I Basic Principles: Error, Complexity, and Human Behavior

The first section of the book addresses the relevance of human error as a contributory factor to incidents and accidents in acute medical care. Basic principles of human error, complexity, and human action are outlined.

Chapter 1 focuses on "the human factors" which provide both, the potential to trigger critical situations as well as the skills to master them. An overview of published data on the incidence of human error and accidents in acute medical care underscores the fact that human behavior dominates the risk to modern socio-technical systems such as healthcare. Nevertheless, the human factors should never be equated with "risk factors," because they also include "nontechnical skills" which enable healthcare providers to cope with critical situations.

Healthcare in a high-stakes environment has a number of properties that make it considerably more challenging than decision-making in an every day context. Chapter 2 describes these characteristics which psychologists call the "complexity of a working environment." The response of healthcare professionals corresponds with the levels of familiarity with a task or an environment. These varying levels at which behavior is controlled are described.

Chapter 3 provides workable definitions on error and contrasts two current perspectives (consequential and causal classification) which give rise to two different approaches to deal with human fallibility (person-based and system-based approach). Emphasis is placed on the fact that accidents occur as a result of latent conditions which combine with other factors and local triggering events to breach the defensive barriers of the system.

Chapter 4 attempts to provide understanding about how humans arrive at decisions. The "psycho-logic" of human action regulation is presented which conceptualizes that human behavior does not strictly follow the consistency of logical arguments but instead is always influenced by motivation and emotions. The combination of all three factors gives rise to decisions and, hence, action.

1 The Human Factors: Errors and Skills

1.1 Case Study

During an afternoon shift two hemodynamically unstable patients were admitted to the cardiac ICU (CCU), one immediately after the other. The physician's attempt to stabilize both patients at the same time completely overwhelmed him. Because of this, he was unable to give adequate attention to a patient being anticoagulated with warfarin who had several episodes of coffee-ground emesis during the previous 2 h. After finally stabilizing the two new admissions, the resident prepared for an upper endoscopy, but the patient suddenly became hemodynamically unstable. The patient had a recent hemoglobin value of 6.9 g/dl. With the working diagnosis of acute upper gastrointestinal (GI) bleeding, the patient received several peripheral IV lines. Crystalloid infusions were started. Six units of cross-matched packed red blood cells (PRBCs) were ordered from the blood bank, which was short of personnel and unusually burdened by many orders for blood products. The 6 units of PRBCs were sent together with 2 units of PRBCs for another patient in the CCU. The blood products arrived in the CCU while one of the recently admitted patients was being stabilized. After a quick glance at the bag containing the PRBCs, the resident asked the nurse to start the blood transfusion. Within minutes of starting the first infusion of blood, the patient complained of dizziness and shortness of breath and began to deteriorate rapidly. The resident then focused his complete attention on the treatment of this patient. Severe and generalized erythema and edema, together with hemodynamic instability and respiratory distress, indicated a severe anaphylactic reaction. Following a comment by the nurse concerning the transfusion, the physician suspected a transfusion error and stopped the infusion immediately. The patient was then anesthetized and intubated. Controlled ventilation was difficult due to severe bronchospasm. Under high-dose continuous infusion of catecholamines, aggressive volume resuscitation, and administration of corticosteroids and histamine receptor antagonists, the resident managed to stabilize the hemodynamic situation and improve the bronchospasm. In the course of the following hours the patient developed severe disseminated intravascular coagulation (DIC) which led to uncontrollable upper GI bleeding. Despite massive transfusion with coagulation factors and blood products, the patient died several hours later as a result of his uncontrolled bleeding.

An intensive care patient suffers harm from a medical error. Despite maximum therapeutic efforts, the patient died several hours later as a consequence of a massive transfusion reaction. At first sight, the cardiology resident could be readily identified as the responsible agent. He was the person in direct contact with the patient, he gave orders for the transfusion, and he did not adhere to standard treatment protocols, thus displaying negligence in the transfusion process. A closer look, however, reveales additional factors which contributed to the adverse event: a share of workload which overwhelmed the resident; staff shortage in the blood bank; the simultaneous arrival of PRBCs for two different patients; and the acceptance of final responsibility for the transfusion on behalf of the nurse. None of these factors alone would have been able to compromise patient safety. Taken together, however, all these factors combined and managed to breach the defensive barriers of the system. The unlikely combination of several contributing factors on different levels within an organization created a condition where a single moment of inattention on behalf of the resident sufficed to trigger a deadly outcome. "Human error" was one link only in a longer chain of human factors.

Faulty actions, however, represent only one aspect of human factors in a medical high-stakes environment. It is often overlooked that the ability to rapidly detect, diagnose, and treat a medical emergency is rooted in human factors as well. Healthcare providers can only perform successfully in critical situations because the "human factors" enable them to do so. More often than not, healthcare professionals can provide safe and efficient patient care even under the most unfortunate circumstances.

1.2 Human Factors in Healthcare: the Problem

Almost a decade ago the Quality of Healthcare in America Committee of the Institute of Medicine (IOM) issued their report "To Err Is Human: Building a Safer Healthcare System" (Kohn et al. 1999), which examined the quality of the U.S. healthcare delivery system. The numbers presented were alarming and stirred up healthcare systems all around the globe: Year for year a staggering figure of 44,000 people, and perhaps as many as 98,000 people, died in U.S. hospitals as a result of preventable medical error. Even when using the lower estimate, the number of deaths attributable to preventable medical errors exceeded the mortality rate of severe trauma, breast cancer, and HIV.

The IOM report spurred patient safety initiatives all around the globe and triggered an unparalleled endeavor within the healthcare community to identify medical errors and to design interventions to prevent and mitigate their effect. One of the report's main conclusions was in diametrical opposition to hitherto existing assumptions within the healthcare community: that the majority of medical errors did not result from individual recklessness, but instead were caused by faulty systems, processes, and conditions that led people to make mistakes or failed to prevent them. Although new to many within healthcare, the idea of a "systemic approach" to safety was no novelty: A sizable body of knowledge and successful experiences from other high-risk industries had proven all along that mistakes can best be prevented by systematically designing safety into processes thereby breaking down a culture of blame. Healthcare, despite the considerable efforts within the past years, is still in its infancy when compared with efforts of other high-risk industries to ensure basic safety.

For over three decades interdisciplinary research groups from the field of cognitive and social psychology, anthropology, sociology, and reliability engineering have been investigating human and organizational factors that shape the behavior of human beings in high-risk socio-technical systems. The analysis of catastrophic breakdowns of high-hazard enterprises (e.g., Three Mile Island, Bhopal, Cernobyl, Challenger) betrayed a recurrent pattern: Independently from the task environment 70–80% of the accidents were not caused by technological problems but by inadequacies in problem-solving, faulty decision-making, and substandard or non-existent team work: The so-called human error. Despite the results from industrial accident investigations, the medical community was reluctant for a long time to participate in discussions of human error. For the obvious reason of exposure to litigation, the medical community avoided public scrutiny of medical errors. Only in the past two decades has the medical community become open to taking a close look at medical error. As a result of the increasing openness, the 70–80% contribution of human error as trigger for incidents and accidents has been confirmed for the medical high-stakes environment (e.g., Cooper et al. 1978; Hollnagel 1993; Reason 1997; Williamson et al. 1993; Wright et al. 1991).

1.3 Levels of Human Factors

Human behavior clearly dominates the risk to modern socio-technical systems. Figures around 80–90% are not surprising considering that people design, build, operate, maintain, organize, and manage these systems. Human error, however, in contrast to prevailing assumptions, cannot be equated with negligence, sloppiness, incompetence, or lack of motivation on the part of the healthcare provider. On the contrary, serious errors are often committed by highly motivated and experienced people (Amalberti and Mosneron-Dupin 1997). Most of the time human error is the result of an unlikely confluence and interaction of several causal streams originating not in the corruption of human nature but rather in the interaction with normal cognitive processes and "upstream" systemic factors. This assessment is also true for the dynamics of accident causation in the presented case study: A multitude of organizational factors (e.g., human resource allocation, lack of supervision, staff qualification; ► Chaps. 14, 15) were hidden as latent failures within the system for considerable time until they combined with other factors and local triggering events (► Chap. 3). The unforeseen combination of factors opened a limited window of accident opportunity. All it needed to trigger the accident was a moment of inattention by a healthcare professional.

In order to fully understand human error with all its implications, an understanding of the basic principles of human cognition and action regulation of both, the individual and the team, is indispensable. The same principles apply to management and organizational levels, and on an even larger scale, to the political and legal framework of the healthcare system (◘ Fig. 1.1).

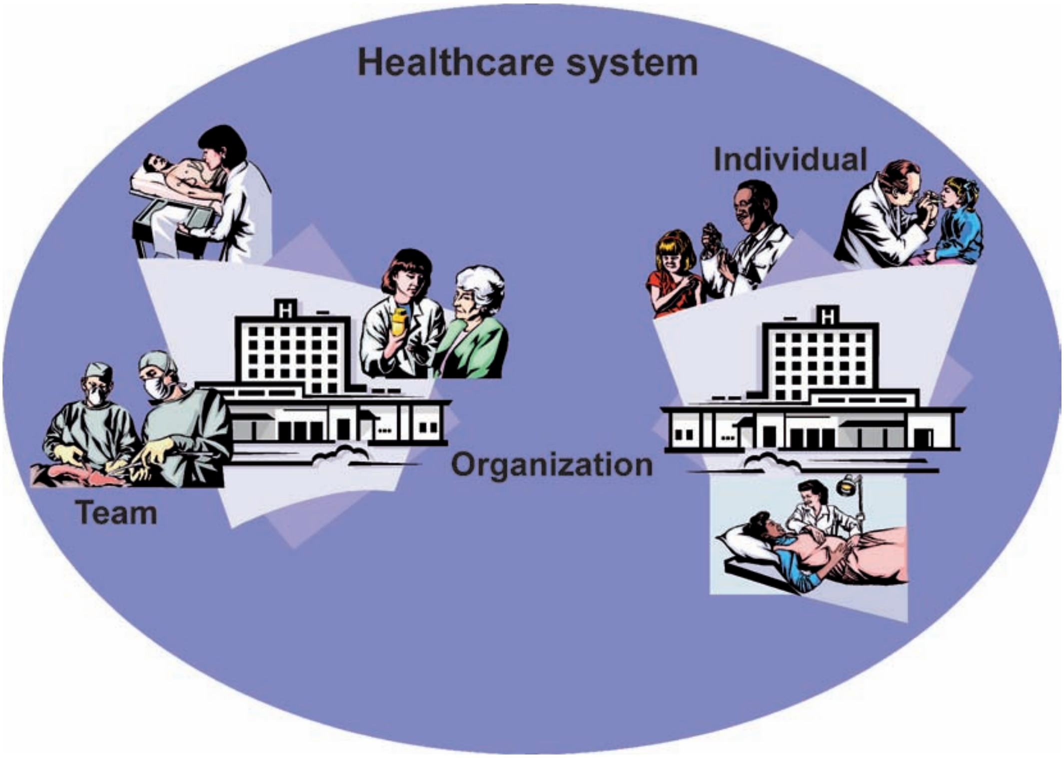


Fig. 1.1 The different levels of patient care which human-factors research addresses

1.3.1 The Individual

Although human error can manifest in various ways, there are nevertheless only a few cognitive principles which contribute to these failures. These principles can be identified on the level of perception, information management, and decision-making. Some examples that are explained in Chaps. 4–10 are as follows:

- Behavior always follows the "psycho-logic" of action regulation (▶ Chap. 4). There is no such thing as a "purely rational" action.
- Humans do not perceive reality but rather "construct" their worldview on a level as early as visual perception.
- Humans tend to "adjust" information to their preferred mental model instead of challenging their current point of view. Data is selected and distorted to fit present assumptions.
- Humans try to defend the feeling of competence at any cost. More important than the solution of a problem, as vital as it may be, will be the necessity of the feeling that the situation, or at least some relevant aspect of it, is under control.
- Problem-solving and decision-making are impaired by many factors.

In the case study, the physician's perceptual error – he did not notice the wrong name on the blood packs – is obvious. Errors in information processing are not as easily observable; here we rely on theories from cognitive psychology (▶ Chap. 4).

1.3.2 The Team

Compared with an individual, teams represent increased cognitive resources which can contribute a substantial amount of information, situational models, and proposed courses of action. In addition, workload can be shouldered by all team members. The physician in the case study lacked this kind of support. The presence of others, however, can degrade the performance of an individual team member. If basic principles of a successful team process are neglected, or if teams get under stress, internal team dynamics may develop which will lead to a lower performance (▶ Chaps. 11–13). In such a case the following occurs:

- Team members tend to conform their opinion to the majority in the team. Legitimate concerns are not articulated, and criticism is withheld.
- Misunderstanding may result from the use of ambiguous and nontechnical terminology as well as from relational problems.
- Groups tend to centralize information flow and decision-making when external pressure arises.

1.3.3 The Organization

Healthcare delivery has become one of the largest and most complex systems in western culture. This system is composed of many organizations as subsystems (e.g., prehospital emergency medical service, hospitals, outpatient clinics, manufacturers) with each having a distinct culture and differing financial, technical, and personal resources. Healthcare organizations try to achieve explicit goals which often are mutually exclusive: The delivery of safe patient care and medical excellence vs economy and cost reduction.

In the case study, examples for organizational factors influencing the transfusion error would be the staffing of ICU and blood bank as well as the hierarchical culture that prevented the nurse from challenging unsafe decisions.

Organizations can influence the quantity and quality of healthcare by influencing the following variables (▶ Chaps. 14–15):

- Structure and processes
- Equipment and technologies
- Human resource management
- Teamwork and leadership
- Communication
- Organizational culture

1.3.4 The Health Care System

Healthcare organizations have to operate within a political and legal framework that limits the scope for organizing patient care. The influence of these factors is more difficult to trace in concrete cases than individual or organizational factors, but the data presented in the following section shows their importance on a larger scale. Some of the factors beyond influence of individual healthcare organizations are as follows:

- The increasing economic pressure on cost explosion within healthcare
- The funding of healthcare systems (e.g., general taxation, social health insurance, voluntary or private health insurance)
- Working time directives
- Regulations enacted by federal governments
- Professional development

1.3.5 Errors in Acute Patient Care

In the mid-1980s several interdisciplinary research groups started to investigate the issue of human error in medical high-stakes environments. Because anesthetists understood that their task characteristics have much in common with those of more widely studied groups in industrial high-risk settings (e.g., pilots, process control), they were the first to initiate collaborations with human factors specialists (e.g., Cooper et al. 1978; Currie 1989). Because the characteristics of the high-stakes medical work environment can challenge human problem-solving, decision-making, and teamwork considerably (▶ Chap. 2), it would be quite natural to expect that the likelihood for active failures in acute patient care is higher than the error rate in routine task environments (e.g., on ward).

The past decade has witnessed an increased awareness of the contribution of human error to suboptimal patient care and adverse events. Despite a large body of scientific work, the attempt to present an overview on errors in acute patient care is highly problematic. On one hand, too many issues surrounding the identification of errors and adverse events in a medical high-stakes environment are still unresolved: Which form of data collection is the most appropriate? Retrospective chart reviews, mandatory reportings, solicited voluntary reportings, surveillance systems, or a direct observation approach (Handler et al. 2000)? On the other hand, the data available provides a very heterogeneous picture, as study design, local structure of the respective hospital, and the healthcare systems studied vary greatly. Given the differing methodological approaches, it is almost impossible to draw sound conclusions about the "real" magnitude of the problem. It is only with these limitations that we present the following data; neither do they claim completeness nor do they provide an adequate picture of the problem. All they can do is to give the reader an idea of the nature and scale of errors in acute care medicine.

1.3.5.1 Errors in the Prehospital Emergency Medical Service

Reports on errors in the Emergency Medical Service (EMS) focus on two aspects of emergency medical care: the *appropriateness of on-scene performance* and the *reliability of the primary diagnosis* as compared with the discharge diagnosis. Incorrect therapeutic measures included drug-related errors (e.g., unfamiliarity with drugs due to infrequent use of the medication, dosage calculation errors, incorrect dosage given), nonadherence to guidelines or standardized treatment protocols, and choice of an unsuitable means of transportation (Arntz et al. 1996; Rittenberger et al. 2005).

Severe errors of assessment included unrecognized life-threatening conditions, underestimation of the severity of injury, and an on-site diagnosis different to the discharge diagnosis. The majority of data seem to confirm the reliability of prehospital diagnoses for adult patients independently of national prehospital medical care strategies (e.g., physician based: Arntz et al. 1996; EMS/paramedic system: Buduhan and McRitchie 2000; Enderson et al. 1990; Esposito et al. 1999). For the treatment of the pediatric population, however, there seems to be still some need for further improvement and training of healthcare providers (e.g., Esposito et al. 1999; Peery et al. 1999).

Despite a growing body of scientific knowledge about clinical errors in healthcare, there is still scarce information concerning the performance and error rate of healthcare professionals in the prehospital emergency care setting. The question of whether or not emergency medical care on-site (characterized by constantly changing environments, uncertainty and time pressure, performance as ad-hoc teams) carries an inherently higher risk for committing an error as compared with the provision of patient care in familiar working situations

Table 1.1 Incidence of diagnostic and therapeutic errors in prehospital emergency care

Incidence of error	References
8–24% of all injuries in adult trauma patients are missed	Buduhan and McRitchie (2000) Linn et al. (1997)
Severe errors of assessment by the emergency physician in 3% of cases	Arntz et al. (1996)
9% preventable trauma deaths and 16% inappropriate care for pediatric trauma patients	Esposito et al. (1999)
EMS on-scene evaluation misdiagnosed 28% of stroke/TIA patients	Kothari et al. (1995)
Self-reported incidence of medication administration errors in 9.1%	Vilke et al. (2007)
Medical team's scene diagnostic accuracy of spinal injury was 31%	Flabouris (2001)
The incidence of missed injuries in pediatric trauma to be 20%	Peery et al. (1999)

(i.e., in-hospital) has still to be answered. An overview of errors in the EMS is given in ◘ Table 1.1.

1.3.5.2 Errors in the Emergency Department

Many of the sickest patients enter the Emergency Department (ED) and are at increased risk of adverse events because of the serious nature of their presentation and time constraint on diagnosis. Adverse events involving emergency medicine providers are attributed to task complexity (▶ Chap. 2) and time constraints: Errors in care delivery are facilitated by the necessity of multitasking, constant interruptions (Chisholm et al. 2000), a quick turnaround of patients with insufficient time to be thorough, and inadequate supervision (Hendrie et al. 2007). In addition, the large number of differential diagnoses contributes to the element of diagnostic uncertainty and may be responsible for the high rate of negligence attributed to diagnostic errors (Thomas et al. 2000). Because many EDs around the world are not subspecialized, emergency healthcare providers are confronted with nearly any type of injury or disease. This puts especially the pediatric population at risk: Staff without specialized pediatric training and with little experience is expected to provide adequate patient care in infants and children, often without the supplies necessary for handling pediatric emergencies (IOM 2006). As EDs in many large cities are overcrowded and operate at or near full capacity, even a multiple-car highway crash can create havoc in an ED. A major disaster with many casualties would be something that many hospitals have no adequate capacity to handle.

Because of the nature of task performance and the many obstacles, teamwork plays an important role in detecting and preventing adverse events. Active failures in trauma patient care include problems arising from the interaction of the trauma team with the patient or other team members (Schaefer et al. 1994). ◘ Table 1.2 shows some of the typical teamwork-associated problems and errors frequently encountered in the ED. As with prehospital patient care, the question of whether or not acute patient care in an emergency is more error-prone than routine patient care remains unanswered.

◘ **Table 1.2** Incidence of diagnostic and therapeutic errors in the Emergency Department (ED)

Incidence of errors	References
27% of patients with acute myocardial infarction were missed in the ED due to absence of chest pain or lack of ST elevation in the ECG	Chan et al. (1998)
3% of all adverse events occur in the ED; a high rate is associated with negligence in diagnostics	Kohn et al. (1999)
5.9% of all trauma patient deaths were considered preventable. The most common single error was failure to appropriately evaluate the abdomen	Davis et al. (1992)
In 9% of patients injuries are missed during the initial work-up	Enderson et al. (1990)
3.5 errors per patients with spinal/cerebral injury are committed; errors contribute to neurological disability	McDermott et al. (2004)
2–3% of patients with acute myocardial infarction or unstable angina are not hospitalized after presenting at the ED	Pope et al. (2000) McCarthy et al. (1993)
23% of all airway management cases show performance deficiencies	Mackenzie et al. (1996)
Per case an average of 8.8 teamwork failures occur	Risser et al. (1999)

1.3.5.3 Errors in the Intensive Care Unit

Critically ill patients require high-intensity care and may be at especially high risk of iatrogenic injury because of their underlying severe illness. Many reports confirm the notion that adverse events and serious errors involving critically ill patients are common and often potentially life-threatening (e.g., Rothschild et al. 2005). Root causes for errors in the ICU are found in the serious nature of the underlying disease as well as in structural, technical, and organizational deficiencies. Many studies ascribe adverse events to the chaotic arrangement of tubes and lines, the limited access to the patient, lighting, ambient noise, frequent interruptions, insufficiently labeled drugs, and to problems with medical devices (e.g., Donchin and Seagull 2002; Sanghera et al. 2007). In addition, poor communication between physicians and nurses has been made responsible for a multitude of adverse drug events and treatment errors: The case report is only one of countless examples that confirm this fundamental flaw of intensive patient care. Recently a review of critical incident studies in the ICU was able to identify a series of contributory factors that were associated with the lack of specific nontechnical skills (Reader et al. 2006). At present, the available data do not allow for any conclusion as to whether

Table 1.3 Incidence of diagnostic and therapeutic errors in the intensive care unit

Incidence of errors	References
31% of all ICU patients suffer iatrogenic complications during their stay in the ICU	Donchin et al. (1995)
Medication errors and adverse drug events occur in 3.6.%; 81% are clinically important	Buckley et al. (2007)
One error for every five doses of medication administered (20%)	Kopp et al. (2006)
20.2% of critically ill patients suffer from adverse events	Rothschild et al. (2005)
15% of patients suffer consequences from an error; 92% are judged as avoidable	Graf et al. (2005)
63–83% of all critical incidents can be attributed to human error	Wright et al. (1991); Giraud et al. (1993); Beckmann et al. (1996); Buckley et al. (1997)
13–51% of all critical incidents pose a major threat for patient safety	Donchin et al. (1995); Beckmann et al. (2003)
One of 10 new patients in ICU is transferred to ICU because of a previous treatment error	Darchy et al. (1999)
For the ICU as a whole about 1.7 errors per patient per day occur. Twice a day a severe or potentially detrimental error is committed	Donchin et al. (1995)
Adverse event rates on neonatal ICUs are high: 0.75 adverse events occur per infant; 56% would have been preventable	Sharek et al. (2006)
The majority of adverse events were errors in medication (15–60%)	Giraud et al. (1993); Donchin et al. (1995)
The rate of preventable adverse drug events in ICUs is nearly twice that rate of non-ICUs	Cullen et al. (1997)
One of three errors in ICU is caused by communication problems	Giraud et al. (1993)

the frequency of errors increases when healthcare providers have to manage critical situation as compared with routine procedures. Table 1.3 illustrates the magnitude of the problem of treatment errors in the ICU.

1.3.5.4 Errors in Anesthesia and Postoperative Patient Care

The induction and maintenance of anesthesia has always been a potentially harmful undertaking without having any therapeutic benefit in itself. The use of highly potent drugs with the associated loss of consciousness and vital functions bears the risk that patients may be harmed by adverse events. As early as in the mid-1950s of the past century anesthetists were the first group of healthcare providers who systematically addressed the issue of incidence and nature of peri-operative adverse events (Beecher and Todd 1954). The increased insight into the contribution of anesthesia to peri-operative morbidity and mortality has led to a considerable improvement in the safety and quality of anesthetic patient care. As a consequence of its leading role in the prevention and detection of medial error and in pioneering a patient safety movement, the IOM report referred to anesthesiology as the model for addressing patient safety (Kohn et al. 1999). Adverse drug events, circulatory events, problems with airway management, and pulmonary complications are among the most frequent critical situations. As a result of major improvements in technology, equipment failure has become a rare event. Patients in the postanesthesia care unit (PACU) can experience an adverse event from a residual sedative or anesthetic effect, persistent muscle-relaxant effect, inappropriate fluid management, allergic reaction, and upper airway obstruction. Human error plays a significant role in the development of these critical situations and accidents (Table 1.4). Human error in anesthesia occurs on the individual level (e.g., judgment) as well as on the interpersonal level (e.g., communi-

Table 1.4 Incidence of diagnostic and therapeutic errors in anesthesia and postoperative patient care

Incidence of errors	References
31–82% of all incidents are caused by human error, 9–21% by technical failure	Cooper et al. (1978); Kumar et al. (1988); Currie (1989); Chopra et al. (1992); Webb et al. (1993); Buckley et al. (1997); Arbous et al. (2001); Bracco et al. (2001)
Critical incidents occur in 2.5 % of all pediatric anesthesia cases	Marcus (2006)
0.2% of all patients in the PACU need emergency reintubation; 70% are directly related to anesthesia management	Mathew et al. (1990)
A drug administration error occurs at a rate of 1 in 133 anesthetics. Incorrect doses (20%) and substitutions (20%) with i.v. boluses of other drugs are the most common errors	Webster et al. (2001)
4% of all incidents are caused by the patient's unpredictable reactions; 69–82% of all critical incidents could have been avoided	Arbous et al. (2001)
The most common presenting problems are related to respiratory/airway issues (43%), cardiovascular problems (24%), and drug errors (11%). Contributing factors included error of judgment (18%), communication failure (14%), and inadequate preoperative preparation (7%)	Kluger and Bullock (2002)
29% of all critical incidents lead to a major physiological disturbance and require management in intensive care unit	Kluger and Bullock (2002)

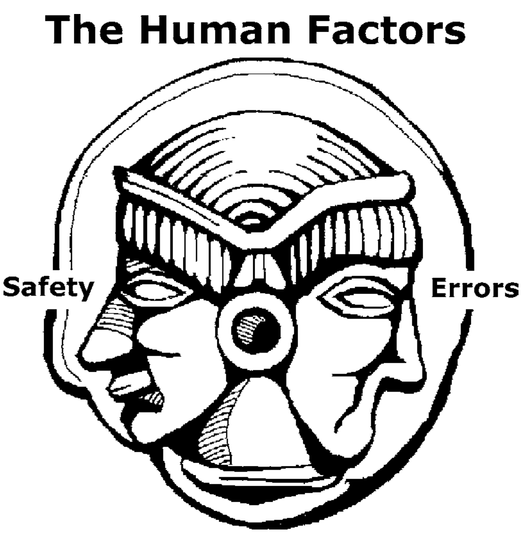
cation failure) and the organizational level (e.g., standards for preoperative management).

1.3.6 The Human Factors: Nontechnical Skills for Acute Patient Care

Poor outcomes do occur, but what is perhaps surprising given the complex circumstances of critical situations is that good outcomes happen as often as they do. Despite the manifold ways in which human factors contribute to faulty systems, processes, and conditions as well as to active failures of healthcare providers, it should not be overlooked that human factors, the way people think and feel, and interact with each other and with their environment, are the essential resource for safe patient care: Like Janus, the two-faced god of Roman mythology looking in opposite directions, human factors, too, provide both the potential to trigger as well as the skills to master a critical situation (◘ Fig. 1.2). As a result, human factors should never be equated with "risk factors." Each time mindful healthcare professionals detect, diagnose, and correct a critical situation or an error before it has an opportunity to unfold, the human factors prevent patient harm (◘ Fig. 1.3). Correct performance and systemic errors are two sides of the same coin, or, perhaps more aptly, they are two sides of the same cognitive balance sheet (Reason 1990).

The past years have witnessed a growing interest in these skills, which are crucial for delivering safe and high-quality medical care but which are not directly related to technical expertise: the "nontechnical skills." Nontechnical skills include *interpersonal skills*, such as communication, teamwork, and leadership, and *cognitive skills*, such as situation awareness, planning, decision-making, and task management. The aviation industry was among the first to recognize that technical proficiency in pilots was not enough to guarantee safe flight operations and to identify the most relevant nontechnical skills (Wiener et al. 1993). Training programs were introduced which taught and reinforced nontechnical skills as a set of countermeasures against error. Because the workload profile of anesthetists shows similarities with pilots (i.e., high intensity at task initiation and completion, monitoring, and rapid response to critical events), these nontechnical skills were adopted for medical care in a high-stakes environment (e.g., Gaba et al. 1994). Because there is increasing evidence that these skills may not extrapolate directly from aviation to the medical high-stakes environment, several research groups have begun to identify and validate the specific nontechnical skills important for safety in different high-stakes medical domains (Aggarwal et al. 2004; Flin and Maran 2004; Fletcher et al. 2003; Reader et al. 2006; Yule et al. 2006).

The resident from the case report, too, experienced both sides of the human factors: After hav-



◘ **Fig. 1.2** The human factors and the two faces of Janus. Similar to the god of Roman mythology, the human factors have two opposite aspects: they combine to trigger critical situations and at the same time provide the skills to master them

◘ **Fig. 1.3** Human factors prevent adverse events. Because healthcare professionals detect critical situations and errors before these can cause accidents, the human factors provide a vital resource for patient safety ing triggered the transfusion reaction, the management of the critical situation was up to him as well. As the critical situation unfolded he had to manage the emergency under utilization of all resources and team members available. He suddenly needed a broad variety of these "nontechnical" skills. He had to do the following:

- Rapidly detect and diagnose the nature of the emergency situation
- Resist the emotional strain caused by the awareness that he himself had triggered the adverse event
- Call for help
- Make good decisions under time pressure
- Know his environment and resources available
- Set priorities
- Lead a team
- Reassess the situation and make changes in his plan

The case study teaches another important lesson as well: despite maximum effort, the patient suffered irretrievable harm from the adverse event. Nontechnical skills are no magic bullet, nor are new technologies or drugs. Healthcare professionals can provide the best emergency care possible and still fail to save the patient's life.

One way to understand the relationship between technical and nontechnical skill is that of a conversation: Technical skills provide the context-specific vocabulary; nontechnical skills are the grammar which enables a meaningful interaction. The following chapters should be regarded as a kind of "grammar" which helps healthcare providers of every profession and specialty to engage in a constructive conversation with each other and with the critical situation. The most frequent "grammar errors" will demonstrate possible pitfalls of this conversation and will hopefully sharpen the providers' focus. The conversation, however, is made difficult by certain characteristics that distinguish emergency situations from any other situation in healthcare. We explore these characteristics in this book.

1.4 "The Human Factors": in a Nutshell

- The mortality rate of preventable medical error exceeds the number of deaths attributable to severe trauma, breast cancer, and HIV.
- Human behavior dominates the risk to modern socio-technical systems: 80–90% of all errors are due to "human factors."
- Available data on error in acute care medicine provides a heterogeneous picture: study design, local structure of the healthcare organization, and healthcare systems vary greatly.
- The human factors should never be equated with "risk factor." Human factors provide both, the potential to trigger for critical situations as well as the skills to master them.
- The skills necessary to manage critical situations are called "nontechnical skills." This term includes interpersonal skills (e.g., communication, teamwork, leadership) and cognitive skills (e.g., situation awareness, planning, decision-making, task management).

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