient's hospitalization or increase the medical costs associated with that patient's care. Still others, as in the case scenario, result in devastating consequences for the patient, the patient's family, and the entire medical team involved. Although prevention of all possible errors unrelated to patient outcome could be pursued, the cost of such action would surely exceed the benefit. Thus, prior to embarking on investigation of all instances of misuse, some have suggested identifying failed processes that have been linked to adverse outcomes (eg, preventable morbidity or mortality, poor patient satisfaction) [4].

Health care systems will need to carefully choose the misuse events that should be investigated and that are indicative of the need for system improvements. For example, the case described in the opening scenario (ie, a death from digoxin overdose) contrasts sharply with a case of an elderly hospitalized patient with multiple medical problems who dies of cardiac arrest, in whom the endotracheal tube inserted during the resuscitation effort is found to be in the right bronchus [4]. In the first case, a clear link seems to exist between the misuse problem and patient mortality. A thorough investigation to identify the failed processes that allowed such an error to occur was indicated and was undertaken [1]. The second example is also a case of misuse, but the effect this error had on the final patient outcome is questionable. Although intubation of the right bronchus is an error not to be condoned, statistics on the success of resuscitation in a hospitalized patient in cardiac arrest would suggest that this error was unlikely to have affected the patient's outcome.

Given a fixed amount of resources to correct all misuse incidents, should the same intensity investigation be launched to correct both errors? [4]. In the first example, all patients are at risk for similar overdose errors due to widespread system problems; preventable morbidity or mortality can be impacted for a large number of patients and an intense investigation is warranted. In the second example, the problem is more likely to be limited to a single provider with limited impact on preventable morbidity or mortality; a lower intensity investigation (perhaps retraining in intubation skills of the involved provider) would be indicated.

What is Being Done to Address This Problem?

National Efforts

Legislation. Fueled in part by sensational headlines in the popular press (eg, "Surgical inexperience proves deadly" [20]), federal and state lawmakers have turned their attention to the problem of medical errors. Recent sessions of Congress have been particularly prolific in introducing legislation intended to improve patient safety (**Table 3**). Much of the proposed legislation establishes a "minimum standard" of performance. In this way, truly poor providers or processes can be culled and especially egregious errors avoided. However, setting a minimum standard without also providing incentives for organizations to exceed these standards results in health care delivery systems that aim to be average rather than excellent [8].

Two provisions common to many of these bills, however, do offer hope in reducing medical errors. Recognition that additional research is needed to determine not only how errors occur but also how best to prevent them is encouraging. In addition, providing confidentiality protection for those who report errors eliminates one of the barriers (fear of retribution) to reporting errors.

JCAHO. External quality oversight began in the United States in 1917 with a physician-led effort. The resulting hospital standardization program was a forerunner to the current Joint Commission on Accreditation of Healthcare Organizations as well as federal and state regulatory programs [21]. (A full discussion of the history and goals of the JCAHO can be found elsewhere [22].) JCAHO standards require organizations to identify, report internally, and analyze serious adverse (sentinel) events and to take action to prevent their recurrence [21]. Recently, these standards were expanded [23]. Among the new requirements, hospitals must now assess high-risk activities proactively, before an error has occurred, and undertake appropriate improvements. Also, they must create an environment that encourages error identification and minimizes individual blame or retribution. As James [16] and others have suggested, when investigating a misuse problem, a health care system should ask "why," "what," or "how," rather than "who." Such an approach does not seek to hold an individual culpable but rather sees medical systems and processes as the source of most errors.

AHRQ. The Agency for Healthcare Research and Quality is charged with the responsibility of sponsoring research to improve the quality, appropriateness, and effectiveness of health care services. Research supported by this organization was instrumental in the development of the IOM report on medical errors [2]. This

Table 3. Congressional Bills Related to Reducing Medical Errors

Bill	Sponsor	Date Introduced	Summary	Action
The Patient Safety Act of 1999 (HR 1288; S 966)	Rep Maurice Hinchey (D-NY); Sen Harry Reid (D-NV)	3/25/99; 5/5/99	Requires providers under the Medicare program to publicly disclose nursing staff levels and outcomes data	Referred to House Ways and Means and Commerce Health Subcommittees; referred to Senate Finance Committee
The Medical Error Reduction Act of 2000 (S 2038)	Sen Arlen Specter (R-PA)	2/8/00	Health Care Financing Administration to establish medical error demonstration projects	Referred to Senate Committee
The Medical Error Prevention Act of 2000 (HR 3672)	Rep Constance Morella (R-MD)	2/16/00	Provides for the voluntary reporting of medication errors	Referred to House Commerce Health Subcommittee
Stop All Frequent Errors (SAFE) in Medicare and Medicaid Act of 2000 (S 2378)	Sen Charles Grassley (R-IA)	4/6/00	Requires providers to report sentinel events to a new reporting system, to establish patient safety systems; protects reported data from discovery	Referred to Senate Finance Committee
Voluntary Error Reduction and Improvement in Patient Safety Act of 2000 (S 2743)	Sen Edward Kennedy (D-MA)	6/15/00	Establishes voluntary reporting system with confidentiality protections; establishes Center for Quality Improvement to conduct research	Referred to Senate Health, Education, Labor, and Pension Committee
Patient Safety and Errors Reduction Act (S 2738)	Sen James Jeffords (R-VT)	6/15/00	Establishes voluntary confidential reporting system, a national database, provisions for research	Referred to Senate Health, Education, Labor, and Pension Committee
Departments of Labor, Health and Human Services, Education, and Related Agencies Appropriations Act of 2001 (HR 4577)	Sen Don Nickles (R-OK), by amendment	6/29/00	Establishes voluntary reporting systems with confidentiality protections, a national database, provisions for research	Passed Senate, 6/29/00

Adapted with permission from Parsons DW. Federal legislation efforts to improve patient safety. Eff Clin Pract 2000;3:311.

organization has also been responsible for the funding of a variety of projects in hospitals that have demonstrated significant reductions in patient care errors [24].

Leapfrog Group. The Leapfrog Group is a consortium of Fortune 500 companies and other large health care purchasers working together to improve patient safety. Group members have agreed to adhere to a set of purchasing principles in buying health care for their enrollees, which include educating and informing enrollees about patient safety and recognizing and rewarding health care providers for major advances in protecting patients from preventable medical errors. The group hopes to leverage their purchasing power to initiate breakthrough improvements in the safety and overall value of health care for American consumers [25].

FAACT. The Foundation for Accountability is a nonprofit organization whose mission is to help Americans make better health care decisions. While not specifically aimed at misuse quality problems, this organization believes that America's ability to create a more responsive health care system depends on informed, motivated consumers who help shape the system, hold it accountable for quality, and act as partners in improving health [26]. FAACT has an interactive database that allows consumers

to compare their health care experiences with the experiences of other consumers. Areas of comparison include the consumer's perception of her physician's ability to manage her care, her physician's ability to develop a trusting and caring relationship with her, and the quality of the health care organization's customer service.

Other organizations. The reduction of medical errors is a goal of several other national organizations. The Institute for Safe Medication Practices [27] is a nonprofit organization that works closely with health care practitioners and institutions, regulatory agencies, professional organizations, and the pharmaceutical industry to provide education about ADEs and their prevention. The National Patient Safety Foundation [28] seeks to measurably improve patient safety in the delivery of health care through the identification of a core body of knowledge and the development of pathways to apply this knowledge. This organization intends to raise public awareness and to foster communication about patient safety. The United States Pharmacopoeia [29] is a nonprofit organization that promotes public health by developing standards to ensure quality medicines and authoritative information about the appropriate use of those medicines. The Accelerating Change Today program [30], an initiative of the National Coalition on Health Care and the Institute for Healthcare Improvement, aims to improve the quality of health care by building public awareness of the need for quality improvements, identifying innovations and best practices, accelerating the spread of best practices throughout the health system, and changing the culture of medicine to nurture acceptance of best practices and evidence-based care.

System Improvement at the Local Level

The health care industry cannot rely on regulatory agencies or oversight organizations to resolve misuse problems. Standards developed at the national level to reduce errors tend to be delineated in broad strokes. Achieving national goals requires that implementation programs be developed at the local level.

Nolan [31] pointed out that many errors are attributable to characteristics of human cognition and that systems can be designed to help prevent them. Tactics to reduce errors and mitigate their adverse effects include reducing complexity, optimizing information processing, using automation and constraints, and managing unwanted effects of change [31]. In particular, the computerized medical record and computerized order entry (whereby physicians enter prescriptions on-line so the order can be checked for problems) can be very effective in reducing ADEs. In a number of studies, anywhere from 28% to 95% of ADEs were prevented with the assistance of computer monitoring [24,32].

In the study by Classen [12] on ADEs in hospitalized patients, 42% of avoidable ADEs were due to excessive drug dosage secondary to decreased renal function, 4.6% were due to drug interactions, 1.5% were due to drug allergies, and 1% were due to wrong drug administration. To reduce ADEs, the hospital implemented several preventive measures, including timely feedback on ongoing ADEs to physicians (a nurse or pharmacist contacted the prescribing physician and discussed the ADE and its management as soon as the ADE was verified); a more effective tracking system for drug allergies; automatic creatinine clearance measurement based on height, weight, and serum creatinine levels; and physician order entry for antibiotics. This group found that the most effective approach in reducing medication errors appeared to be computer programs that continually monitored drug use for appropriate selection and dosage, with intervention through disease management programs.

Evans [33] found that prospective surveillance of computer-based medical records for known drug allergies and appropriate drug administration significantly reduced the number of all ADEs. Early notification of physicians in this same organization permitted changes in drugs and dosages, reducing progression of mild and moderate ADEs to more serious or life-threatening conditions. In another study by this group, a computer-assisted management program for use of antibiotics and other anti-infective agents was associated with significant reductions in orders for drugs to which the patients had reported allergies, excess drug dosages, and antibiotic-susceptibility mismatches as well as reductions in the overall number of adverse events caused by anti-infective agents [34]. The patients in this latter study had significantly shorter hospital stays and lower hospital costs.

Some other examples of local efforts to identify and reduce misuse problems can be cited. One organization found that unit dosing reduced the frequency of medication errors by 82% [35]. In another example, clinical pharmacists participating in rounds as part of an intensive care unit team helped reduce ADEs by 66% [36].

How Can Practitioners and Training Programs Get Involved?

Individual Physicians

Although much work is needed at the health system level to reduce misuse quality problems, individual physicians can contribute to this effort in many ways [37]. For example, practitioners should strive to keep up with and promote the application of medical knowledge about

error prevention within their practice areas and support quality improvement efforts to report and reduce medical errors. Documenting and reporting (eg, to local medical societies or researchers) innovations that have proven successful in reducing errors and improving patient safety will enable others to learn from these successes [37]. Individual physicians also should adopt the use of technology that has been shown to help reduce errors. For example, handheld electronic prescription pads not only check for adverse drug interactions and drug allergies when prescriptions are entered, but also help to avoid the problem of prescribing the wrong drug with a sound-alike or look-alike name. Finally, use of computer-generated reminders (eg, for follow-up testing) can ensure that tests are performed within the appropriate time frame to yield useful results and, thus, avoid unnecessary repeat testing [37]. Without such active involvement of individual practitioners and a willingness to change practice behaviors, all of the efforts to reduce medical errors at the legislative, national, and local levels are likely to fall short of their full potential.

Training Programs

Medical schools and residency training programs are uniquely positioned to provide physicians-in-training with education on error prevention. Estrada [38] found that 100% of a graduating medical student class had personal knowledge of a medical error, 45% of students reported that the error resulted in major harm or death to the patient, but only 9% of students were involved with the case or had first-hand information about this serious error [38]. These findings suggest that physicians-in-training are aware of medical errors and need a safe forum, such as a classroom setting, for discussing issues surrounding errors. At the hospital where the case scenario occurred, residents took part in the ensuing root cause analysis of the digoxin overdose, which was the first ever performed at that institution. From that point on, root cause analyses have been routinely performed to investigate errors, and involved residents are always included.

The challenge for teaching hospitals has always been to provide optimal education for house officers while protecting patients from medical errors. Although it is clear that flaws in the medical delivery system exacerbate many errors and that these flaws must be corrected, clinical trainees must learn to take responsibility for their role in errors (not just blame them on "the system") and be willing to change their practice behaviors to prevent errors in the future. Residency programs have the opportunity to promote an environment whereby house officers feel safe from feeling shame, fear, or inadequacy when they are involved in a medical error. If faculty members are willing to take the lead, they can serve as role models in these programs to encourage residents to disclose errors and assist them in making appropriate changes in their behaviors [39].

No magic solution exists that will solve all medical errors. Carefully identifying errors linked to an adverse outcome is the first step. A combination of efforts on a national level (through legislation and oversight organizations) and active local participation by health care organizations and individuals will be required to realize the full potential of error-reduction efforts.

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