CHAPTER 1

SYSTEMS ANALYSIS AND REDESIGN: THE FOUNDATION OF MEDICAL ERROR PREVENTION

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An error can be defined as an unintended act (either of omission or commission) or as an act that does not achieve its intended outcome. Until recently, medical errors were seldom discussed. The public preferred to believe that errors in medical practice were rare. Health professionals, fearing loss of trust and impaired reputation, sought to perpetuate that misconception. The adversarial climate produced by the threat of malpractice litigation exacerbated this "see nothing, do nothing" approach.

All this has changed in the past 10 years. A new "movement" for patient safety began in 1995, when a series of apparently egregious errors resulting in death or inappropriate surgery were widely publicized. Hospitals began to recognize that they could do more to prevent patient injuries by using a nonpunitive approach to errors. The result has been substantial increases in both research on the causes of medical error and implementation of preventive mechanisms.

EXTENT OF MEDICAL INJURY

The toll of medical error is substantial. A significant number of patients suffer treatment-caused injuries while in the hospital.[1–5] The Harvard Medical Practice Study (HMPS),[1,2] a population-based study of iatrogenic injuries in patients hospitalized in 1984 in New York State, is the most comprehensive examination to date. Nearly 4% of patients suffered an injury that prolonged their hospital stay or resulted in measurable disability. Approximately 14% of these injuries were fatal.

If these findings are typical of the United States as a whole, each year an estimated 1.3 million people are injured by treatment intended to help them, and 180,000 people die as a result of medical accidents. More than two-thirds of the injuries found in the HMPS were due to errors and thus, by definition, were preventable.[6] Other researchers have reported similar findings.

The HMPS has been replicated in Australia,[7] New Zealand,[8] Denmark,[9] the United Kingdom,[10] and Canada,[11] and significantly higher rates of adverse events (9% to 13%) have been found. In all of these studies, approximately half of the adverse events were deemed preventable.

In 1991, Bedell et al.[5] reported that 64% of cardiac arrests at a teaching hospital were caused by errors. Misuse of medications was the leading cause. Many studies have found medication errors to be common. The rate of dosing errors by nurses is reportedly as high

as 20%.[12] Most of these errors are minor, such as giving a medication late or failing to watch the patient take the dose. However, a study of adverse drug events (ADEs) in two Harvard teaching hospitals showed that serious, injury-producing errors in the use of medications occurred in nearly 2% of patients, while an additional 5.5% of patients were exposed to "near misses," errors with potential for injury that were intercepted or, by luck, failed to cause harm.[13]

Other studies[14–18] have shown that medication errors account for 10% to 25% of all errors. Most do not result in serious injury.[19] Given the complex nature of medical practice and the multitude of interventions with each patient, a high error rate is perhaps not surprising. Delivery of a single dose of a medication is the end result of a complicated process involving 30 to 40 steps, each of which offers an opportunity for error. Using process steps instead of patient admissions as a denominator suggests that the medication error rate in hospitals may be as low as 1 in 1,000 to 1 in 10,000 (0.01%).[20] Even a failure rate of 0.01%, however, is substantially higher (10 to 100 times) than that tolerated in other industries, particularly in hazardous fields such as aviation and nuclear power. Health care can, and must, do better.

TRADITIONAL APPROACH TO ERROR

Health professionals—physicians, nurses, and pharmacists, in particular—have difficulty dealing with human error, in part because of the emphasis during their training on error-free practice.[21] In everyday practice, they continue to hear the message that mistakes are unacceptable. Physicians, nurses, and pharmacists are expected to function without errors, which means that they feel ashamed and inadequate when errors inevitably do occur. Their laudable striving for perfection is consistent with another goal of professional training: developing a sense of responsibility for the patient. If one is responsible for the patient, one also feels personally responsible for any errors that occur.

The high standards of practice that are taught to nurses, pharmacists, and physicians have often been reinforced in hospital practice by an unforgiving system of censure and discipline. Attempts are made to eliminate errors by requiring perfection and responding to failure (error) by blaming individuals. Errors are regarded as someone's fault, caused by a lack of sufficient attention or, worse, a lack of caring. In severe cases, the person at fault may be fired or subjected to retraining.

Not surprisingly, this "blame and train" approach to medical error has created strong pressure on individuals to cover up mistakes rather than admit them.[22] Even if punishment is not overt, the realization that colleagues will regard them as incompetent or careless makes many health professionals reluctant to admit or discuss their errors. The threat of malpractice litigation provides an additional incentive to keep silent.

Students of error and human performance reject the blame and train approach to error prevention. Although the nearest error leading to an accident is usually a human one, the causes of that error often are beyond the individual's control. Systems that rely on perfect performance by individuals to prevent errors are doomed to fail, for the simple reason that all humans err, and frequently. If physicians, nurses, pharmacists, and administrators are to succeed in reducing errors in health care, they must change the way they think about why errors occur. Fortunately, much has been learned about error prevention in other disciplines, and this information is relevant to the hospital practice of medicine.

PSYCHOLOGICAL AND HUMAN-FACTORS RESEARCH

Cognitive psychologists and human-factors specialists have been concerned with the biology, psychology, and sociology of errors for several decades. By developing models

of human cognition and studying complex environments such as airplane cockpits and nuclear power plant control rooms, they have learned a great deal about why people make errors and how to prevent them.[23] The principles developed by experts in these fields are pertinent to the redesign of health care systems to reduce errors. In simple terms, there are two modes of mental functioning: automatic and problem-solving.

Most mental functioning is automatic—effortless and rapid. We don't have to think about the process of eating or driving to work, for example. These "unconscious" functions are performed in a parallel-processing mode. We have to pay attention only when there is a change or interruption in the process.

Problem solving, on the other hand, requires intense mental activity. To solve problems we have to recall stored knowledge and apply rules. In contrast to the automatic mode, problem-solving thought processes are conscious, slow, and sequential, and therefore difficult.

Errors in the Automatic Mode

Errors that occur when an individual is functioning in the automatic mode are called "slips." They usually result from distractions or failure to pay attention at critical moments. An example is setting out in an automobile to go shopping and finding that one has driven to work instead. Psychologists' term for this phenomenon is "capture." Another common error mechanism is loss of activation, in which attention is distracted and a thought process is lost. An example is entering a room and failing to remember why.

Both physiological and psychological factors can divert attentional control and make slips more likely. Physiological factors include fatigue, sleep loss, alcohol, drugs, and illness. Psychological factors include other activity ("busyness") as well as emotional states such as boredom, frustration, fear, anxiety, and anger. All lead to preoccupations that divert attention. Psychological factors, though considered internal or endogenous, may be triggered by external factors such as overwork, interpersonal relations, and other forms of stress. Environmental factors such as noise, heat, visual stimuli, and motion can also divert attention and lead to slips.

Errors in the Problem-Solving Mode

Errors of problem-solving thought ("mistakes," in human-factors jargon) are more complex. They include rule-based mistakes, which occur when a wrong rule is chosen—either because one misperceives the situation and applies the wrong rule or because one simply misapplies a rule. Knowledge-based mistakes occur when the problem solver confronts a situation for which he or she possesses no programmed solutions. Errors arise because of lack of knowledge or because of misinterpretation of the problem.

Familiar patterns are assumed to have universal applicability because they usually work. We see what we know. It is simpler to apply a pattern than to rethink each situation. Errors can arise from discrepancies in pattern matching; sometimes we unconsciously match the wrong patterns. One form of pattern mismatching is caused by biased memory. Decisions are based on what is in our memory, but memory is biased toward overgeneralization and overregularization of the commonplace.[24]

Another aberration of thought that leads to error is the availability heuristic. This is the human tendency to grab the first answer that comes to mind and to stick with it despite evidence to the contrary. This tendency may be compounded by another mechanism, confirmation bias, which is the natural inclination to accept evidence that confirms one's hypothesis and to reject evidence that negates it. Many other mechanisms have been described. The important point is that these things happen every day to all of us. Rule-based and knowledge-based functioning are affected by the same physiological, psychological, and environmental influences that produce slips.

Stress is often cited as a cause of errors. Although it is often difficult to establish a causal link between stress and specific accidents, there is little question that both slips and mistakes are increased when people are under stress.

Three clear lessons emerge from this research. First, errors are normal. Everyone errs every day. To err is indeed to be human. Second, errors result from well-known cognitive mechanisms—mechanisms that are complex but understandable. Third, distractions are a common cause of errors. Errors truly result from a "normal" pathology.

SYSTEMS CAUSES OF ERRORS

Although insights from cognitive psychology and human-factors research help us understand how and why people make mistakes, they offer limited help in devising methods for preventing errors. It may be possible to avoid distractions, for example, or at least to recognize when one is at risk of being distracted, but individuals have a limited ability to "think straight" all the time. Successful methods of preventing errors require additional insight and understanding.

The major breakthrough in thinking about errors was the recognition that systems factors play a major role in increasing the likelihood that an individual will make an error. A watershed event in this understanding was the nuclear power plant accident at Three Mile Island in 1979. Although initial investigations revealed the expected operator errors (i.e., "human error"), it became clear that preventing many of these errors was beyond the capabilities of the specific individuals operating the system at the moment the accident occurred. Many of the errors were caused by faulty interface design or breakdowns that were not discernible by the operators or their instruments. The errors were the result of major failures of design and organization that occurred long before the accident.

Investigations following the accident at Three Mile Island revealed that faulty design provided gauges that gave a low pressure reading both when pressure was low and when the gauge was not working. Therefore, the operator thought the pressure was low when actually the gauge was broken. Also, the system had a control panel on which 100 lights started flashing simultaneously; faulty maintenance had disabled a safety backup system. Operators had been trained in how to respond to each light individually but not in how to prioritize should multiple lights go on at once. Thus, although an operator error may have been the proximal cause of the accident, the root causes had been present in the system for a long time.

Faulty systems design has two effects: It causes operator errors, and it makes them impossible to detect in time to prevent an accident. The operators at Three Mile Island were "set up" for failure by poor design, faulty maintenance, inadequate training, and poor management decisions. Together, these factors created a situation in which a minor operator error could result in a serious injury.

Reason[23] terms errors resulting from these situations "latent" errors—errors whose effects are delayed. Latent errors can be described as accidents waiting to happen. The effects of active errors, in contrast, are felt immediately.

Psychological precursors, one type of latent error, are working conditions that predispose to errors.[23] Inappropriate work schedules, for example, can result in high workloads and undue time pressures, two conditions that induce errors. Poor training can lead to inadequate recognition of hazards or inappropriate procedures that may lead to accidents. A precursor can be the product of more than one management or training failure. For example, excessive time pressure can result from poor scheduling, but it can also result from inadequate training or faulty division of responsibilities. Because they can affect all cognitive processes, precursors can cause an immense variety of errors that result in unsafe acts.

The primary objective of systems design for safety is to make it difficult for individuals to err. Even with the best system, however, errors will inevitably occur. A mechanism is needed for recognizing and correcting errors before they cause accidents. Ideally, systems should be designed to automatically correct errors when they occur. If this cannot be done, mechanisms should be in place to detect errors as soon as possible so that corrective action can be taken to minimize patient injury. In addition to designing the work environment to minimize psychological precursors, designers should provide feedback mechanisms in the form of monitoring instruments. They must also build in buffers and make provisions for redundancy. Buffers are design features that automatically correct for human or mechanical error. Redundancy is duplication (or triplication or quadruplication) of critical mechanisms and instruments. If a system is redundant, a single failure does not result in loss of the function.

Accident prevention efforts must focus on systems failures—on errors in design and implementation of systems. Most errors result from failure to use basic human-factors principles in the design of tasks and systems. Excessive reliance on memory, lack of standardization, inadequate availability of information, and poor work schedules all create situations in which individuals are more likely to make mistakes.

INDUSTRIAL MODELS

Aviation, nuclear power generation, and space travel employ technology that is at least as complicated and risky as that used in health care. Nonetheless, these industries have developed highly reliable systems for minimizing human error. For example, airline travel in the United States is indeed safe: The statistical chance of dying when you board a scheduled airliner is less than 1 in 3 million.

The difference between the approach used in the aviation industry and that used in medicine is that the aviation industry designs its systems for safety. Preventing accidents is a principal objective of aircraft design and flight procedures. First, aircraft designers assume that errors and failures are inevitable. They therefore design systems to absorb them by building in multiple buffers, automation, and redundancy. Second, procedures are standardized to the maximum extent possible. Specific protocols must be followed for trip planning, operations, and maintenance. Pilots go through a checklist before each takeoff.

Third, the training, examination, and certification process is highly developed and strictly enforced. Airline pilots take proficiency examinations every 6 months. Much of the content of these examinations is directly concerned with safety procedures. Finally, safety in aviation has been institutionalized. The Federal Aviation Administration regulates all aspects of flying and prescribes safety procedures, and the National Transportation Safety Board investigates every accident. The adherence of airlines and pilots to safety standards is closely monitored.

A unique feature of the aviation industry is the Aviation Safety Reporting System, which provides immunity against disciplinary action for pilots, controllers, or others who report a dangerous situation, such as a near-miss midair collision. This program has been highly successful in ensuring the prompt reporting of unsafe conditions, communication problems, and traffic control inadequacies. The Aviation Safety Reporting System receives more than 5,000 notifications each year.[25]

THE MEDICAL MODEL

In contrast, accident prevention has not been a primary focus of hospital medicine. Health care personnel typically react to a specific accident and focus on the error rather than

attempting to understand the systemic cause. For example, a typical response to a dosing error is the institution of an additional checking stage. Human-factors experts recognize the futility of concentrating on solutions to the unsafe acts themselves. Other errors, unpredictable and infinitely varied, will soon occur if the underlying systems failure goes uncorrected. Correcting systems failures will not eliminate all errors, because individuals still bring various abilities and work habits to the workplace. Nonetheless, correcting systems failures will substantially reduce the probability of error.

Most important, rather than designing systems to prevent or absorb errors, designers of medical systems rely largely on faultless performance by individuals to prevent errors. They expect individuals not to make errors, rather than assuming that they will.

There are, of course, exceptions. For example, unit dose drug distribution was a major systems change in medication dispensing that has markedly reduced medication dosing errors. In intensive care units, monitoring is sophisticated and extensive (though perhaps not sufficiently redundant). Equipment and procedures for anesthesia have been developed that make it difficult for personnel to commit errors. Mortality from anesthesia has been estimated at less than 1 in 200,000, compared with 1 in 10,000 to 20,000 a decade earlier.[26] Anesthesiologists have led the medical profession in recognizing systems factors as causes of errors, in the design of fail-safe systems, and in training to avoid errors.[27–29]

MEASURING ERRORS

Health care organizations that want to reduce errors need to develop reliable methods for measuring them. The errors that occur provide clues as to which systems need to be targeted for redesign. Changes in the error rate are the measure of the effectiveness of system changes. Accurate and reproducible measurement of errors is difficult, but the purpose of measuring is to discover errors, quantify the extent and types of errors, and document trends.

Discovering Errors

Most health care organizations rely on spontaneous reporting to identify errors. This method is not only inadequate but also misleading, because the punitive nature of most hospitals' responses to error reporting stifles such reporting. Typical incident reports identify only 2% to 5% of reportable ADEs.[30] This is beginning to change as more and more hospitals implement a nonpunitive approach to errors. When immunity is provided, the yield is sometimes astonishing.[13]

Identification of errors, as well as investigation of all errors that cause injuries, should be a routine part of hospital practice. Only when errors are accepted as an inevitable, though manageable, part of everyday practice will it be possible for hospital personnel to shift from a punitive to a creative frame of mind that seeks out and identifies the underlying systems failures.

Quantifying Types of Errors

It is neither feasible nor necessary to measure all types of errors on a continuous basis. Periodic, focused data collection is sufficient. Once systems changes have been selected, specific indicator errors can be identified and measured intensively over a short period to determine the base error rate.

Documenting Trends

Once indicator errors have been identified and systems changes have been introduced, errors or adverse events should be measured periodically to assess the effectiveness of

the systems changes. It is helpful to present such data over time in the form of control charts that show the baseline rate, upper and lower control limits (usually three standard deviations), the error rate after the intervention, and maintenance of the improvement over time. Chapter 23 provides more information on measuring medication safety.

Measuring errors may be expensive, but the consequences of errors are more so. In industry, the savings from reduction of errors and accidents more than make up for the costs of data collection and investigation. In hospitals, the additional savings from reduced patient care and liability costs for hospitals and physicians are substantial. In one hospital, the average cost of each preventable ADE has been estimated to be $4,685.[31]

FRAMEWORK FOR SYSTEMS ANALYSIS

Once the extent of errors is known in a health care system (e.g., the medication system, the radiology department, or the emergency room), the next question is to determine where remedial efforts can be most profitably targeted. Systems failures can be grouped into two broad categories: design failures and organizational and environmental failures.

Design Failures

Many hospital systems were never "designed" in the true sense; they just grew. Errors occur because the processes used in these systems have not been well thought out. Basic human-factors principles have been disregarded in the design of these systems. Design failures can be classified into three categories: process design, task design, and equipment design.

Process design failures result from failure to analyze the purposes of the system and how best to achieve them. What are the objectives of the system? How can it best meet users' needs? What are its potential hazards? One must think through the system and determine the consequences of actions that can go wrong at each point.

In a study of medication errors causing ADEs, my colleagues and I[20] found that failures in just three systems accounted for more than half of the errors that either caused an ADE or were near misses (intercepted errors). These three systems were drug knowledge dissemination, checking dose and identity of drugs, and making patient information available.

Drug knowledge dissemination is a major problem. Because of the number, variety, and complexity of drugs, it is impossible for any individual to recall all that he or she needs to know in order to use a drug appropriately and safely. Health professionals need to have drug information available at the time decisions are made and in a form they can easily use.

Methods for tracking and identifying drug, dose, and patient are often primitive compared with those used in industry. Supermarkets keep better track of groceries than many hospitals do of medications. Creative ways need to be developed for making patient information more readily available: displaying it where it is needed, when it is needed, and in an accessible form. Computerizing the medical record, for example, would facilitate bedside display of patient information, including test results and medications.

Task design failures result from the failure to incorporate human-factors principles into planning tasks. Norman[24] has pointed out the importance of designing tasks to minimize errors and has recommended a set of principles that have general applicability. Tasks should be simplified to minimize the load on the weakest aspects of cognition (i.e., short-term memory, planning, and problem solving). The power of constraints should be exploited. One way to do this is with forcing functions. These are design features that make it impossible to perform a specific erroneous act (e.g., the lock that prohibits release

of the parking gear of a car unless the brake pedal is depressed). Standardization of procedures, displays, and layouts reduces errors by reinforcing the pattern recognition that humans perform well. Finally, where possible, operations should be easily reversible or, when not reversible, difficult to carry out.

Checklists, protocols, and computerized decision aids could be used more widely. For example, physicians should not have to rely on their memories to retrieve a laboratory test result, nor should nurses have to remember the time a medication dose is due. Computers can do these tasks more reliably than humans.

Standardization is one of the most effective ways to prevent errors; examples in the airline industry include maintenance protocols and pilot checklists. The advantages of standardizing drug doses and administration times, for example, are obvious. Is it acceptable to ask nurses to follow six different "K scales" (directions for how much potassium to give according to the patient's serum potassium level) solely to satisfy idiosyncratic physician prescribing patterns? Other areas in which standardization would be beneficial include information displays, methods for common practices (e.g., surgical dressings), and the location of equipment and supplies in a patient care unit.

Forcing functions can be used to structure critical tasks so that errors cannot be made. For example, a computerized system for medication orders can be designed so that a physician cannot enter an order for a lethal overdose of a drug or prescribe a medication to which a patient is known to be allergic.

Equipment design failures result from failure to apply basic human-factors principles to the design of equipment displays and controls. It is astonishing that most people using most of the equipment in hospitals do not understand how that equipment works. This is primarily a design problem; manufacturers have not seen to it that equipment offers the user information and controls that are readily understandable. In other words, the manufacturers, too, have failed to apply basic human-factors principles. It is also remarkable that it is possible to connect an epidural catheter to a syringe with medication prepared only for intravenous use. A simple forcing function design, such as has long been used with oxygen and nitrous oxide connections in anesthesia, could prevent this error.

Organizational and Environmental Failures

Organizational and environmental failures, unlike design failures, can often be remedied through changes at the departmental or unit level (i.e., the pharmacy or nursing unit). Institutionwide changes may not be needed. Three types of organizational failures may induce errors: psychological precursors, inadequate team building, and training failures.

Psychological precursors are conditions in the workplace, such as schedules, work assignments, and interpersonal relationships, that cause stress and lead to errors. These include environmental factors, such as excessive heat, inadequate light, crowded space, and high noise levels, as well as excessive workloads, long working hours, and poor managerial styles. Although the influence of the stresses of everyday life on human behavior cannot be eliminated, stresses caused by a faulty work environment can be. Eliminating fear and creating a supportive working environment are powerful methods for preventing errors.

Team building requires a supportive environment and skilled leaders who can encourage individuals to work together effectively, help each other avoid mistakes, intercept errors, and reduce psychological precursors. Hospitals have historically been poor team builders because physicians and nurses have functioned semiautonomously and autocratically.

Training is essential. If personnel neither understand their responsibilities nor possess adequate skills, they will be more likely to make errors. Health professionals need more

training in error prevention and identification. They need to learn to think of errors primarily as symptoms of systems failures. Many interns need more rigorous instruction and supervision than is currently provided. Young physicians need to be taught that safe practice is as important as effective practice.

RETROSPECTIVE SYSTEMS ANALYSIS

Most hospitals consider systems analysis, if they consider it at all, only in response to a serious adverse event. A root cause analysis (see Chapter 5) may be carried out, focusing on the specific error. Vincent et al.[32] caution against such a simplistic approach: "While it is sometimes straightforward to identify a particular action or omission as the immediate cause of an incident, closer analysis usually reveals a series of events leading up to adverse outcome. The identification of an obvious departure from good practice is usually only the first step of the investigation." Instead, they counsel, one should look broadly for all potential contributing factors. These include task factors, such as availability of protocols; environmental factors, such as staffing levels and workloads; team factors, such as communication and supervision; and organizational and management factors.

Systems analysis of an adverse event is difficult and time-consuming. However, it can be extremely rewarding. Investigation almost always reveals a host of contributing factors (e.g., poor work schedules, inappropriate protocols, poor labels on drugs, and inadequate training or supervision) that are the underlying causes of the event. For example, investigation of a fatal medication error in an infant (see Chapter 5 appendix) revealed more than 50 systems failures.[33]

PROSPECTIVE SYSTEMS ANALYSIS

An organization that is seriously committed to patient safety will not wait for tragedy to strike before identifying systems failures. It will adopt a practice widely observed in engineering, the prospective search for potential systems failures, or "accidents waiting to happen"—also known as failure mode and effects analysis (FMEA). A small group of frontline caregivers identifies a potential hazard and then brainstorms about all of the possible things that could go wrong, diagramming relationships in a "fishbone" or similar diagram (see Chapter 21).

OBSTACLES TO SYSTEMS REDESIGN

Like any established institution, the modern hospital presents significant barriers to those who seek to change its practices. These barriers appear to be both extensive and daunting, but recognizing them is the first step in designing methods to overcome them. The following obstacles are found in most hospitals:

1. A culture of shame and blame. Often, there still are strong sanctions (overt or covert) against those who make mistakes. Because errors are thought to be due to carelessness, workers are punished when they make mistakes. For physicians, punishment is likely to be covert (i.e., disapproval or shunning). As a result of this culture, most failures are not reported.[30] They are also not discussed, which makes improvement (i.e., systems redesign) impossible.

2. Infrequent occurrence of events. Despite the alarming statistics, serious errors are uncommon in the experience of most hospital professionals. For example, the widely quoted estimate from the Institute of Medicine of 98,000 preventable deaths annually

works out, on average, to only 1 death every 7 years for a physician. Evidence abounds that most errors are not recognized, so it is likely that an average physician is aware of a preventable death only two or three times in a lifetime. Similarly, nonfatal errors are often unrecognized. This perceived low error rate leads to complacency. It also means that a change targeted at a low-frequency problem can potentially result in an increase in overall work for a relatively low yield.

3. Complexity and lack of ownership. Hospital systems are complex, involving a wide variety of personnel and interlocking flows of materials and information. Many individuals have interests in multiple operations, and each system and subsystem has multiple stakeholders, but none of the stakeholders has complete control of any of the systems; there are no owners. The system for ordering, dispensing, and administering medications is a good example of the challenges posed by complex systems. This system is characterized by multiple actors (physicians, nurses, pharmacists, clerks, and technicians), multiple choices (drugs, names, routes, doses), multiple handoffs that are frequent and fragile, no ownership, no natural team, and no one with hospitalwide authority to make changes and ensure quality.

4. Unavailability of information. Because of the complexity of processes, information transfer can pose a major challenge to knowledge-based problem solving. A systems analysis of ADEs showed that lack of information about the patient and lack of knowledge of drugs were the most common systems failures, accounting for 40% of the serious, injury-producing errors.[20] Modern medicine is complicated; it is difficult to remember everything one needs to know to diagnose, treat, and monitor care in all kinds of patients. It is also difficult to ensure that all the pertinent information about each patient is readily available to all who are involved in decisions about care. Physicians, nurses, pharmacists, and others need to have information available when it is needed, where it is needed, and in a form that can be readily used.

5. Physician resistance. Physicians have been reluctant participants in the modern safety movement. Why? An obvious and often-cited reason is the fear of inciting malpractice litigation. Many physicians do not believe that state peer-review statutes provide adequate protection. But there are no studies demonstrating that internal review of mishaps increases malpractice risk. Those hospitals that are making major strides in safety do not have a greater frequency of lawsuits. Still, many physicians choose not to take the chance.

A second reason is that many physicians do not accept the systems concept. It seems like a vague and complicated solution to a simple problem: you made a mistake, so take your punishment. It goes against all we've been taught: that if we're careful and do our homework, we won't make mistakes. And, it smacks of irresponsibility: "Don't blame me; it's the system." Finally, as suggested above, many do not believe the numbers; the high rates of injury and death are not consistent with their personal experience.

6. Lack of leadership. It is not just physicians who have not signed on to the safety movement; neither have the chief executive officers (CEOs) of most hospitals and health care systems. CEOs do not believe the numbers and are caught in the blaming approach to safety. Like physicians, they are not sure they believe in the systems approach. They are leery of getting ahead of their physicians, since they have limited control over the physicians' practices. Finally, they do not feel much pressure from the public or from their boards to change.

7. Tolerance of individualistic practices. One manifestation of the lack of leadership is hospitals' tendency to cater to the idiosyncrasies and special demands of individual physicians. In drug prescribing, for example, tolerance of illegible and nonstandard orders and catering to prescribing differences contribute to the likelihood of error. Noncompliance

with safety practices, such as hand-disinfecting and "sign your site" policies, is also tolerated. No other business or industry would tolerate such flagrant disregard of its policies. Following rules is basic. Safe practice cannot be achieved in such an environment. Changing such long-standing practices can be a challenge.

CONCLUSION

Few American institutions are as ripe for systems redesign as hospitals. The current drive for efficiency will necessitate reexamination of the most serious form of inefficiency: injury-producing errors. Significant improvements will require major commitments to error reduction by each organization's leadership, as well as acceptance by all professionals and administrators that error is an inevitable aspect of the human condition. Until errors are recognized as symptoms of systems flaws, not of character flaws, substantial progress in reducing medical errors is unlikely.

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