



# Reduce Human Error

*How to analyze near misses and sentinel events, determine root causes and implement corrective actions*

by

**James J. Rooney, Lee N. Vanden Heuvel and Donald K. Lorenzo**

**W**HAT CAUSED THE last sentinel event (an unexpected occurrence involving death or serious physical or psychological injury) at your healthcare facility? The last quality of care problem? The last near miss? In most cases, human error is determined to be either the direct cause—a pharmacist incorrectly filling a medication order, or a nurse failing to respond to an IV alarm—or a significant contributor—an oxygen bottle running empty when the technician fails to notice it needs replacing.

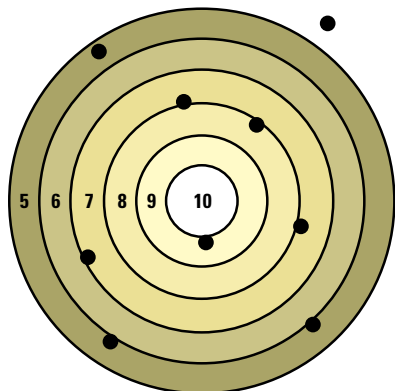
In many cases, if the human mistake results in only a minor quality of care problem, no follow-up action is necessary. However, if this human mistake results in a near miss or sentinel event, a report will be completed, and the responsible person might be coached, disciplined or maybe even fired. As a result, most managers and team leaders feel relatively confident the mistake will not occur again. However, experience shows us mistakes will likely recur.

Historically, human errors are significant factors in almost every quality problem, equipment shutdown or accident in industrial and manufacturing facilities. One study of refining and petrochemical plants identified the following causes of accidents: equipment and design failures, 41%; operator and maintenance errors, 41%; inadequate or improper procedures, 11%; inadequate or improper inspection, 5%; and miscellaneous causes, 2%.<sup>1</sup>

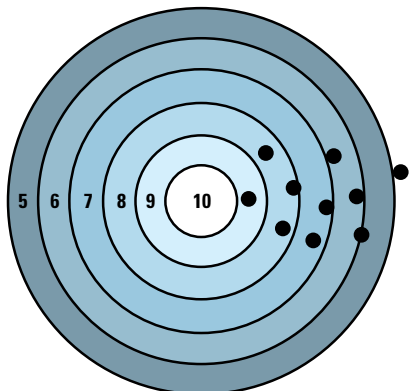
An adverse event in the healthcare field is defined as an injury caused by medical management rather than by the patient's underlying disease or condition.<sup>2</sup> Not all, but a sizable number, of adverse events are the result of human error.

A Harvard Medical Practice study examined more than 30,000 randomly selected discharges from 51 randomly selected hospitals in New York in 1984 (the most recent statistics available).<sup>3</sup> Adverse events occurred in 3.7% of the hospitalizations. The proportion of adverse events attributable to errors was 58%, while the proportion due to negligence was 27.6%.

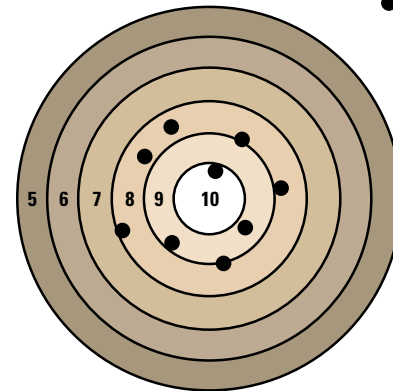
**FIGURE 1** Random Variability



**FIGURE 2** Systematic Variability



**FIGURE 3** Sporadic Variability



Although most of these adverse events resulted in disability lasting less than six months, 13.6% resulted in death and 2.6% caused permanently disabling injuries. The most common adverse events were:

- Drug complications, 19%.
- Wound infections, 14%.
- Technical complications, 13%.

Today, the challenge for healthcare management is to implement systems to reduce the frequency of human errors and devise ways to mitigate the consequences of the errors that do occur. Instead of blaming human error on ill trained or unmotivated workers, systems must be established to investigate and analyze near misses and sentinel events so root causes can be determined and corrective actions implemented. By doing this, healthcare teams should begin to experience significant improvements in overall system performance and safety.

**Understanding human error**

Opportunities for error exist in every task performed by a nurse, physician or any other healthcare employee. Even though a single task may never be performed exactly the same way twice, minor variations in performing a task are usually of no concern. However, when some limit of acceptability is exceeded, a variation is considered a human error.

Human error is any human action or lack thereof that exceeds the tolerances defined by the system with which the human interacts.<sup>4</sup> For example, a nurse asked to administer a medication to a patient might administer too much or too little, administer the

wrong type of medication or administer the medication to the wrong patient.

All these variations are inconsequential unless they cause an adverse impact on the quality of care, such as extended hospitalization, temporary or permanent injury to the patient or even death. In such cases, the variation would be considered a human error. Unfortunately, these limits of variability are usually not well-defined until a person makes a mistake that results in a problem big enough to warrant corrective action.

**Human errors**

Human errors are divided into two types:

- **Unintentional errors:** Actions committed or omitted with no prior thought. These errors, such as misreading a gage, bumping the wrong switch or forgetting to properly set the dose on an X-ray device, are usually thought of as accidents.
- **Intentional errors:** Actions deliberately committed or omitted because workers believe their actions are correct or better than the prescribed actions. For example, a physician might intentionally perform an erroneous action if the cause of a patient’s symptoms is misdiagnosed. Other intentional deviations include shortcuts that are not recognized as human errors until circumstances arise in which the actions exceed the system tolerances. To speed up the filling of an automated medication dispenser unit, for example, a pharmacy technician might not perform the verifications specified by the procedure.

Remember, the important distinction between an intentional deviation and malevolent behavior is

motive. An intentional deviation is not intended to harm the system, but its effect on the system may be undesirable. A malevolent act is not an error—it is a deliberate action intended to produce a harmful effect. The term “human error” in this article does not include malevolent acts.

### Variability

Even though a nurse, doctor or instrument specialist may be well-trained and highly motivated, human errors are still a natural and inevitable result of the variability of human interaction with a system. There are three types of variability. Knowing which one occurs in a given case will help explain why errors happen and what can be done to control them. To understand these types of variability, think of a rifleman firing 10 shots at a target, and consider any shot off the target an error:

- **Random variability:** Characterized by a dispersion pattern centered around a desired norm—in this example it’s the bull’s-eye (see Figure 1). Personnel selection, training, supervision and quality control programs are all ways to control random variability. Random errors occur when these programs are deficient, when tolerance limits are too tight or when workers cannot control key performance factors.
- **Systematic variability:** Characterized by a dispersion pattern offset from a desired norm (see Figure 2). Such errors are called systematic errors. These errors occur, for example, when workers are given only one limit instead of a lower and upper limit. In this case, they may deliberately try to be on the safe or unlimited side. Biases can also exist in tools, equipment, instructions or the worker’s personality, training or experience. Telling workers how well they are doing with respect to real goals will help reduce systematic errors.
- **Sporadic variability:** Characterized by an occasional outlier, such as a tight cluster of shots with one shot substantially off the mark for reasons

**TABLE 1** Internal Performance Shaping Factors

Training/skill	Emotional state
Practice/experience	Gender
Knowledge of required performance standards	Physical condition/health
Stress: mental or bodily tension	Influences of family and other outside persons or agencies
Intelligence	Group identifications
Motivation/work attitude	Culture
Personality	

Source: A.D. Swain and H.E. Guttman, *Handbook of Human Reliability Analysis With Emphasis on Nuclear Power Plant Applications* (Washington, DC: U.S. Nuclear Regulatory Commission, 1985).

## ASQ Lends a Hand At Reducing Healthcare Errors

Although widespread agreement exists on the causes of prescription drug errors, there is little consensus on the methods needed to address these problems. A new paper presented to congressional health policy staff by ASQ advocates the wider adoption of proven quality methods in an effort to reduce medication errors.

As part of the Society’s ongoing effort to cultivate contacts with national policymakers in Washington, DC, ASQ officials met with the health policy advisor to Congressman Michael Bilirakis of Florida earlier this year. The advisor asked for suggestions from ASQ on ways quality methods could be used to reduce prescription drug errors.

ASQ staff, with input from members of the Health Care Division and the Food, Drug & Cosmetic Division, prepared a position paper titled “Using Quality Methods To Reduce Prescription Drug Errors.” It is available at [www.asq.org/news/interest/prescription.pdf](http://www.asq.org/news/interest/prescription.pdf).

ASQ has also joined with the National Patient Safety Foundation (NPSF) to form an alliance that will offer solutions for reducing errors and increasing patient safety in healthcare delivery. The two groups will collaborate to develop a toolbox of products and services for leaders of healthcare organizations and acute care settings to increase patient safety. ASQ-NPSF events will share successful case study implementation of the toolbox methods such as Six Sigma and distribute applicable patient safety solutions to various healthcare channels.

For more information on the NPSF, go to [www.npsf.org](http://www.npsf.org).



that are readily imaginable, such as a sudden distraction or an involuntary twitch (see Figure 3, p. 28). These errors are often not correctable by additional training or indoctrination because they

are not the result of inadequate knowledge or motivation. To reduce sporadic errors, we must categorize the errors and the conditions under which they occur in such a way that the errors can be related to controllable conditions.

**TABLE 2** External Performance Shaping Factors

Situational characteristics	Task, equipment and procedural characteristics
Architectural features	Procedures: written or not written
Environment: temperature, humidity, air quality, lighting, noise, vibration or general cleanliness	Written or oral communications
Work hours/work breaks	Cautions and warnings
Shift rotation	Work methods/practices
Availability/adequacy of special equipment, tools or supplies	Dynamic vs. step-by-step activities
Staffing levels	Team structure and communication
Organizational structure: authority, responsibility or communication channels	Perceptual requirements
Actions by supervisors, co-workers or accreditation and regulatory personnel	Physical requirements: speed and strength
Facility policies	Anticipatory requirements
	Interpretation/decision making
	Complexity: information load
	Long- and short-term memory load
	Calculational requirements
	Feedback: knowledge of results
	Hardware interface factors: design of control equipment, test equipment, process equipment, job aids or tools
	Control-display relationships
	Task criticality
	Frequency/repetitiveness

Source: A.D. Swain and H.E. Guttman, *Handbook of Human Reliability Analysis With Emphasis on Nuclear Power Plant Applications* (Washington, DC: U.S. Nuclear Regulatory Commission, 1985).

**TABLE 3** Psychological and Physiological Stressors

Psychological stressors	Physiological stressors
Suddenness of onset	Long duration of stress
High task speed	Fatigue
Heavy task load	Pain or discomfort
High jeopardy risk	Hunger or thirst
Threats of failure or loss of job	Temperature extremes
Monotonous, degrading or meaningless work	Radiation
Long, uneventful vigilance periods	Exposure to diseases
Conflicting motives about job performance	Vibration
Negative reinforcement	Movement constriction
Sensory deprivation	Movement repetition
Distractions: noise, glare or movement	Lack of physical exercise
Inconsistent cueing	Disruption of circadian rhythm
Lack of rewards, recognition or benefits	

Source: A.D. Swain and H.E. Guttman, *Handbook of Human Reliability Analysis With Emphasis on Nuclear Power Plant Applications* (Washington, DC: U.S. Nuclear Regulatory Commission, 1985).

**Performance shaping factors**

Healthcare workers are an essential element of any healthcare system. To minimize human errors in medical activities, managers must ensure the healthcare worker/machine interface, including interactions with other workers and with the equipment and environment, is compatible with the capabilities, limitations and needs of the worker.

A performance shaping factor (PSF) is anything that affects a worker’s performance of a task within the system. PSFs can be divided into three classes:<sup>5</sup>

- Internal PSFs that act within an individual.
- External PSFs that act on an individual.
- Stressors.

Internal PSFs are the individual skills, abilities, attitudes and other characteristics a worker brings to the job (see Table 1, p. 29). Some of these, such as training, can be improved by managers; others, such as a short-term emotional upset triggered by a family crisis, are beyond any practical management control.

Table 2 lists external PSFs that influence the environment in which tasks are performed. External PSFs are divided into two groups:

- **Situational characteristics:** General PSFs that may affect many different jobs.
- **Task, equipment and procedural characteristics:** Related to a specific job or a specific task within a job. Job and task instructions are a particularly important part of the task characteristics because they have such a large effect on human performance. By emphasizing the importance of preparing and maintaining clear, accurate task instructions, managers can significantly reduce the likelihood of human errors.

Mismatches between internal and external PSFs result in disruptive stress that degrades job performance.

If too little stimulation is present, a worker will not remain sufficiently alert or motivated to do a good job. For example, a pharmacy worker who repetitively fills medication orders may not be alert enough to notice a tablet was omitted.

On the other hand, too much stimulation will quickly overburden a worker and degrade job performance. In such situations, workers tend to focus on the largest or most noticeable signals and ignore some information entirely, omit or delay some responses, process information incorrectly and reject information that conflicts with their diagnosis or decision, or mentally or physically withdraw. See Table 3 for some examples of disruptive psychological and physiological stressors.

Although stress usually has a negative connotation, some stress is actually necessary for humans to function at optimum performance (see Figure 4, p. 32). Facilitative stress is anything that arouses us, alerts us, prods us to action, thrills us or makes us eager. When a positive balance exists between internal and external PSFs, workers experience facilitative stress and their job performance is at its best.

Managers must recognize most PSFs, including many internal PSFs, are within their control. By designing work situations that are compatible with human needs, capabilities and limitations, carefully matching workers with job requirements, and rewarding positive behaviors, managers can create conditions that optimize worker performance and minimize human errors.

### General approaches for reducing human error

When contemplating ways to improve human performance, managers must address two basic types of errors:

- Those whose primary causal factors

## ASQ Facilitates Application Of ISO 9000 to Healthcare

By **Michael Stoecklein**, ASQ's healthcare market development manager, and **Mickey Christensen**, Health Care Division standards committee chair

Since the publication of the Institute of Medicine's 1999 report *To Error Is Human: Building a Safer Health System*, there has been increasing interest in trying to identify and use methods to help reduce errors and improve safety while simultaneously improving an organization's operating margin. Other industries have proven ISO 9000 is a very powerful quality management tool, and some healthcare service organizations have found it can help provide better healthcare systems and reduce the incidence of avoidable adverse events.

ASQ's Health Care Division and the Automotive Industry Action Group collaborated to develop ISO 9004:2000 based document guidelines for process improvements in health service organizations. ASQ's Health Care Division helped lead the group effort in drafting the document. At an international workshop in 2001, attendees modified the draft, which was later accepted for publication by the International Organization for Standardization, known as ISO. After the workshop in Detroit, the attendees voted to publish the ISO IWA-1 document.

The IWA-1 document can be used by healthcare organizations to implement an ISO 9000 quality based management system and make accreditation with other agencies easier, thereby minimizing the number of resources required to comply. IWA-1 contains much of the text of ISO 9004:2000 but also includes specific guidance for its implementation in the healthcare sector.

The guidelines are voluntary and not intended for certification or accreditation. Copies of the IWA-1 document and the reports published by the Institute of Medicine are available from ASQ Quality Press, <http://quality-press.asq.org>.

ASQ has also developed a training course, IWA-1 Train the Trainer, and some training materials. The next course is scheduled for Sept. 23-26 in San Diego. Go to [www.asq.org/ed/courses/descriptions/iwahealthcare.html](http://www.asq.org/ed/courses/descriptions/iwahealthcare.html) for more information.

In addition, ASQ recently began hosting quality conversations on a variety of topics, the most recent being one about Six Sigma in healthcare. To read a copy of the transcript, go to [www.asq.org/ed/qconvs/062002sixsigmahc/index.html](http://www.asq.org/ed/qconvs/062002sixsigmahc/index.html).



are individual human characteristics unrelated to the work situation.

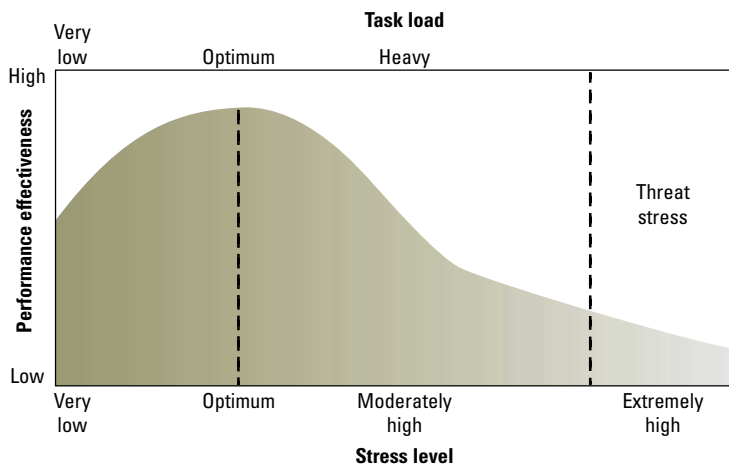
- Those whose primary causal factors are related to the design of the work situation.

Employing appropriate hiring and job assignment policies is an important means for managers to reduce the causes of the first type of error. But, on any given day, a worker could be emotionally upset or fatigued and commit an error even though human factors specialists estimate only 15 to 20% of workplace errors are primarily caused by such internal human conditions.<sup>6</sup>

The majority, 80 to 85%, of human errors result from the design of the work situation, such as the tasks, equipment and environment.<sup>7</sup> Managers can directly control these factors. A work situation where the PSFs are not compatible with the capabilities, limitations or needs of an employee is called an error likely situation. In a sense, an error likely situation is one in which a person has unintentionally been set up to make a mistake. Error likely situations can result from a variety of causes:

- Deficient procedures.
- Poor communication between workers.
- Inadequately trained workers.
- Conflicting interests of workers.
- Inadequately labeled equipment.
- Poorly designed equipment.

**FIGURE 4** Facilitative Stress



**TABLE 4** When To Use a Self-Checking Technique

1. Are you unsure about the intent of the steps or the task or performance standards?	6. Is this a routine or boring, but critical task?
2. Are you confused or do you sense something is not right?	7. Can you clearly see and identify the equipment you are working on?
3. Has the task been interrupted, causing you to begin the task again, or is it a departure from a well-established routine?	8. Do you have insufficient indication of system or component status?
4. Have you received verbal instructions on performing the task?	9. Have you had an unexpected encounter with a system, system interlock or system alarm?
5. Are you hurried or performing several tasks simultaneously?	10. Are you fatigued?

Here are two examples that can serve as a starting point in identifying error likely situations in your own healthcare facility:

1. A 6-year-old boy died after undergoing a magnetic resonance imaging (MRI) exam when the machine’s powerful magnetic field jerked a metal oxygen tank across the room and crushed the child’s head. The force of the device’s 10-ton magnet is about 30,000 times as powerful as the Earth’s magnetic field, and 200 times stronger than a common refrigerator magnet.
2. A bar coding system was implemented for the administration of medications. When the system was designed, the display units were intended to be used at the patient’s bedside. However, the batteries in the units run down so quickly the staff ends up leaving them plugged in in the hallway. Now the nurses cannot see or hear the terminal indications when they administer medications to patients.

By providing the resources necessary to identify and eliminate error likely situations, managers can improve the PSFs and dramatically reduce the frequency of human errors. This strategy is called the work situation approach and involves the five elements described below.

To maximize the benefits of such a strategy, managers should solicit healthcare workers’ input into this strategy at every opportunity. After all, the workers can best identify the factors that hinder their perfor-

mance and will likely support such a strategy if they are not penalized for telling the truth.

### **Element 1: Implement good human factors engineering**

Human factors engineering and ergonomics are concerned with ways to design jobs, machines, operations and work environments so they are compatible with human capacities and limitations. Many human errors in healthcare are caused by equipment and work environments that were not initially designed with an emphasis on maintainability and human factors engineering principles. Maintainability is the probability a piece of equipment will be restored to specified conditions within a given period after maintenance is performed in accordance with prescribed procedures and resources.

A new system design should account for all necessary maintenance behaviors through proper labeling; accessibility for repair, removal and replacement; proper inspection and testing; and availability of spare parts and tools. Some examples include knobs that can be grasped and turned with reasonable force, labels that can be read from a reasonable distance and critical or unique tools permanently located at the job site.

Identification and elimination of error likely situations early in the system design phase are obviously more desirable than the frustrating and costly task of retrofitting. Because most system designs are based on a similar system currently in service, it would be prudent to evaluate the existing system to help determine future requirements.

Reviewing old drawings, performing walk-throughs and interviewing physicians and nurses are worthwhile ways to evaluate an existing system. Including these personnel in design reviews or as permanent members of the design team are good ways to involve the users of the new process and draw on their knowledge and experience to help identify

## *Leapfrog Group Forms Coalition To Improve Patient Safety*

In response to a serious problem, the Leapfrog Group, a coalition of more than 100 public and private organizations that provide healthcare benefits, is taking action. The group was created to help save lives and reduce preventable medical mistakes. It mobilizes employer purchasing power to initiate breakthrough improvements in healthcare safety and gives consumers information to make more informed hospital choices.

This voluntary program is aimed at getting large purchasers to alert the healthcare industry that big leaps in patient safety and customer value will be recognized and rewarded with preferential use and other intensified market reinforcements. The Leapfrog Group was founded by the Business Roundtable, a national association of *Fortune* 500 CEOs.

Hospitals are already taking important steps to ensure patients' safety. Based on overwhelming scientific evidence, the Leapfrog Group decided to focus on three practices that have tremendous potential to save lives:

- Computerized physician order entry.
- Evidence based hospital referral.
- ICU physician staffing.

While these steps will not prevent all mistakes in hospitals, they are a vital first effort. For more information on the Leapfrog Group and these practices, visit [www.leapfroggroup.org](http://www.leapfroggroup.org).



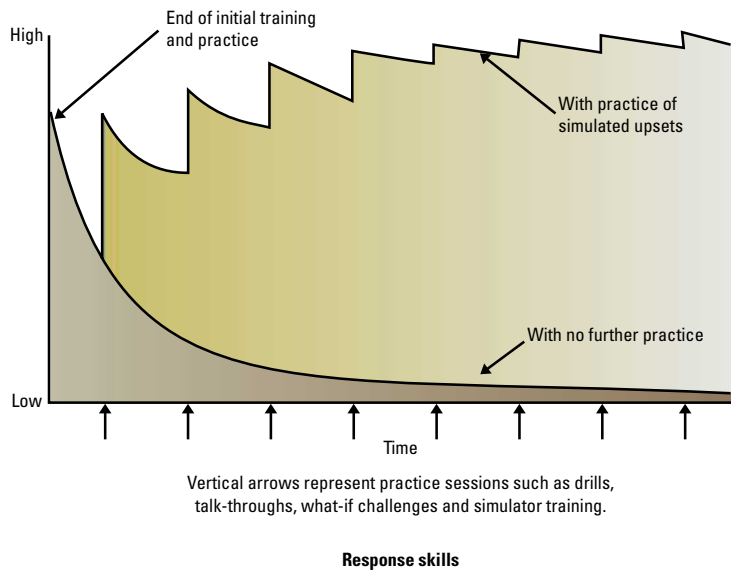
potential error likely situations. Having these resources available during design reviews has other advantages, too. It helps:

- Provide a cost effective and practical way to resolve the identified problem areas.
- Provide an excellent opportunity for training on the new process.
- Develop a sense of ownership of the new process among workers.

### **Element 2: Provide clear, accurate procedures and instructions**

Many human errors in healthcare can be prevented by ensuring clear, accurate procedures and job aids are available and used by all workers. This will help reduce workers' reliance on skill and memory to perform a task, assist workers in decision making and

**FIGURE 5** Conversion of Knowledge to Skill



help ensure a given task is performed consistently.

Written procedures provide step by step directions describing how and when to perform portions of the task. Job aids such as flowcharts, decision tables and checklists can be used to concisely organize information needed to perform problem diagnosis and aid workers who are performing tasks involving numerous steps.

You can increase a procedure or job aid’s effectiveness by incorporating these key principles:

- Select a procedure style or format that is usable, familiar and best communicates the information to the worker.
- Ensure the procedure is accurate and complete to maintain credibility and guarantee continued use. If procedures contradict the way tasks are performed in practice, workers will soon lose faith in the procedures and will not use them. Involving experienced workers in procedure development and establishing a proper frequency for updating procedures will help create and maintain accurate procedures. To further ensure procedures remain accurate, experienced workers should conduct a periodic review.
- Include the appropriate level of detail in each procedure. Too little detail will make the procedure unusable by the inexperienced worker, and too much detail may discourage the experienced worker from using it. The appropriate level of detail will be determined by the level of worker expertise and the

criticality of the task, but it is important to include warnings, cautions and other critical parameters for workers at all levels of expertise.

- Use language understandable to the worker to reduce the potential for errors, especially in stressful situations. Procedures can be made more understandable if you include only one action in each procedure step and use short but complete language, active voice, simple sentences and positive phrases.

Besides being well-written, procedures and job aids must be readily available to workers. Ideally, the procedures should be located where they will be used. For example, the directions on how to use an autoclave to clean surgical instruments should be located on the front of the machine. If that’s not possible, a single set of procedures should be kept in a centrally located place.

**Element 3: Provide job relevant training and practice**

Training ensures healthcare workers possess the basic skills necessary to effectively perform their functions. Several types of training have proven most effective in reducing human errors, including initial skill training, refresher training and management systems training.

Initial skill training is generally conducted in the classroom and supplemented with on-the-job experience. It prepares workers for experiences they will routinely encounter and those they will infrequently encounter. If training does not include the infrequent events or situations, the likelihood of successfully handling such situations will depend solely on the problem solving and decision making skills of the worker.

In addition to initial training, refresher training on nonroutine or modified tasks will minimize worker errors and reduce the potential for a worker’s skills to deteriorate. A refresher training program is needed to assist workers in developing and maintaining a high skill level. Such a program will address a worker’s loss of skills and enhance skills beyond the initial training level.

The sawtooth curve in Figure 5 presents the potential benefits of a refresher training program on worker responses vs. performing only initial training. The curve illustrates the conversion of knowledge to skill through repeated training and practice.

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To round out a healthcare training program, management system training is required on a regular basis to ensure healthcare workers can readily identify and follow relevant management systems. For example, on many safety critical systems, a management system exists to help prevent systematic human variability. To prevent a common cause human error, many hospitals have policies for redundant checking of medication and treatments. Many of these systems are in place to prevent human errors and should not be overlooked when developing a healthcare training program.

#### **Element 4: Provide ways to detect and correct human errors**

Many human errors in healthcare can be prevented by implementing certain administrative controls and systems. For instance, some companies have policies that require healthcare workers to work in pairs for certain activities. This buddy system can be effective in detecting a human error before an undesired consequence occurs.

For example, after an X-ray technician finishes work on a patient, the X-rays can be viewed to verify the work was satisfactory. Healthcare workers should identify opportunities to proof their work to detect mistakes before patients are returned to their rooms and the equipment is returned to service. Whenever possible, these proofs should be incorporated into written procedures to help guarantee they are performed and to provide training for new employees.

Another way healthcare workers can detect and correct human error is by using self-checking techniques. A self-checking technique is a practice in which a person consciously and deliberately reviews the intended action and expected response before performing a task. One technique is the five “rights” used to administer medications:

- Right patient.
- Right medication.
- Right dose.
- Right route.
- Right time.

#### **Element 5: Help workers achieve their social and psychological needs**

Worker motivation will likely be high if management applies accepted human factors principles to job tasks, training provides the necessary skills to handle all contingencies and workers are actively involved in their jobs through participation strategies. In addition, many first-line healthcare managers are given the opportunity to shape the work environment and moti-

vate workers to improve their levels of performance.

A motivated workforce with a positive attitude is less likely to commit errors; therefore, a healthcare team leader or supervisor should introduce various motivational factors into the work situation:

- **Recognize achievement.** Praise a technician in the presence of his peers.
- **Provide access to information.** Train a nurse’s aide to obtain information on a computer system normally used only by the nurses.
- **Allow use of one’s ability.** Allow a physician who is familiar with computers to provide input into the selection of the hardware and software for the new computerized healthcare management system.
- **Give challenging assignments.** Give the central stores staff the opportunity to help determine the optimum distribution of medical gas bottles to units in the hospital.
- **Assign extended responsibilities.** Allow a clerk who has shown both the interest and the ability to move into a healthcare position.
- **Provide the freedom to act.** Empower a technician to requisition a new testing instrument without prior approval from his or her immediate supervisor.
- **Seek involvement in planning, problem solving or goal setting.** Invite healthcare workers to participate in quality of care investigations, healthcare budget forecasting or goal setting.

#### **Improve overall system performance**

Many times, human errors are the result of error likely situations that come about due to the way the procedures are written, the training is conducted, or the systems are designed, operated or maintained. Today’s management is challenged by a paradigm shift from blaming mistakes on carelessness and incompetence to implementing methods to identify the root cause of why a person makes a mistake.

Allocating time and resources to understanding human factors, and identifying and eliminating error likely situations through methods such as the work situation approach, will significantly help improve overall system performance and process safety.

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