

CHAPTER 1

Errors: Terminology and Background

In effect, all animals are under stringent selection pressure to be as stupid as they can get away with.

P.J. Richardson and R. Boyd in Not by genes alone: How culture transformed human evolution. University of Chicago Press, 2005.

The rule that human beings seem to follow is to engage the brain only when all else fails—and usually not even then.

D.L. Hull in Science and selection: Essays on biological evolution and the philosophy of science. Cambridge University Press, 2001.

Error: terminology

Why read about taxonomy and terminology? They seem so boring and too “ivory tower.” When starting to write this section, I (J.W.L.) recalled a warm September afternoon many years ago when I was a first-year veterinary student at Washington State University. It was in the anatomy lab that my lab partner and I were reading *Miller’s Guide to the Dissection of the Dog* and thinking how we would rather be outside enjoying the lovely fall weather. At one point, my lab partner, now Dr Ron Wohrle, looked up and said, “I think I’m a fairly intelligent person, but I’ve just read this one sentence and I only understand three words: ‘and,’ ‘the,’ and ‘of.’” Learning anatomy was not only about the anatomy of the dog, cat, cow, and horse, it was also about learning the language of veterinary medicine.

Each profession or specialty has its own language—terminology—and the study of errors is no exception. Indeed, words and terms convey important concepts that, when organized into an agreed taxonomy, make it possible for those involved in all aspects of patient safety to communicate effectively across the broad spectrum of medicine. However, despite publication of the Institute of Medicine’s report “To Err is Human” (Kohn *et al.* 2000) in 2000 and the subsequent publication of many articles and books concerning errors and patient safety, a single agreed taxonomy with its attendant terminology does not currently exist. This is understandable for there are many different ways to look at the origins of errors because there are many different settings within which

they occur, and different error classifications serve different needs (Reason 2005). But this shortcoming has made it difficult to standardize terminology and foster communication among patient safety advocates (Chang *et al.* 2005; Runciman *et al.* 2009). For example, the terms “near miss,” “close call,” and “preventable adverse event” have been used to describe the same concept or type of error (Runciman *et al.* 2009). Runciman reported that 17 definitions were found for “error” and 14 for “adverse event” while another review found 24 definitions for “error” and a range of opinions as to what constitutes an error (Runciman *et al.* 2009).

Throughout this book we use terms that have been broadly accepted in human medicine and made known globally through the World Health Organization (WHO 2009) and many publications, a few of which are cited here (Runciman *et al.* 2009; Sherman *et al.* 2009; Thomson *et al.* 2009). However, we have modified the terms used in physician-based medicine for use in veterinary medicine and have endeavored to reduce redundancy and confusion concerning the meaning and use of selected terms. For example, “adverse incident,” “harmful incident,” “harmful hit,” and “accident” are terms that have been used to describe the same basic concept: a situation where patient harm has occurred as a result of some action or event; throughout this book we use a single term—“harmful incident”—to capture this specific concept. Box 1.1 contains selected terms used frequently throughout this text, but we strongly encourage the reader to review the list of terms and their definitions in Appendix B.

Box 1.1 Selected terms and definitions used frequently in this book.

Adverse incident An event that caused harm to a patient.

Adverse reaction Unexpected harm resulting from an appropriate action in which the correct process was followed within the context in which the incident occurred.

Error Failure to carry out a planned action as intended (error of execution), or use of an incorrect or inappropriate plan (error of planning).

Error of omission An error that occurs as a result of an action not taken. Errors of omission may or may not lead to adverse outcomes.

Harmful incident An incident that reached a patient and caused harm (harmful hit) such that there was a need for more or different medication, a longer stay in hospital, more tests or procedures, disability, or death.

Harmless incident An incident that reached a patient, but did not result in discernible harm (harmless hit).

Latent conditions Unintended conditions existing within a system or organization as a result of design, organizational attributes, training, or maintenance, and that lead to errors. These conditions often lie dormant in a system for lengthy periods of time before an incident occurs.

Mistake Occurs when a plan is inadequate to achieve its desired goal even though the actions may be appropriate and run according to plan; a mistake can occur at the planning stage of both rule-based and knowledge-based levels of performance.

Near miss An incident that for whatever reason, including by chance or timely intervention, did not reach the patient.

Negligence Failure to use such care as a reasonably prudent and careful person would use under similar circumstances.

Patient safety incident A healthcare-related incident or circumstance (situation or factor) that could have resulted, or did result, in unnecessary harm to a patient even if there is no permanent effect on the patient.

Risk The probability that an incident will occur.

Root cause analysis A systematic iterative process whereby the factors that contribute to an incident are identified by reconstructing the sequence of events and repeatedly asking "why?" until the underlying root causes have been elucidated.

System failure A fault, breakdown, or dysfunction within an organization or its practices, operational methods, processes, or infrastructure.

Veterinary healthcare-associated harm Impairment of structure or function of the body due to plans or actions taken during the provision of healthcare, rather than as a result of an underlying disease or injury; includes disease, injury, suffering, disability, and death.

Terminology in and of itself, however, does not explain how errors occur. For that we need to look at models and concepts that explain the generation of errors in anesthesia.

Error: background

The model often used to describe the performance of an anesthetist is that of an airplane pilot; both are highly trained and skilled individuals who work in complex environments (Allnutt 1987). This model has both advocates (Allnutt 1987; Gaba *et al.* 2003; Helmreich 2000; Howard *et al.* 1992) and detractors (Auerbach *et al.* 2001; Klemola 2000; Norros & Klemola 1999). At issue is the environment of the operating room, which by virtue of the patient, is more complex than an airplane's cockpit (Helmreich 2000). Furthermore, in the aviation model, pilot checklists are used to control all flight and control systems, and are viewed as a

fundamental underpinning of aircraft safety. In contrast, anesthesia safety checklists, although very important, are incomplete as they are primarily oriented toward the anesthesia machine and ventilator, but not cardiovascular monitors, airway equipment, catheters and intravenous lines, infusion pumps, medications, or warming devices (Auerbach *et al.* 2001). Another factor limiting the applicability of the aviation model to anesthesia is that as a general rule, teaching does not occur in the cockpit whereas teaching is prevalent in the operating room (Thomas *et al.* 2004). Regardless of the pros and cons of the aviation model, the important concepts are that the operating room is a complex work environment, made more so by the presence of the patient. Thus, by definition, a veterinary practice, be it small or large, is a complex system. But what other features are the hallmark of complex systems and how do errors occur in them?

In general terms, complex, dynamic environments or systems have the following characteristics (Gaba *et al.* 1994; Woods 1988):

- Incidents unfold in time and are driven by events that occur at indeterminate times. Practically speaking this means that when an incident occurs an individual's ability to problem solve faces a number of challenges, such as pressures of time, overlapping of tasks, requirement for a sustained performance, the changing nature of the problem, and the fact that monitoring can be continuous or semi-continuous, and can change over time.
- Complex systems are made up of highly interconnected parts, and the failure of a single part can have multiple consequences. If we consider the operating room, the loss of electricity would affect a multitude of individuals (surgeon, anesthetist, technicians) and devices (monitoring equipment, cautery, surgical lighting). Our patients are complexity personified. For example, a hypotensive crisis places a patient's heart, kidneys, and brain at risk of failure, which can lead to failure of other organ systems; couple hypotension with hypoxia and the complexity with which we deal during anesthesia becomes quickly apparent.
- When there is high uncertainty in such systems, available data can be ambiguous, incomplete, erroneous, have low signal to noise ratio, or be imprecise with respect to the situation. For example, monitoring devices such as indirect blood pressure monitors, can provide erroneous information, especially during hypo- or hypertensive crises.
- When there is risk, possible outcomes of choices made can have large costs.
- Complex systems can have complex subsystems.

Furthermore, systems possess two general characteristics that predispose to errors: complexity of interactions and tightness of coupling (Gaba *et al.* 1987). Interactions can be of two types. Routine interactions are those that are expected, occur in familiar sequence, and are visible (obvious) even if unplanned. Complex interactions are of unfamiliar sequences, or are unplanned and of unexpected sequences, and are not visible or not immediately comprehensible. Within complex interactions there are three types of complexity (Gaba *et al.* 1987):

1 Intrinsic complexity: the physical process is only achieved using a high-technology system that uses precision components acting in a closely coordinated fashion (e.g., space flight and nuclear power).

2 Proliferation complexity: the physical process, although simple, requires a large number of simple components (wires, pipes, switches, and valves) interconnected in a very complex fashion (e.g., electrical grids, chemical plants).

3 Uncertainty complexity: the physical process is achieved simply but is poorly understood, cause-effect relationships are not clear-cut, have a high degree of unpredictability, and the means of describing and monitoring the process are limited or are of uncertain predictive value (e.g., anesthesia).

Using the airplane pilot as a model of the anesthetist within a complex, dynamic system, M.F. Allnutt describes the anesthetist as "a highly trained professional who uses highly technical equipment, is a member of a team for which the time of work and work conditions are not always ideal, and who uses a high level of cognitive skills in a complex domain about which much is known, but about which much remains to be discovered" (Allnutt 1987). Within this model, human error is synonymous with pilot error. But the pilot may be taking the blame for the individual or individuals who created the error-generating conditions: the manager, trainer, aircraft designer, or ground controller (Allnutt 1987). In other words, it is the individual at the sharp end of a process who takes the blame for mistakes and errors made hours, days, or months earlier by other persons at the blunt managerial end; the individual at the sharp end is only the final common pathway for an error, thrust there by a flawed system (see Case 5.1) (Allnutt 1987). Applying the pilot analogy to an anesthetist, human error in anesthesia may be attributable to the anesthetist, but it may be equally attributable to the anesthetist's trainer, the person who failed to pass on a message to the anesthetist concerning patient- or system-related issues, or the person who designed, bought, or authorized the purchase of an inadequate piece of equipment (Allnutt 1987).

Anesthesia involves the use of drugs that have complications, both known and idiosyncratic (Keats 1979). In an attempt to overcome the **uncertainty complexity** inherent in anesthesia, extensive monitoring may be used, but this in turn generates substantial **proliferation complexity**. A large number of monitors, which may or may not be specific for or sufficiently sensitive to detect a problem early, may overwhelm the anesthetist with data not all of which provide useful information. Indeed, the environment in which

anesthetists work may be data-rich but information-poor (Beck & Lin 2003). In fact, when many monitors and drug delivery devices are in use simultaneously there is a high probability that a single component will fail, and the complexity of the interaction between equipment, anesthetist, and patient may be hidden until unmasked by a failure (Gaba *et al.* 1987).

Coupling refers to the degree of interaction or linkage between components of a system (Gaba *et al.* 1987; Webster 2005). Components are loosely coupled when there is a great deal of slack or buffer between them such that a change in one component slowly or minimally affects another component. A loosely coupled system is more forgiving of error and allows greater opportunity for an error to be corrected in time to avoid serious consequences (Webster 2005). In contrast, components that are tightly coupled have very little slack or buffer, and a change in one component quickly or directly affects another (Gaba *et al.* 1987). Thus, tightly coupled systems result in more adverse incidents because minor mistakes or slips can become amplified in their effects before a mistake can be corrected (Webster 2005). An anesthetized patient is a decidedly more tightly coupled system than an awake individual, as many normally self-regulating physiological subsystems have been suspended, altered, or taken over by the technology of the anaesthetic (Webster 2005). For example, at sub-anesthetic levels the ventilatory response (in terms of minute ventilation; $L \text{ min}^{-1}$) of a patient breathing a gas mixture low in oxygen is significantly depressed and becomes more depressed as anesthetic depth increases (Hirshman *et al.* 1977). Anesthetists know that during anesthesia various physiological components, such as oxygenation and ventilation, become more tightly coupled. Recognizing that anesthesia tightens coupling, anesthetists use techniques to loosen coupling between components so as to create a greater margin of safety for the patient. Continuing with the example of anesthesia and ventilation, the simple technique of pre-oxygenating patients prior to induction of anesthesia builds up a reservoir of oxygen in the patient so that if apnea occurs during induction the patient has a sufficient oxygen reserve to draw upon until spontaneous or mechanical ventilation commences.

What, then, are errors within complex environments? There are a number of definitions, the most common are:

- Errors are performances that deviate from normal or from the ideal (Allnutt 1987).
- Errors are all occasions in which a planned sequence of mental or physical activities fail to achieve their intended outcome (Reason 1990).
- Errors are failure of a planned action to be completed as intended (i.e., error of execution), or the use of a wrong plan to achieve an aim (i.e., error of planning) (Leape 2002). **This is the definition we use throughout this text.**

These definitions, although broad in scope, do not explain how errors occur. One way of getting to “why” and “how” is to divide errors into two broad categories:

1 Active errors, failures, or conditions—those errors made by operators directly involved in the provision of care (e.g., administering the wrong drug to a patient) and that create weaknesses or absences in or among protective mechanisms in a system (Garnerin *et al.* 2002; Reason 2004; Reason 2005). They are those errors that usually immediately precede an incident.

2 Latent failures or conditions (also known as root causes, resident pathogens, or James Reason’s “bad stuff” (Reason 2004))—those errors waiting to happen because they exist in the environment or system well before the occurrence of an incident.

Three taxonomic categories have been used to describe active errors: **contextual**, **modal**, and **psychological** (Reason 2005; Runciman *et al.* 1993).

A **contextual model** describes errors in terms of particular actions performed in a particular environment (Runciman *et al.* 1993). Using this model, errors in anesthesia would be analyzed based on whether an error occurred during induction, intubation, maintenance, or recovery. This model cannot be applied across different types of environments because it is specific to the anesthetist’s domain, so it cannot be a general predictive account of errors; it is only suitable for particular tasks in a particular work environment (Runciman *et al.* 1993).

The **modal model** is a more generalized approach to errors, one that expects errors of omission, substitution, insertion, and repetition to occur in complex systems (Runciman *et al.* 1993). This taxonomy allows one to gain an idea of how frequently a particular type of error, such as substitution, occurs across a variety of systems, but it will not explain how that mode of error manifests itself (Runciman *et al.* 1993).

The **psychological model** tries to describe where in an individual's cognitive processes the error occurred and why it occurred (Runciman *et al.* 1993). This approach is broadly applicable across all circumstances if we recognize, as we should, that errors are actions that have failed, and actions are the results of decisions made (cognitive processes). Thus it follows that we need to look at cognitive processes as the underlying sources of errors (Leape 1994; Stiegler *et al.* 2012; Wheeler & Wheeler 2005). However, as this discussion has shown, errors occur not just as a result of human cognition and action, but as a result of multiple factors existing outside of the individual, including technical, environmental, and organizational. These factors are more fully discussed in the next chapter.

Conclusion

Errors occur not just as a result of human cognition and action, but also as a result of multiple factors existing outside of the individual, including technical, environmental, and organizational factors. The next chapter reviews these factors in greater depth so as to describe more fully how and why errors occur.

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