

## Human factors in anaesthetic crisis

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Received: February 9, 2014 Revised: April 14, 2014

Accepted: July 17, 2014

Published online: November 27, 2014

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**Key words:** Safety; Errors; Human errors; Human factors; Crisis; Anaesthesia crisis

**Core tip:** Human factors contribute to human errors and anaesthetic crisis situation. These human factors can be identified and studied in detail. Progression of the non-routine events coupled with human factors when left unchecked lead to serious errors in health care. When the knowledge of human factors is incorporated into the practice of anaesthesia, patient safety is promoted.

### Abstract

This paper discusses some of the key aspects of human factors in anaesthesia for the improvement of patient safety. Medical errors have emerged as a serious issue in healthcare delivery. There has been new interest in human factors as a means of reducing these errors. Human factors are important contributors to critical incidents and crises in anaesthesia. It has been shown that the prevalence of human factors in anaesthesia can be as high as 83%. Cognitive thinking process and biases involved are important in understanding human factors. Errors of cognition linked with human factors lead to anaesthetic errors and crisis. Multiple errors in the cognitive thinking process, known as "Cognitive dispositions to respond" have been identified leading to errors. These errors classified into latent or active can be easily identified in the clinical vignettes of serious medical errors. Application of the knowledge on human factors and use of cognitive de-biasing strategies can avoid human errors. These strategies could involve use of checklists, strategies to cope with stress and fatigue and the use of standard operating procedures. A safety culture and health care model designed to promote patient safety can compliment this further. Incorporation of these strategies strengthens the defence layers against the "Swiss Cheese" models, which exist in the health care industry.

Chandran R, DeSousa KA. Human factors in anaesthetic crisis. *World J Anesthesiol* 2014; 3(3): 203-212 Available from: URL: <http://www.wjgnet.com/2218-6182/full/v3/i3/203.htm> DOI: <http://dx.doi.org/10.5313/wja.v3.i3.203>

### INTRODUCTION

Patient safety has taken centre stage in all aspects of anaesthesia. In the last few years, human factors have appeared time and again as an important contributor in many aspects of patient safety. Lessons from aviation safety have also made way into training in anaesthesia. Many of these lessons involve human factors, which are less spoken about, generally not included in the routine training of anaesthesia or at least certainly not studied in great depth.

In the past decade, many critical incidents in anaesthesia have been compared to the aviation disasters, leading to human factors affecting the performance of anaesthetist to be looked into at a greater depth. Understanding the nature of interaction between these various factors can be complex. However it is pertinent that every anaesthetist should possess a basic idea of human factors, which can affect his or her performance in a crisis situation. Knowledge on this subject can be used in orga-

nizing training programs, creating simulation sessions, debriefing critical incidents and most importantly looking into one's own practice to refine the non technical skills to make the anaesthetic practice much safer.

Retrospective analysis of critical incidents and disasters in anaesthesia often brings human factors to be flagged up as important contributors. Therefore, gaining an insight into human factors in itself can mitigate the risks associated with them in times of anaesthetic crisis. Research in this field has shown that important contributions can be made to patient safety<sup>[1]</sup>.

### Importance

Mishaps, errors, critical incidents, near misses all speak the same language geared towards promoting patient safety. It is now well recognized that human factors play an important role in preventable anaesthetic mishaps. A review of critical incidents by Cooper *et al*<sup>[2]</sup> revealed that human factors were contributory in 82% of the 359 incidents reported. These incidents ranged from simple equipment malfunction in some cases, to death in others, indicating seriousness and importance of the problems. These errors due to human factors are not isolated events picked up by researchers and studies. In fact it has been reported that 44000 to 98000 deaths occur annually in the United States secondary to medical errors<sup>[3]</sup>.

Human errors have been blamed in over 60% of nuclear power plant accidents and 70% of all commercial aviation accidents. It has been shown that human error was an important contributory factor in 83% of anaesthetic incidents in analysis of 2000 incident reports from Australia<sup>[4]</sup>.

### Lessons from aviation

The necessity of safety system in any organization is of paramount importance. This safety system is most needed as a provider to a medium, wherein systematic approach to safety is sought. The analysis and use of human factors can be embedded into this system<sup>[5]</sup>. Anaesthetists often have a unique way of practice, rather a safety system unique to their practice. This safety system is refined, acquired or adopted through the lessons learnt in their working lives. In aviation a similar system exists, this is known as the Safety Management System<sup>[5]</sup>.

It is under the tenets of this safety system, often referred to as clinical governance in the health care setting, the understanding of human factors gains a strong hold in enhancing patient safety. In the 1970's, rising concerns over the safety of anaesthesia gas machines triggered interest in the application of human factors. In the late 1990's medical error emerged as a serious issue in the delivery of healthcare, spawning new interest in human factors as a means of reducing error.

## HUMAN FACTORS AND HUMAN ERRORS

In simple terms, "human factors include all the factors that can influence people and their behaviour"<sup>[6]</sup>. The In-

stitute of ergonomics and human factors (United Kingdom) defines human factors as a "scientific discipline dealing with the interactions among humans and other factors in the system and deals with the theory, principles, data and methods to design and optimise human well being and overall system performance"<sup>[6]</sup>. It can also be defined in terms of performance of a person working within a complex mechanical system. Performance is dependent on the individual's capabilities, limitations and attitudes. Performance is also directly related to the quality of instructions and training provided.

Human error is defined as performance that deviates from the ideal<sup>[7]</sup>. This may take the form of cognitive or procedural error. Cognitive errors are usually thought-process errors in decision-making, and may be attributed to the individual or to the anaesthetic team. They usually cause morbidity or mortality. Procedural errors occur when the wrong drugs are administered<sup>[8]</sup> or if mistakes are made with nerve blocks or other similar procedures.

## COGNITIVE ERRORS

The most important human error is the error of cognition. Studies have shown cognitive errors as important contributors in medical errors. Groopman<sup>[9]</sup> reported that most medical errors are mistakes in thinking and that technical error only constituted a small proportion. This aspect of psychology involved with decision-making has been looked into with interest as an important contributor of human factor in errors. Despite the ample evidence of cognitive bias in decision-making leading to errors, the need to focus on this area in greater depth has been long over due<sup>[10]</sup>. The impact of cognitive errors in medicine needs to be acknowledged and it is time, that anaesthetists and every other healthcare personnel pay heed to lessons on cognitive errors and enter a new era of patient safety.

Whilst a detailed discussion on cognition is beyond the scope of this article, it is important to understand some basic fundamental principles of cognition. Cognition is generally defined as a process involving conscious intellectual activity<sup>[11]</sup>. This intellectual activity consists of many different aspects such as attention, memory, logic and reasoning.

Croskerry<sup>[10]</sup> defined multiple aspects of the cognitive thinking process leading to diagnostic errors and called them cognitive dispositions to respond (CDR's). These errors occur due to failures in perception, failed heuristics and biases. Some of the CDR's mentioned by Croskerry<sup>[10,12]</sup> and Stiegler *et al*<sup>[13]</sup> have been listed below.

### Anchoring

Also known as fixation, is focusing on some of the features of patient's initial presentation and not responding to other aspects of patient care in the light of other new information being presented.

Much discussed in literature is the case of Elaine Bromiley, where in the focus was to intubate rather than rec-

ognizing a “cannot intubate, cannot ventilate situation” (CICV) and proceeding for emergency cricothyroidotomy. More common examples include focus on alarms of the infusion pump and ignoring the surgical bleed and hypotension<sup>[13]</sup>.

These errors of fixation can be classified into three main categories<sup>[14]</sup>: (1) This and only this: *e.g.*, in a case of airway obstruction, having a persistent belief of bronchospasm and not thinking of kinked EndoTracheal tube; (2) Everything but this: *e.g.*, not looking for wrong drug administration when the drug does not solve the problem. In a hypertensive patient not responding to antihypertensive infusion should arouse the suspicion of wrong drug administration; and (3) Everything is OK: *e.g.*, A clinician assumes that a low pulse oximeter value is due to equipment malfunction or peripheral vasoconstriction when, in fact, there is severe hypoxemia.

### Ascertainment

The thought process is governed by prior expectation in this bias, *e.g.*, expectations of intubation to be easy when the assessment of airway point towards a difficult intubation, *e.g.*, apnoea after administration of opioids is a prior expectation, but when this occurs due to wrong drug administration of muscle relaxant, it becomes an error due to ascertainment bias.

### Aggregate

Aggregate fallacy is the belief that clinical guidelines do not apply to the individual's patients. This often leads to errors of commission, *e.g.*, choosing to perform a central neuraxial blockade in a patient with coagulation disorder, clearly against the guidelines and standards, *e.g.*, administering non steroidal anti inflammatory drug in a severe asthmatic patient.

### Availability

This bias can be defined as a tendency to judge things based on what comes to mind readily. This is also influenced by previous bad experience, *e.g.*, diagnosing a simple case of bronchospasm as anaphylaxis because of a previous bad experience<sup>[13]</sup>, *e.g.*, treating ST depression, purely as an effect of bleeding and hypotension and not worrying about myocardial infarction.

### Commission bias

In simple words, the tendency to act rather than be inactive in response to information. It is more likely seen in physicians who believe that harm to the patient can only be prevented by active intervention. Unnecessary interventions and investigations fall under this category, *e.g.*, trying to fix a central vein catheter in a simple case of bronchospasm and producing pneumothorax.

### Confirmation bias

This is the tendency to look for confirming evidence to support a diagnosis rather than disconfirming evidence. It's also known as “Cherry-picking” or trying to force

data to fit a desired or suspected diagnosis, *e.g.*, repeated check at the blood pressures, changing the blood pressure cuff in order to get a better blood pressure reading and failing to acknowledge the low reading<sup>[13]</sup> or changing the pulse oximeter probe when there is low reading due to actual hypoxemia.

### Diagnosis momentum

Typical example is that of a differential diagnosis when carried over on multiple records by multiple health care workers tends to become a more definitive diagnosis. This bias often ends in excluding all other possibilities.

### Omission bias

Contrary to the commission bias, this is exactly the opposite. Here the physician has a tendency towards inaction, *e.g.*, delays seen in use of cardioversion in fast arrhythmias when the clinical situation demands it.

### Overconfidence bias

The tendency to believe that one knows much more than what he or she actually does. Both anchoring and availability augment this bias. Fuelled by commission bias, this may lead to catastrophic results, *e.g.*, often linked to unconscious incompetence, examples of this bias include a junior anaesthetist with little or no skill of fibre-optic intubation attempting an “awake fibre-optic” technique on a patient with difficult airway.

### Premature closure

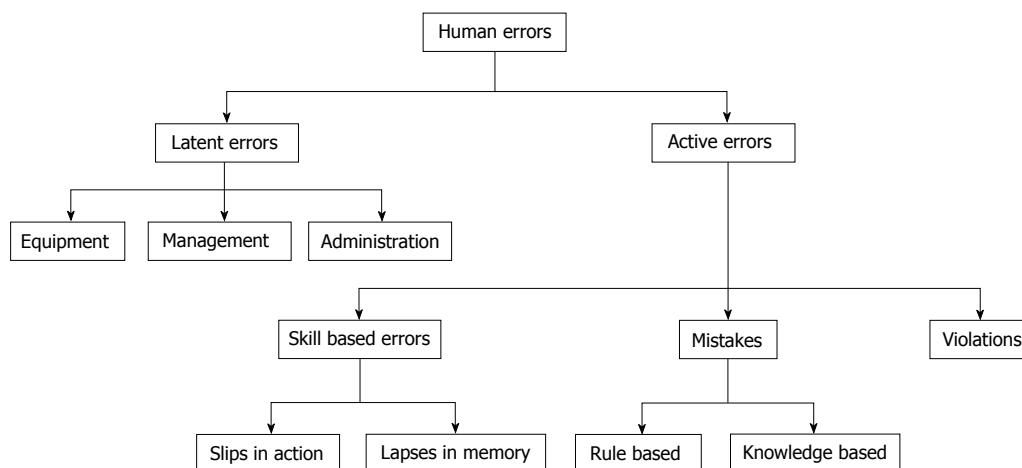
The tendency to stop the decision making process prematurely and accept a diagnosis before it has fully been verified is known as premature closure, *e.g.*, assessing and diagnosing the cause of low oxygen saturations (as displayed on the monitor) to be secondary to the low perfusion of the cold fingers on which the pulse oximetry probe has been placed, rather than looking for other reasons.

### Unpacking principle

This is the failure to elicit all information in making a diagnosis, *e.g.*, failure to elicit information regarding ischaemic heart disease or angina in the pre-anaesthetic assessment.

Linked to these errors of cognition are human failures causing errors in health care. Human failures can be broadly classified into latent and active errors. Latent errors include the equipment, management, administration and the processes involved. Active errors include the errors occurring at the site of action<sup>[15]</sup>. Active errors can further be classified as shown in the Figure 1.

Skill based errors commonly occur when analytical thinking is not employed. These occur with normal routine tasks. Knowledge based errors occur when an expert judgement is used contrary to the prevailing standards<sup>[15]</sup>. Knowledge based errors occur when there is deficiency of knowledge. This needs to be differentiated from violations, which are deliberate deviations from the prevailing

Figure 1 Human errors based on cognitive mechanisms<sup>[15]</sup>.**Table 1 Human factors in pediatric anaesthesia incidents by Marcus<sup>[15]</sup> (modified)**

Human factors	Cognitive mechanism
Error of judgement	Rule or knowledge
Failure to check	Violation
Technical failures ok skill	Skill
Inexperience	Knowledge
Inattention/distracton	Skill
Communication	Latent
Poor preoperative assessment	Rule or knowledge
Lack of care	Skill
Drug dosage slip	Skill
Teaching	Skill
Pressure to do the case	Latent

standards.

Rule based errors occur when the standard rules in practice are not used or inappropriately used<sup>[16]</sup>.

The list of human factors influencing anaesthetic practice is endless. Some of the important human factors influencing anaesthetic practice have been well elucidated by Marcus<sup>[15]</sup>. In his study of human factors, in which 668 incidents were reported, a total of 284 anaesthetic human factors were identified. These human factors accounted for 42.5% of the total incidents. Needless to say, the involvement of human factors in critical incidents ranked high. These factors are presented in the Table 1.

A combination of non-routine events (NRE's) and human factors provides a medium prone for medical errors to thrive. These when unchecked by the safety measures incorporated by the hospital safety net or even worse when unchecked by the anaesthetists individual safety system often lead on to anaesthetic crisis with catastrophic results.

## ANAESTHESIA CRISIS

Merriam Webster defines crisis as “a situation that has reached a critical phase”, “an unstable or crucial time or state of affairs in which a decisive change is impending;

especially with the distinct possibility of a highly undesirable outcome”<sup>[11]</sup>.

In simple words it is a disaster waiting to happen. The difference between an anaesthetic emergency and a crisis is often difficult to elucidate. Not all emergencies are crisis bound by human factors. The following sections look into the human factors, which contribute in some way to anaesthetic crisis and its management.

The clinical vignettes below illustrate some of the many anaesthesia crises in which human factors have had an important role to play.

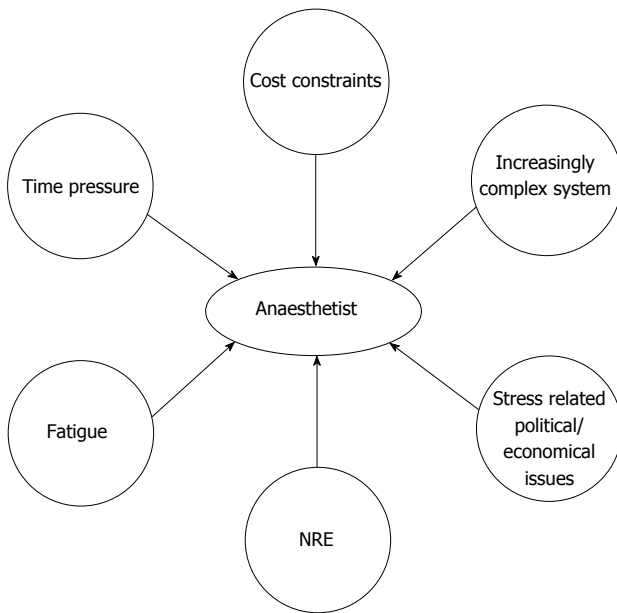
### Clinical vignettes

**Epidural/spinal blunders:** (1) Theatre nurse Myra had received an epidural for labour analgesia. Post delivery, the epidural anaesthetic was mistakenly connected into her arm intravenous cannula. Myra died<sup>[17]</sup>; (2) Grace Wang's spinal canal was mistakenly injected with chlorhexidine instead of the local anaesthetic solution. Grace Wang is now virtually quadriplegic<sup>[18,19]</sup>; and (3) Wayne Jowett aged 18 was recovering from leukaemia. Vincristine, which was to be given intravenously, was administered intrathecally. Wayne Jowett died a month later<sup>[20]</sup>.

**Air embolism:** Baby Aaron was being operated for pyloric stenosis. Towards the end of the operation, the anaesthetist was asked to inject air into the nasogastric tube to distend the stomach. The air was injected mistakenly into the veins. Baby Aaron died<sup>[21]</sup>.

**Airway disasters:** (1) A 9-year-old boy was posted for a minor operation. The cap of the intravenous fluid administration set blocked the angle piece of the anaesthetic tubing. Treatment for presumed bronchospasm was unsuccessful. The 9-year-old died from hypoxemia<sup>[22]</sup>; and (2) Elaine Bromiley was due to have surgery on her nose. After induction of anaesthesia, a CICV situation was encountered. In the prolonged period of hypoxia, which ensued, repeated attempts at intubation were unsuccessful. Elaine died of severe hypoxic brain injury a few days





**Figure 2** Factors affecting the performance of anaesthetist. NRE: Non routine events.

later<sup>[23]</sup>.

**Wrong side errors:** A medical student warned the surgeon of the concerns of wrong kidney being removed. The surgeon dismissed the concerns of the medical student and proceeded with the operation. Patient was left with no kidney function and died a few weeks later<sup>[24]</sup>.

The above clinical vignettes are just a few of the many medical errors, which have occurred with catastrophic consequences. An impossible error as it may seem, these impossibilities become distinct realities when the levels of defence are weak, latent conditions supportive of errors are rampant and human factors contributory.

Reflection of one's own practice of anaesthesia would identify multiple instances of similar "Swiss cheese models" often ending up in near misses or critical incidents. The multiple layers of defence as described by Reason<sup>[25,26]</sup> in his Swiss cheese models consisted of engineered defence systems, procedures and administrative controls and finally the individuals and their skills. For errors to occur, they need to originate from a chain of failures percolating through all the defence layers. The last layer of defence is the human. And humans sometimes fail. Human factors play a major role in these failures. The following section looks into the various human factors, which contribute to human error and lead to anaesthetic crisis.

## THE HUMAN FACTORS ASSOCIATED WITH ANAESTHETIC CRISIS

Time pressure, cost constraints, complex environment, fatigue, stress related to political and economic issues, non-routine events and many other factors can affect anaesthetist's performance (Figure 2).

Frequently, NRE are precursors of anaesthetic disasters. Weinger *et al*<sup>[1]</sup> defined NRE as an unusual, out of ordinary or atypical event contributing to a dangerous dysfunctional clinical system<sup>[1]</sup>. Not all NRE's lead to disasters or patient harm. It is however important to note that retrospective analysis of NRE's often represent a disruption to the other wise smooth processes involved in health care<sup>[1]</sup>. Most often it is the progression of the non-routine events coupled with human factors that lead to serious errors in health care.

Among the important human factors are: (1) Lack of vigilance. Clearly, recognizing NRE's will require the anaesthetist to be vigilant. Vigilance is nothing but situational awareness and depends on a number of factors. These factors include alertness, attention span and diagnostic skills<sup>[1]</sup>. It has been shown that increased workload is associated with an increased incidence of critical incidents<sup>[27]</sup>. Cognitive resources are diminished when the anaesthetist is exposed to a heavy workload leading to a decreased attention span and vigilance. This predisposes the anaesthetists to errors<sup>[1]</sup>. Cooper *et al*<sup>[2]</sup> presented evidence of this important role of vigilance in preventing anaesthetic mishaps as early as 1978. They reported that the causes of common anaesthetic errors could all have been avoided if appropriate attention was directed to the patient. Some researchers have reported the inattention and distraction as a cause in 5.6% of incidents studied<sup>[15]</sup>. It is easy to say that the wrong administration of drugs, wrong site surgery, injection of air into the venous system could all have been avoided if the concerned anaesthetist was more vigilant. "Asking staff to be more vigilant is a weak improvement approach to providing safer care"<sup>[28]</sup>. Performing a task analysis and workload assessment provides valuable clues on the performance of individuals with increased workload<sup>[1]</sup>. Organizations promoting patient safety and keen to deal with human factors should look into this aspect as well; (2) Stress. Stress is defined as "divergence between the demands and capabilities of a person in a situation, giving rise to impaired memory, reduced concentration and difficulties in "decision making"<sup>[29]</sup>. Researchers<sup>[30-32]</sup> have shown that the indecision and delays with decision-making are frequently seen in resuscitation practice courses. These are secondary to stress reaction from the stressful situations faced. It can only be extrapolated that anaesthetic crisis and emergencies can be extremely stressful and can lead to situations wherein delays with decision-making are witnessed. The stress during anaesthetic crises or emergencies should be differentiated from the stress occurring from life's stress events.

Increased awareness is needed in understanding the effects of stress. It is illusory to believe that anyone can be immune to stress. In fact stress is normal and seen in many. This however is transitory and most people cope well. Having an already stressed person (from life's many stressors) in a stressful situation such as an anaesthetic crisis will generally be accepted as a bad idea. A similar situation when occurs in aviation is known as "aviator

at risk”<sup>[16]</sup>. Stressed anaesthetists are aviators at risk and need help. In many countries, systems are in place to help these “anaesthetists at risk”. This can be in the form of local arrangements with colleagues to ease the workload, allocation of mentors, arranging time off or avail stress related sick leave. It is important that a request for help should not be looked upon as a failure to function. All these are geared at one thing, and that is to make the entire system safe and improve the overall quality of care in terms of patient safety. Not all anaesthetists will admit that they are stressed and need help. Some experts<sup>[16]</sup> opine that vigilance should also be employed by colleagues to identify “anaesthetists at risk”; (3) Error of judgement. Marcus<sup>[15]</sup> showed that error of judgement was as high as 43% in 668 paediatric anaesthetic incidents reported in his study. The flawed clinical decisions made can be categorized into rule-based and knowledge-based mistakes. It is often difficult to inherit knowledge-based mistakes into the spectrum of human factors. However an argument can still be made for the case. As discussed above error of judgement and decision-making can be flawed under stressful conditions or when the anaesthetist is stressed; (4) Fixation errors. Lessons from Elaine Bromiley case speak in great depth about fixation errors. Fixation errors are errors which occur when the anaesthetist’s attention and focus is fixated on one aspect of care. The other aspects of care are often overlooked or ignored; and (5) Physical demands. Physical tiredness in itself contributes to the decision making process and can make the anaesthetist prone for errors. It will be wrong to say that vigilance can and should be maintained at all times, when we fail to address other parts of the equation. Analytical thinking involved in decision-making and vigilance are linked to physical tiredness. Anaesthetists like other humans are prone to physical and mental fatigue especially after a long busy night shift. Effective and safe patient care involves thorough patient assessment, planning and executing strategies complimented with intense monitoring. The ability to perform at various levels of physical and mental fatigue is variable, differing amongst individuals. This process requires high amounts of energy. It is not surprising that the level of vigilance falls when physical stress of fatigue sets in<sup>[33]</sup>. Continuing to work under fatigue, invariably leads to exhaustion. Decisions can be erroneous, attention to detail can be lacking and vigilance generally poor. Sinha *et al*<sup>[33]</sup> reported some of the frequently observed problems due to fatigue. These include lapses in attention, inability to stay focussed, reduced motivation, compromised problem solving, confusion, irritability, impaired communication, faulty information processing and diminished reaction. Needless to say, anaesthetists showing symptoms of fatigue as mentioned above are prone to make errors. These errors can translate to patient harm and in some cases even death.

## STRATEGIES TO AVOID HUMAN ERRORS

Mere understanding of the list of human factors dis-

cussed in the above paragraphs is not enough to reserve a definite momentum towards patient safety, and may lead only to illusory benefits. To obtain true and real benefit, this needs to be coupled with practice of multiple cognitive de-biasing strategies and in-depth reflection on the important lessons learnt from human errors.

As opined by Croskerry<sup>[10]</sup> and Yates *et al*<sup>[34]</sup>, “one of the first steps is to overcome the bias of overcoming bias”.

Table 2 illustrates the Cognitive de-biasing strategies, which can be used to reduce diagnostic errors<sup>[10]</sup>.

Other strategies (Table 3) include application of knowledge of human factors in practice to prevent errors. These include: (1) Checklists. Some of the common examples in healthcare, which can be drawn as a parallel to that in the aviation industry, include checklists. It is common knowledge that wrong side surgeries have been prevented by the use of these checklists. So is the case with anaesthetic machine checks, checking the emergency intubation trolley, emergency drugs trolley and so on. The list of checklists is non-ending. But is important to realise that the checklists in itself act as a deterrent in preventing some very basic errors, which might be caused, but with catastrophic results. The importance of these checklists should never be underestimated. Evidence to the seriousness it commands can be derived from the 9000 critical incidents reported between 1990 and 2010 from the United States<sup>[35]</sup>. These incidents resulted in a mortality of 6.6%, permanent injury in 32% and resulted in total malpractice payments of \$1.3 billion in payouts. The World Health Organization checklist, which addresses some of the issues leading to these 9000 critical incidents, has largely reduced the mortality and morbidity in major surgeries. These were mainly in the way of avoiding wrong site, wrong patient, and wrong procedure surgery. It is however interesting to note that the implementation and usage of checklists designed to counter some of the human factors leading to critical incidents in itself can largely be influenced by human factors. O’Connor *et al*<sup>[35]</sup> showed that the sociocultural issues, workload and support from senior personnel often affected the desired performance of these checklist. Munigangaiah *et al*<sup>[36]</sup> opined that human factors in the form of decision making, lack of communication, leadership and team work were largely responsible for the 152017 incidents reported by the National Reporting and Learning System database in England in 2008. The aim of the checklists is to have a structured communication to avoid these basic errors<sup>[36]</sup>. Enough evidence has been drawn to support the routine use of checklists prior to surgeries. Learning from aviation, checklists can be used under normal and emergency situations. It is in the emergency situations like an anaesthetic crisis, when things are missed easily, a checklist is most mandated. The AAGBI checklist for the anaesthetic equipment 2012, checklists for sedation, handover checklist, all look into the same basic human factors, which make our practice of anaesthesia prone to effect of human factors. It is extremely important for the junior doctors and the anaesthetists in training

**Table 2 Cognitive de-biasing strategies<sup>[10]</sup>**

Plan	Action	Example
Develop insight or awareness	Illustration of the errors caused by biases in the cognitive thinking process with the help of clinical examples leads to a better understanding and awareness	The case of intraoperative low oxygen saturations presumed to be due to cold fingers, when the actual cause was endo-bronchial intubation
Consider alternatives	Forming a habit wherein alternative possibilities are always looked into	Continuing with the above example, establishing a habit of looking for other (true) causes of low oxygen saturation, rather than simply blaming the cold fingers could direct the anaesthetist to look for other causes including a possible endotracheal intubation
Metacognition (strategic knowledge)	Emphasis on a reflective approach to problem solving	Knowing when and how to verify data is a good example of Strategic Knowledge
Decreased reliance on memory	Use of cognitive aids, pneumonics, guidelines and protocols protects against errors of memory and recall	Use of guidelines and protocols in the use of intralipids to treat Local Anaesthetic toxicity
Specific training	Identify specific flaws and biases and providing appropriate training to overcome these flaws	Early recognition of a “cannot intubate, cannot ventilate” scenario to guard against fixation errors
Simulation exercises	This is focussed at the common clinical scenarios prone for errors and emphasis on prevention of these errors secondary to human factors	Use of simulation training for difficult airway management
Cognitive forcing strategies	A coping strategy to avoid biases in particular clinical situations is often reflected in the practice of experienced clinicians	Checking for the availability of blood products as a routine ritual prior to the start of major surgery every single time can be considered as strategy to avoid
Minimize time pressures	Allowing adequate time for decision making rather than rushing through	Allowing time to check on patients airway prior to induction can help avoid surprises in airway management
Accountability	Establish clear accountability and follow up for decisions made	A decision to use frusemide intra operatively is followed up by checking the serum potassium levels
Feedback	Giving a reliable feedback to the decision maker, so that the errors are immediately appreciated and corrected	Junior anaesthetist reminding the senior of the allergy to a certain antibiotic, when the antibiotic is about to be administered

**Table 3 Practical strategies to prevent human errors**

Practical strategies to prevent human errors
Checklists
Resuscitation training or simulations
Managing Stress
Dealing with Fatigue
Standard operating procedures or protocols or guidelines
Team work with good communication

to understand that irrespective of the growing number of checklists available for use, the most important one is the checklist one can prepare for himself/herself to guard the patient from their own inadequacies and that of others; (2) Resuscitation training. The increasing focus on human factors and anaesthesia has found its way into training as well. Norris *et al.*<sup>[30]</sup> reported the emphasis of human factors in resuscitation training. Multiple problems have been identified in resuscitation practice. These problems identified can be used as a possible guide to the difficulties faced in a real resuscitation scenario. These included team dynamics, influence of stress, debriefing and conflict within teams. Team dynamics and team leadership play an important role in resuscitation. Emphasis has also been given to the importance of debriefing in resuscitation training; (3) Coping with Stress. A number of methods for dealing with stress have been proposed. Meichenbaum<sup>[37]</sup> proposed the stress inoculation training in which use of conceptualization, coping strategies

and application phase have all been proposed as a way of dealing with stress. Multiple other techniques, which have been proposed, include the STOP technique described by Norris *et al.*<sup>[30]</sup> and Flin *et al.*<sup>[38]</sup>. This technique helps with cognitive thinking by allowing the person to assess the situation and not acting immediately as a “knee jerk reaction”. “S-stop, do not act immediately, and assess the situation. T-take a breath in and out a couple of times. O-observe. What am I thinking about? What am I focusing on? P-prepare oneself. P-practice what works? What is the best thing to do? Do what works.” Other techniques include “Mindfulness” as described by Norris *et al.*<sup>[30]</sup> and Hayes *et al.*<sup>[39]</sup>. Mindfulness involves removal of panicky thoughts and replaces them with ordered thinking; (4) Dealing with fatigue. Organizations should ensure that the anaesthetists are properly rested between shifts. This can be carried out at a departmental level or at an organizational level. The Joint Commission<sup>[33]</sup> recommends a number of steps to be carried out by organizations to ensure that anaesthetists are adequately rested. These include awareness amongst senior authorities of the organization, evaluation of risks, analysis of inputs from staff and generating a fatigue management plan. This fatigue management plan can incorporate sleep breaks, maximum hours of continuous work, mandatory rest period, *etc.*; (5) Standard operating procedures. These are standard formal procedures in aviation and include a number of steps and procedures, which are carried out as a ritual every time. The use of standard operating

**Table 4** The systems engineering initiative for patient safety model components and elements<sup>[41]</sup> (modified)

Components		Elements
Work system	Person	Skills, knowledge, motivation, physical and psychological characteristics
	Organization	Organizational culture and patient safety culture, work schedules, social relationships
	Technology and tools	Human factors characteristics of technologies and tools
	Tasks	Job demands, job control and participation
Process	Environment	Layout, noise and lighting
	care process	Information flow, purchasing, maintenance and cleaning
Outcomes	Employee and organizational outcomes	Job satisfaction, stress and burnout, employee safety and health, turnover
	Patient outcomes	Patient safety, quality of care

procedures with intent of reducing errors has now also been employed in the operating theatre environment and anaesthesia<sup>[5]</sup>. Anaesthetic machine checks, resuscitation trolley checks can be compared to some of the standard operating procedures in aviation. The list of comparables between anaesthesia and aviation is exhaustive. It is important to note that these standard operating procedures are not limited to protocols, guidelines, and checklists. Unique practicing styles of anaesthetists, in itself is a standard operating procedure. Individuals through years of training and experience build in these safety mechanisms to guard themselves against the pitfalls posed by human factors, *e.g.*, a particular way of ensuring that a throat pack is removed at the end of surgical procedure: sticky label on the forehead, tying one end of the throat pack to the endotracheal tube, reminder on the swab count board, reminder on the anaesthetic chart, using laryngoscopy for suctioning prior to extubation. These are nothing but standard operating procedures in the simplest sense, designed to be a safety net guarding the patient against the various human factors and errors. Every anaesthetist should look into his own standard operating procedure and adapt it to the environment making it a safer system, wherein percolation of errors through the various defence layers is not easily possible. This importance of a safety system should be realized both at an individual level and at an organizational level; and (6) Teamwork. The introduction of the concept of teamwork in human factors and patient safety is not new. Teams represent a form of synergy, in which teams work more effectively, efficiently, reliably and safely. The safety aspects of teamwork are much more than an individual or group of individuals working separately<sup>[40]</sup>.

Hunt *et al*<sup>[40]</sup> identified the characteristics of high performing teams. These include situational awareness. Team performance is improved when the team members are constantly aware of the environment and update each other in a process known as shared cognition. This shared cognition helps in having a shared mental model wherein decisions are made based on current state of affairs. The other aspects of high performing teams include leadership skills. An effective leader allows flow of information in both directions, thereby improving safety to the patient. Closed loop communication is also important in understanding that the information has been received and will be acted upon. Various other aspects of teamwork have also been looked into namely, assertive

communication, adaptive behaviours, workload management, *etc.*

## HEALTH CARE MODELS TO PROMOTE PATIENT SAFETY

Lessons on human factors in healthcare can never be complete without acknowledging the added patient safety certain health care models can offer.

It is known that systems addressing human factors emphasize on interactions between people and their environment, and this in turn contributes to patient safety. Carayon *et al*<sup>[41,42]</sup> described the Systems Engineering Initiative for Patient Safety (SEIPS) model as a human factors systems approach. The key characteristics of the SEIPS model include the relationship between the work system and the interacting elements, identification of important contributing factors, integration of patient outcomes with organization/employee outcomes and feedback loops between all the above-mentioned characteristics. In many ways the SEIPS model is employed in different organizations to promote safety. Root cause analysis of critical incidents in anaesthesia is an application of the SEIPS model in itself.

Analysis of the anaesthetist job description and the interaction between various components using the SEIPS model (Table 4) should be performed both at an individual, departmental and organizational level. This would identify some of the factors influencing human errors, and remedial actions can be taken.

The use of the above SEIPS model can be many. It can be used for system design, proactive hazard analysis, and accident investigation and certainly for patient safety research. Utilization of the SEIPS model brings about balance to the work system and steadies the various interactions, making the system less prone for errors secondary to human factors. It is also important to note that individuals can also use the SEIPS model, in looking at their own adaptability to different components of the SEIPS model. This will enhance the performance in a direction towards better patient safety.

## STUDY OF PERFORMANCE SHAPING FACTORS

Irrespective of the health care model used, all models aim



at identifying factors contributing to errors. Performance shaping factors are attributes that affect human performance<sup>[43]</sup>. Examples of performance shaping factors include factors affecting an individual, teams, technology, work environment and the work process involved. Identification of these factors can be used for risk mitigation, simulation training and future research.

## THE CULTURE OF SAFETY

Central to the ways of avoiding human errors and utilising models for safety is to promote a positive safety culture<sup>[28]</sup>. This safety culture can only be established when there is strong commitment from the senior management. Multiple aspects of safety culture need to be adopted by organizations wanting to promote patient safety. These include: (1) Open culture: Patient safety incidents are openly discussed with colleagues and senior managers; (2) Just culture: Staff and carers are treated fairly after a patient safety incident; (3) Reporting culture: A robust incident reporting system, wherein staff are encouraged and not blamed for reporting; (4) Learning culture: The organization is committed to learn safety lessons; and (5) Informed culture: These safety lessons are used to identify and mitigate future incidents.

## CONCLUSION

Human errors continue to be an important cause of industrial accidents, aviation disasters and anaesthesia related deaths. Study of human factors should be encouraged to identify various interactions taking place in the health care systems, which make the practice of anaesthesia prone to the effects of human factors, causing human errors translating to anaesthesia mishaps and incidents. This ultimately affects the overall standard of care given to the patients. The care in terms of technical and non-technical skills, which are influenced by human factors, should be delivered in a manner to promote and maintain patient safety.

When we accept and acknowledge that human factors do play an important role in anaesthesia crisis, it is only imperative that strategies to avoid, cope and deal with these human factors are practiced.

Much more work both in terms of research, training and familiarity is needed to understand human factors at a greater depth to further strengthen the already existing strategies to avoid human errors in the practice of anaesthesia.

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**P- Reviewer:** Kvolik S, Tong C, Velisek J

**S- Editor:** Wen LL **L- Editor:** A **E- Editor:** Liu SQ





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