

Human factors and AAGA



Tim M Cook



John Hitchman



Ellen P O'Sullivan



Helen Torevell

HEADLINE

- 23.1 NAP5 identified human factors (HF) contributors in the majority of reports of AAGA, even though the NAP process is not well suited to robust analysis of such factors. The commonest contributory factor groups were: medication, patient, education/training and task. Preventing awareness by addressing human factors goes beyond simply examining the final 'action error' that leads to relative under-dosing of drugs and should consider the many latent factors that impact on this. This is particularly so for AAGA caused by drug errors.

BACKGROUND

Human factor science

- 23.2 There has been, an increasing acknowledgement that the safe delivery of healthcare is impacted by the manner in which humans delivering it interact with their environment. Amongst the key analyses in this regard have been the Harvard Medical Practice Study (Brennan et al., 1991) and the response by the Institute of Medicine 'To Err is Human' (Kohn et al., 2000) which suggested that between 44,000 and 98,000 people were dying in USA hospitals each year as a result of preventable medical errors. Similar studies from other countries including the UK (Vincent et al., 2001), Australia (Wilson et al., 1995) and elsewhere, estimate that around 1 in 10 hospital in-patients suffer harm as a consequence of their treatment, 50% of which are avoidable, and that around 1 in 10 of these events lead to death. More recent studies have not shown any reduction in this rate of human error in healthcare (Sari et al., 2007).
- 23.3 Gawande (2007) has noted that "progress in medicine will not be made through improved technology but rather through improved application of current knowledge and activity: in short 'doing it better'. While an oversimplification, this sentiment is worthy of consideration.
- 23.4 That such matters impact on complications of anaesthesia has been recognised for many years (Cooper et al., 1978).
- 23.5 However 'human factors' (HF) is not the same as 'human error'. Human factors (broadly equivalent to 'ergonomics') can be defined as "encompassing all those factors that can influence people and their behaviour. In a work context, human factors are the environmental, organisational and job factors and individual characteristics which influence behaviour at work" (Clinical Human Factors Group <http://chfg.org/what-is-human-factors>).
- 23.6 'Clinical human factors' has been defined as "Enhancing clinical performance through an understanding of the effects of teamwork, tasks, equipment, workspace, culture and organisation on human behaviour and abilities, and application of that knowledge in clinical settings." (Catchpole

2011, Clinical Human Factors Group, <http://chfg.org/what-is-human-factors>).

- 23.7 In the UK, an important driver for study and use of the knowledge gained to try to improve the safety, quality and efficiency of healthcare has been the Clinical Human Factors Group (<http://chfg.org/>), founded by Martin Bromiley.
- 23.8 In 2013 the National Quality Board published the *Human Factors in Healthcare Concordat* (National Quality Board, 2013). This is signed by numerous NHS and safety organisations including the Care Quality Commission, Department of Health, NHS England and the GMC.
- 23.9 This authoritative concordat commits to:
- “raising awareness and promoting Human Factors principles and practices in healthcare;
 - understanding, identifying and addressing current capability, barriers to adoption, future requirements and best practice in Human Factors in healthcare;
 - creating the appropriate conditions, through commissioning, quality assurance and regulation, that support the NHS in embedding Human Factors at a local level.”

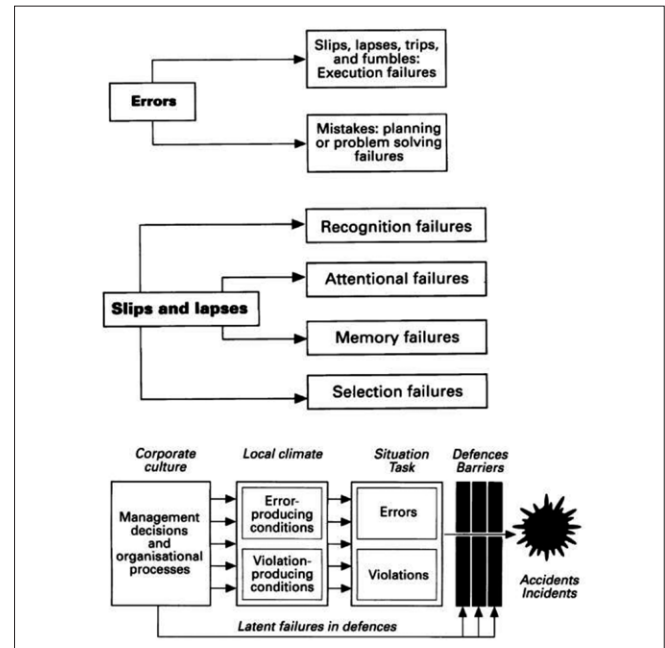
and recognises specifically that “much of the activity to embed Human Factors in healthcare sits with frontline providers.”

Analysing patient safety incidents using an HF approach

- 23.10 Reason (1995) described the final common pathway of medical errors as ‘active failures’ of healthcare professionals. He divided errors into two broad divisions: ‘slips/lapses’ and ‘mistakes’ (Figure 23.1). In turn, slips/lapses were divided into several categories. ‘Violations’ were also defined, as an intentional deviation from rules and standards—whether this be *routine violations* (cutting of corners), *optimising violations* (actions taken to further personal goals) or ‘*necessary/situational violations*’ (made unavoidably to achieve the task) (Figure 23.1). He described contributory factors arising from the surrounding environment (in the widest sense) as ‘latent failures’ (now more often termed ‘factors’ or ‘conditions’) – “those circumstances that provide the conditions under which active errors are more likely to lead to patient harm, by defeating barriers in place to prevent this” and also referred to these as “the inevitable ‘resident pathogens’ within the system”. His model included the extensively quoted ‘Swiss Cheese’ illustration (Reason, 2000) of how latent conditions can ‘line up’ and create a pathway through holes in

safety barriers creating conditions in which events and actions are more likely to cause patient harm (Figure 23.1).

Figure 23.1 Active and latent failures as described by Reason. These include ‘errors’ which are subdivided into ‘slips’ and ‘mistakes’ (also subclassified), and violations. The bottom panel describes how weaknesses in organisational or individual ‘safety barriers’ can line up to enable a series of events and actions to cause patient harm.



Reprinted from Reason J. Understanding adverse events: human factors. *Quality and Health Care* 1995;4:80-9 with permission.

- 23.11 Reason’s work includes a flowsheet for analysis of patient safety incidents to enable ‘just analysis’ of events into groups such as simple error, reckless violation, sabotage etc (Reason 1997).
- 23.12 The National Patient Safety Agency (NPSA), in their report *Seven Steps to Safety* (NPSA, 2004), recommended the formal analysis of contributory factors using a model described by Vincent, (1998) Table 23.1). Gordon et al. (2005) designed a Human Factors Investigation Tool (HFIT) to improve the investigation of the HF causes of accidents in the UK offshore oil and gas industries. It is likely to be suited also to investigation of other industries that depend on high reliability but where accidents can lead to significant harm. The tool is based on a ‘threat/error model’ and emphasises the importance of situation awareness. A modified version was previously used to analyse a subset of reports to NAP4 (Flin et al., 2013). In that paper the tool was described as suitable for analysis of anaesthesia-related events because of its design “for a dynamic, safety critical work domain where monitoring plays a key role and teams must respond to events that can escalate very rapidly.”

Table 23.1. NPSA classifications of contributory factors in patient safety incidents. (NPSA, 2004)

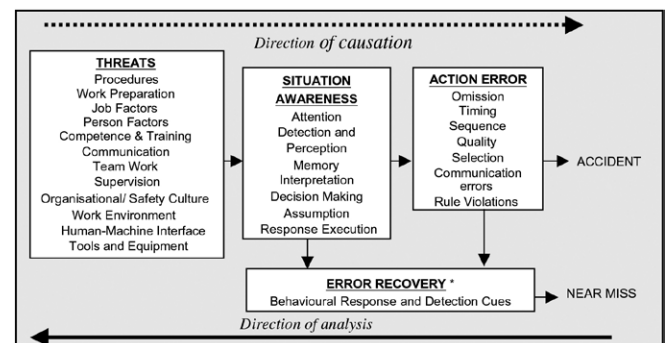
Factors
Communication includes verbal, written and non-verbal: between individuals, teams and/or organisations
Education and Training e.g. availability of training
Equipment/resource factors e.g. clear machine displays, poor working order, size, placement, ease of use
Medication where one or more drugs directly contributed to the incident
Organisation and strategic e.g. organisational structure, contractor/agency use, culture
Patient e.g. clinical condition, social/physical/psychological factors, relationships
Task (includes work guidelines/procedures/policies, availability of decision making aids)
Team and social includes role definitions, leadership, support and cultural factors
Work and environment e.g. poor/excess administration, physical environment, work load and hours of work, time pressures
Other

23.13 The HFIT divides accident trajectory into four elements:

- Threats – underlying work or personal conditions that may be causal
- Situation Awareness – cognitive processes which may have preceded an action error.
- Action Errors – occurring immediately prior to the incident.
- Error Recovery mechanisms – (for near misses) actions that averted an accident.

and uses a large bank of questions to explore 28 HF elements (Figure 23.2 and 23.3). The tool requires specific training for use.

Figure 23.2. Summary of elements explored in the Human Factors Investigation Tool



Reprinted from Gordon R, Flin R, Mearns K. Designing and evaluating a human factors investigation tool (HFIT) for accident analysis. *Safety Science* 2005;43:147–71 with Permission from Elsevier.

Figure 23.3. Simplified Human Factors Investigation Tool categories for coding anaesthetic events as applied to investigation of cases reported to NAP4. (Note error recovery is omitted as no 'near misses' were considered by NAP4).

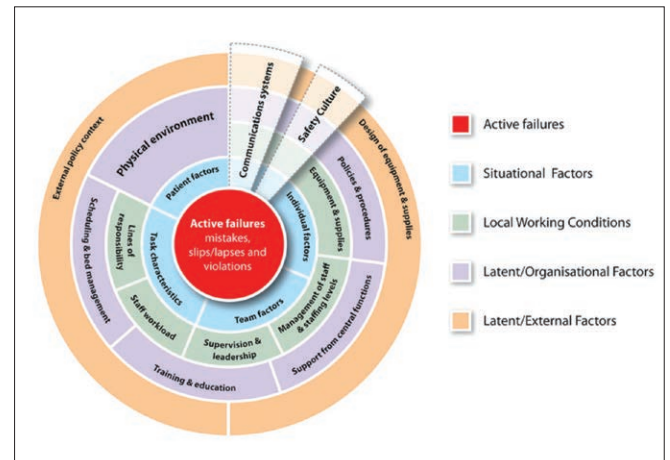
Heading	Subheading and descriptor
Action errors	Actions performed – anaesthetist, surgeon or other team member takes inappropriate action (e.g. gives a wrong drug, does not attach a required monitor)
Situation awareness	Problem detection – delays/difficulty in detecting critical change in state Task cognition – failures in attention, concentration, problem solving, decision making, memory
Threats	Policies, standards & procedures Work preparation – limitations in plans, strategies, contingency plans Job factors – task difficulty, inappropriate staffing levels, work pressure Person factors – fatigue, stress, hunger, improper motivation, physical incapability, feeling unwell Competence & training Communication – interpersonal or technical failures Team work – lack of shared mental model, role confusion, poor coordination Supervision and leadership – ineffective, no pre-task briefing, inadequate monitoring or instruction of trainee Work situation – conditions at work site, e.g. heat, noise, lighting, too many people crowding the workspace, night shift Human-machine interface – design flaws, operability, alarms Tools and equipment – suitability, availability, maintenance, access Organisational/safety culture – management, systems, norms

Reprinted from Flin R, Fioratou E, Frerk C, Trotter C, Cook TM. Human factors in the development of complications of airway management: preliminary evaluation of an interview tool. *Anaesthesia* 2013;68:817–25 with Permission from Elsevier.

23.14 Finally, the Yorkshire contributory factors framework (Lawton et al., 2012) is derived from a systematic review of factors contributing to hospital patient safety incidents. The framework describes five domains ('active errors', 'situational factors', 'local working conditions', 'organisational latent factors' and 'external latent factors') containing 19 types of potential contributory factors (Figure 23.4). As in Reason's model 'active failures' are errors at the point of care delivery and 'latent factors' are conditions which make active errors more likely to happen or more likely to lead to patient harm. In the model the domains are arranged around 'active error', almost like the layers of an onion that must be peeled away one by one to find the centre. The framework uses simple terminology to describe its categories (Figure 23.5) and as such is amenable to non-expert use to improve the identification and modification of factors that cause or contribute to patient safety incidents. The framework has recently been used to analyse a fatal patient safety incident in

Intensive Care (Gupta & Cook, 2013) which illustrates the ease with which it can be used and the increased learning about an incident that can result.

Figure 23.4. The Yorkshire Contributory Factors Framework



Reprinted from Lawton R, McEachan RR, Giles SJ, Sirriyeh R, Watt IS, Wright J. Development of an evidence-based framework of factors contributing to patient safety incidents in hospital settings: a systematic review. *British Medical Journal Quality and Safety* 2012;**21**:369–80 with permission.

Figure 23.5. The Yorkshire Contributory Factors Framework – Category definitions

Factor	Definition
Active failures	Any failure in performance or behaviour (eg, error, mistake, violation) of the person at the 'sharp-end' (the health professional)
Communication systems	Effectiveness of the processes and systems in place for the exchange and sharing of information between staff, patients, groups, departments and services. This includes both written (eg, documentation) and verbal (eg, handover) communication systems
Equipment and supplies	Availability and functioning of equipment and supplies
External policy context	Nationally driven policies / directives that impact on the level and quality of resources available to hospitals
Design of equipment and supplies	The design of equipment and supplies to overcome physical and performance limitations
Individual factors	Characteristics of the person delivering care that may contribute in some way to active failures. Examples of such factors include inexperience, stress, personality, attitudes.
Lines of responsibility	Existence of clear lines of responsibility clarifying accountability of staff members and delineating the job role
Management of staff and staffing levels	The appropriate management and allocation of staff to ensure adequate skill mix and staffing levels for the volume of work
Patient factors	Those features of the patient that make caring for them more difficult and therefore more prone to error. These might include abnormal physiology, language difficulties, personality characteristics (eg, aggressive attitude).
Physical environment	Features of the physical environment that help or hinder safe practice. This refers to the layout of the unit, the fixtures and fittings and the level of noise, lighting, temperature etc.
Policy and procedures	The existence of formal and written guidance for the appropriate conduct of work tasks and processes. This can also include situations where procedures are available but contradictory, incomprehensible or of otherwise poor quality
Safety culture	Organisational values, beliefs, and practices surrounding the management of safety and learning from error
Scheduling and bed management	Adequate scheduling to manage patient throughput minimising delays and excessive workload
Staff workload	Level of activity and pressures on time during a shift
Supervision and leadership	The availability and quality of direct and local supervision and leadership
Support from central functions	Availability and adequacy of central services in support the functioning of wards/ units. This might include support from Information Technology and Human Resources, portering services, estates or clinically related services such as radiology, phlebotomy, pharmacy.
Task characteristics	Factors related to specific patient related tasks which may make individuals vulnerable to error
Team factors	Any factor related to the working of different professionals within a group which they may be able to change to improve patient safety
Training and education	Access to correct, timely and appropriate training both specific (eg, Task related) and general (eg, Organisation related)

Reprinted from Lawton R, McEachan RR, Giles SJ, Sirriyeh R, Watt IS, Wright J. Development of an evidence-based framework of factors contributing to patient safety incidents in hospital settings: a systematic review. *British Medical Journal Quality and Safety* 2012;**21**:369–80 with permission.

HF and AAGA

- 23.15 At its simplest, the immediate cause of AAGA (i.e. that which directly leads to the event) is failure to give enough anaesthetic. However, there are often numerous contributory factors that increase or even cause the administration of 'insufficient anaesthetic'. Reports of AAGA may also arise due to patient perceptions of AAGA based on communication issues. Excepting cases due entirely to equipment or drug malfunction or pure patient resistance to anaesthetic drugs, we might consider that HF is likely to have some role in almost all other cases of AAGA.
- 23.16 Several studies exploring the epidemiology of AAGA have commented in some manner on human factors in their genesis.
- 23.17 Sandin et al. (2000) described seven (37%) of 19 cases of AAGA as having contribution from HF, including failure to fill a vaporiser, administering a muscle relaxant before induction agent, administering inadequate drug doses, backflow of induction agent up a giving set, failure to administer extra anaesthetic agent during difficult intubation and allowing emergence before surgery had finished. In the remaining cases, causes were 'uncertain' in two and 'no cause found' in ten.
- 23.18 Errando et al. (2008) reported a 'human error' contribution in 15 (68%) of 22 cases of AAGA, including absolute or relative hypnotic drug dosage errors and problems with difficult intubation. There were two cases of equipment failure and five in which no cause was identified. Paech et al. (2008) reporting on AAGA in obstetrics, reported two cases (100%) in a series of 753 to be as the result of HF – one lapse and one situational violation.
- 23.19 In contrast, Sebel et al. (2004) described 25 cases of AAGA and, while providing descriptions of anaesthetic type and drug use, made no comment on human error or HF. Similarly the many studies on the impact of depth of anaesthesia monitors on AAGA make no comment and describe no cases of AAGA due to slips, lapses, violations or similar.
- 23.20 So these studies could be interpreted as reporting HF as contributory in anything from 0–100% of cases of AAGA. It is, however, notable that all these analyses focus only on the active failures as causes of AAGA and none on the latent factors that surround the case. The analyses must therefore be considered superficial at best.
- 23.21 In the context of AAGA, HF is therefore not restricted to anaesthetists making 'errors' that lead to the administration of too little drug or the wrong

drug but, on first principles, could also include issues such as:

- **Organisational**
 - a) Duty rotas and times of rest.
 - b) Operating list structure and organisation.
 - c) Anaesthetic assistance.
 - d) Theatre flow (e.g. scheduling, use of anaesthetic rooms or not).
 - e) Anaesthetic room design, theatre design (e.g. anaesthetic room lay out, theatre size and lay out).
 - f) Drug supply and packaging.
 - g) Machine design and interfaces, default alarms etc.
 - h) Design, availability and reliability of anaesthetic equipment (e.g. airway devices, intravenous access, vaporisers TIVA pumps and giving sets).
 - i) Fitness for purpose of equipment (e.g. depth of anaesthesia monitoring).
 - j) Lighting and noise levels.
 - k) Control of distractions and interruptions.
 - l) Rest periods, food breaks.
 - m) Organisational communication.
 - n) Organisational and immediate safety culture.
 - o) Horizontal/vertical hierarchy in the operating theatre.
- **Individual**
 - a) Quality of patient assessment.
 - b) Professionalism (including personal organisation, knowledge, application etc).
 - c) Faculties (cognition, hearing, sight etc).
 - d) Communication skills.
 - e) Concentration skills vs distractibility.
 - f) Personal attitudes to patient safety and risk.
 - g) Response to time pressures and adaptability.
 - h) Attentiveness.
 - i) Health.
 - j) Personal stressors.

HF and NAPs

- 23.22 The nature of the remote, web-based data collection used by NAPs is not ideally suited to collecting HF data. The NAP4 report (Cook et al., 2011) found that 40% of reports included some HF contribution and that in one quarter of these (10% of all reports) such factors were a major contributor to poor outcome. However, in the follow-up study by Flin et al. (2013), telephone interviews with a small cohort of reporters to NAP4 identified this to be a considerable underestimate with HF contribution in 100% of reports with a median of 4.5 HF contributory elements identified per report (range 1–10 per case).

- 23.23 The commonest HF elements reported by anaesthetists involved in major airway complications were, using the HFIT classification: situation awareness (failure to anticipate, wrong decision); job factors (task difficulty, staffing, time pressure); person awareness (tiredness, hunger, stress).
- 23.24 In order to extract some useful HF data, specific questions about the contribution of HF to events were included in the NAP5 case report data collection form. As in NAP4 we also used the NPSA classification of contributory factors to patient safety incidents (NPSA 2004) to evaluate each report (Table 23.1).
- 23.25 NAP5 has been designed in a way that almost inevitably misses much of the HF contributing to AAGA in reported cases. These factors were not actively sought by the data collection process, and may have been overlooked or omitted by the reporter and Local Co-ordinator, who of course have only their own perspective on the events that took place. It is likely that a formal interview using tools such as the Human Factors Interview Tool or in-depth analysis with the Yorkshire Contributory Factors Framework is needed to extract detailed HF coding. Therefore this chapter is principally illustrative and descriptive. The quantitative analysis is indicative of the types and perhaps distribution of HF contributions to AAGA, but will underestimate their frequency. Excerpts from other chapters have been included to illustrate how HF impacts on most analyses within NAP5.

(Dis)organisation of work spaces was associated with drug errors leading to AAGA



NAP5 CASE REVIEW AND NUMERICAL ANALYSIS

- 23.26 Using the NPSA classification, all 110 Certain/probable (Class A) reports (i.e. those reports with the most complete data available) were judged by the Panel to have contributory factors (median number of factors 3, range 1–7), with the commonest being medication, patient and education/training (Table 23.2).

Table 23.2. NPSA classifications of patient safety incidents for 110 Certain/ probable (Class A) reports of AAGA in NAP5

Factors	Contributory/ Causal/ Mitigating	Contributory or Causal; %
Communication	19 / 0 / 0	17.3
Education and training	58 / 6 / 1	58.2
Equipment and resource factors	33 / 4 / 0	33.6
Medication	66 / 20 / 0	78.2
Organisation and strategic	23 / 0 / 0	20.9
Patient	75 / 2 / 0	70.0
Task	27 / 8 / 0	33.6
Team and social	20 / 0 / 0	18.2
Work and environment	27 / 0 / 0	24.5
Other	11 / 0 / 0	10.0

- 23.27 The Panel judged cases according to quality of care and preventability (Table 23.3). However, AAGA was judged preventable in almost three quarters of Certain/probable reports. In only 1 in 9 cases was care judged good and the AAGA not preventable while in only 1 in 11 reports was no cause found for AAGA (Table 23.3).

Table 23.3. NPSA classifications of patient safety incidents for 110 Certain/probable (Class A) cases

	n in NAP5 (%)
Quality of care	
Good	28 (25.5)
Mixed	34 (30.9)
Poor	43 (39.1)
Preventable	81 (73.6)
Quality of care good and not preventable	13 (11.8)
No cause found	10 (9.1)

- 23.28 In Chapter 12 (Sedation) the authors concluded that 'miscommunication was the main contributory or causal factor in 81% of reports'.

23.29 Those reporting cases identified HF in 61% of Certain/probable reports and their causes are listed in Table 23.4.

Table 23.4 Reporters assessment of human factors in Certain/probable (Class A) reports to NAP5; n=104

	n in NAP5 (%)
Judgement	28 (26.7)
Communication	17 (16.2)
Education	9 (8.6)
Tiredness	7 (6.7)
Distraction	4 (3.8)
Theatre design	3 (2.9)
Organisation	3 (2.9)
Decision making	2 (1.9)
Other	11 (10.5)
None	41 (39.0)

Induction

23.30 Human factors contributing to AAGA at induction included (but were not limited to) the following (Reason's error types are in parentheses for illustration):

- Drug errors from mislabelling, failure to mix drugs, omission of drugs or syringe swaps (slips and lapses).
- 'Mind the gap errors' – delayed or omitted maintenance drugs (routine and optimising violations).
- Inadequate dosage of induction agents due to errors of knowledge (knowledge based violation) or judgement (situational violation).

Contributory factors included (The Yorkshire Contributory Factors Framework factors are in parentheses for illustration):

- Ampoule label design (equipment and supplies).
- Errors of judgement or knowledge (training and education).
- Difficult airway management and obesity (patient factors).
- Distraction by colleagues – talking, teaching, interruptions etc. (individual factors/team factors/communication systems).
- Distraction by unexpected difficulty – failed airways, failed vascular access, other unexpected patient complications, equipment failure, (task characteristics, staff workload).
- Busy lists with multiple changes (scheduling and bed management, safety culture).

- Tiredness (individual factors, staff workload).
- Rushing (individual factors, team factors, safety culture).
- Lack of clarity of roles in the anaesthetic room (lines of responsibility).
- The need for rapid sequence induction (task characteristics, patient factors).
- Lack of availability of extra drugs due to local policy (design of equipment and supplies, support from central functions/safety culture).
- Junior trainees working unsupervised (supervision and leadership).

Just prior to induction, because of a history of reflux, the consultant changed the anaesthetic plan to include tracheal intubation. The consultant drew up atracurium while watching the assistant place the IV cannula. When the cannula proved difficult the consultant placed the atracurium on the work surface (unlabelled) and helped with cannulation. The cannula was then flushed but rather than the intended saline flush atracurium was administered. This was promptly recognised and general anaesthesia was induced with propofol. Post-operatively the patient reported an experience of respiratory difficulty, paralysis and a feeling of dread and of death. In the following weeks, severe psychological symptoms were judged to be consistent with PTSD.

During RSI for an urgent procedure, the anaesthetist noticed greater than expected fasciculations after induction. After intubation, a volatile agent was immediately commenced. The anaesthetist then realised that no induction agent had been administered, only suxamethonium. In that hospital, thiopental was kept in a central store, so was not immediately available for mixing. After finishing the previous case, the anaesthetist forgot that the thiopental had not been mixed and proceeded with RSI. The patient was aware of being intubated and was unsure how long it would last but soon after lost consciousness. The patient developed a new anxiety state, flashbacks and possible PTSD.

While the senior trainee anaesthetist was waiting for the patient, the theatre co-ordinator changed the vaporiser for a new 'trial vaporiser' without informing the anaesthetist. Meanwhile the anaesthetist was called to an emergency. On returning, anaesthesia was induced without a further machine check. Following uneventful induction a regional block was performed and the heart rate and blood pressure were observed to be elevated, so more opioid was administered. At incision, heart rate increased further, and at this point the vaporiser was checked and found to be empty. Midazolam and propofol were immediately given to deepen anaesthesia and the vaporiser filled. The patient reported hearing voices, being unable to move and feeling someone "...cleaning their tummy and then a tube going in..."

23.31 Certain phrases and patterns seemed to recur in the reports. Chapter 8 (Induction) reported *"several cases where AAGA had arisen at induction/transfer, apparently because of distraction, fatigue and organisational issues (i.e. a desire to increase rapid turnover of cases, or last minute changes in list order or operating theatre) Five cases (7%) occurred when the induction agent went back up the intravenous line or when the cannula 'tissued'. In two cases the report suggested that the neuromuscular blocking drug had been given too early in the induction process. In neither case was the drug suxamethonium"*.

...distracted by ODP leaving to get supplies
 ...emergency suxamethonium ampoules lying next to general anaesthesia drugs
 ...ACCS trainee drew up drugs and mislabelled
 ...thiopental stored out of theatre

23.32 Chapter 16 (Obstetrics) noted *"both syringe swap cases involved antibiotics. In one, a recent change of policy led the anaesthetist to change practice and draw up the antibiotic before delivery, making the possibility of syringe swap more likely. In the other case, the urgency of the case was a distracting factor."*

23.33 Chapter 11 (Risk Factors) reports *"a disproportionately high proportion of evening and nighttime operating in Class A reports of AAGA compared to the Activity Survey general anaesthetics $p < 0.0001$. There was a disproportionately high proportion of urgent and emergency anaesthesia in Class A reports of AAGA compared to the Activity Survey general anaesthetics $p < 0.0001$. There was a disproportionately high proportion of very junior anaesthetists in Class A reports of AAGA compared to the Activity Survey general anaesthetics $p = 0.003$."*

Multiple drugs used at induction may increase the risk of slips



Maintenance

23.34 Human factors contributing to AAGA during maintenance included (but were not limited to):

- Under-dosing to maintain cardiovascular stability.
- Under-dosing to lessen risk to a fetus.
- Under-dosing due to inattention or judgement errors.
- Termination of anaesthesia too soon before surgery had finished.

An elderly patient returned to theatre two days after cardiac surgery for management of bleeding. The anaesthetist deliberately used reduced doses of induction drugs and maintenance agents, but also monitored anaesthesia with a BIS monitor (charted as < 60 throughout). During repositioning in theatre, the blood pressure and heart rate rose and the anaesthetist administered additional anaesthetic agents. The patient reported brief AAGA the following day, describing awareness during positioning and hearing a discussion about this. The patient could not communicate awareness to the team and this led to moderate psychological distress.

23.35 In Chapter 9 (Maintenance) it was noted *"vaporiser errors included being left switched off after transfer (10 instances (20%), an empty vaporiser unnoticed (two cases) or incorrectly mounted (one case)). Distraction was specifically cited as contributing to vaporiser errors in four (8%) reports."*

23.36 Human factors contributing to AAGA at emergence included (but were not limited to):

- Turning anaesthetic agents off because of poor communication.
- Turning anaesthetic agents off because of poor understanding of offset times of newer volatile agents.
- Rushing.
- Mistiming, overdosing or unnecessary use of muscle relaxants.
- Failure to monitor degree of residual neuromuscular blockade or the effects of reversal agents.

A patient underwent an emergency operation, and immediately reported having heard the stapling of the skin whilst paralysed. The patient also recalled a discussion about 'sweating'. The experience lasted ~30 minutes. There was distress, sleep disturbance and unpleasant dreams. The anaesthetist had mistakenly turned off the vaporiser prematurely at the end of surgery.

23.37 In Chapter 10 (Emergence), it was noted “of the 26 cases, 23 (88%) were judged preventable. One was deemed not preventable, and in two cases, poor charting prevented a judgement. In 11 cases (42%) the absence of, or failure to use, a nerve stimulator was identified by the Panel as contributory or causal. In six patients (23%) the Panel judged that the neuromuscular blocker had been administered too close to the anticipated end of surgery, had been ill-chosen for the duration of the procedure, or had been given in too great a dose for the procedure. In another six, reversal appeared to have been given only after the patient exhibited signs of residual paralysis.

In eight patients (30%) communication between anaesthetist and patient, between anaesthetist and surgeon or between two or more anaesthetists, was assessed as causal/contributory to the episode of AAGA. In one case, the surgeon informed theatre staff that the operation was ‘finished’ when in fact the operation continued; in another, an anaesthetic trainee felt that the consultant had given instruction to reduce the anaesthetic delivery early towards the end of the case. Apparent unfamiliarity with the speed of offset of short acting agents (e.g. desflurane) was cited in four cases and distraction (from handovers or from involvement of other anaesthetists present) in another four.”

Management of AAGA

23.38 When AAGA occurred, HF sometimes contributed to poor quality care during or afterwards. This seemed to exacerbate the adverse experience or potentially contribute to sequelae. Examples included:

- Incomplete communication to patients pre-operatively about the risks of AAGA, especially when the risk was increased (e.g. difficult airway management anticipated, awake extubation planned, relative under-dosing planned due to patient instability).
- Not communicating with patient while AAGA was suspected to be occurring.
- Not deepening anaesthesia when there were signs of inadequate anaesthesia.
- Not adding or deepening anaesthesia when awake paralysis was detected at induction or emergence.
- Not acknowledging, empathising, believing or apologising when patients reported AAGA (including anaesthetists, nurses, surgeons).
- Poor documentation of anaesthetic conduct (including occasional factual inaccuracy).

A patient recalled a burning pain, feeling like a cut, then pulling. The patient was seen by the same anaesthetist afterwards who, the patient felt, did not believe their account and suggested that it had been a dream. The patient was very angry about how the incident had been handled... The anaesthetic record indicated immediate initiation of volatile agent after induction, but the automated machine log showed a gap of several minutes before the vaporiser was turned on.

A patient was upset that they did not get support from the nursing staff in recovery and on the ward...that they were told they had a bad dream and there was nothing to worry about. It was only when the patient spoke to the anaesthetist and recounted what happened that they felt they were believed. On the ward the patient felt they were on a ‘conveyor belt’ getting ready to go home and that the nurses were not sympathetic to their experience.

A patient was very upset by a member of the surgical team who was trying to defend their view that the patient was not aware and that the event was patient imagination.

23.39 There were equally examples when behaviours contrasting to those above appeared to mitigate patient experience and sequelae when AAGA occurred or was reported.

The patient remembered the anaesthetist’s reassuring words that they would soon be asleep, then remembered their arm ‘dropping’ and being unable to hear their breathing. The consultant anaesthetist immediately realised that suxamethonium had been given instead of fentanyl, and administered a dose of propofol whilst continuing to reassure the patient. A single loose ampoule of suxamethonium had been placed lying close to the fentanyl and other induction drugs in the tray. This arose because the hospital had instituted a policy preventing the entire box of suxamethonium being removed from the fridge (to avoid room temperature degradation). Instead, the ODP had placed a single ampoule of suxamethonium on the tray. The patient was supported, a full explanation offered and they suffered no long term impact.

A patient was given suxamethonium before induction inadvertently. The anaesthetist immediately recognised the error and induced anaesthesia. The patient experienced paralysis, was afraid they were dying from a stroke and had flashbacks for 2–3 days afterwards. However, the patient was very reassured by the anaesthetist’s immediate explanation, “I know what’s happening and I can fix it”, during the critical event and had minimal long-term sequelae.

23.40 Excerpts from comments made by Local Co-ordinators offer some insights.

Excerpts from reporters reflections on cases. Classifications are the reporters' and inevitably some overlap with other categories.

Communication

- ... locum Anaesthetist – ? not familiar with surgeon/surgery;
- ... two junior anaesthetists of similar grade with no-one taking complete control;
- ... apparent lack of effective explanation given to patient by medical staff pre-operatively.

Judgement

- ... about adequacy of induction agent and administration of muscle relaxant before confirming loss of reflexes;
- ... possibly underestimated the airway difficulty and might have summoned senior assistance;
- ... in retrospect the anaesthetic was too light and too much reliance was placed on the BIS monitor;
- ... inadequate time between last dose of muscle relaxant and attempt at reversal.

Education

- ... possible that trainee was not aware of need for sedation for transfer;
- ... failure to appreciate that difficulty with the airway, may lead to inability to maintain inhalational anaesthesia;
- ... CT1 not aware of guidelines/recognition of signs required for adequate reversal of NMB during emergence;
- ... understanding of the pharmacokinetics of propofol.

Organisation

- ... consultant not present in the room at the time. Consultant covers a cardiac list simultaneously with the oncology list;
- ... lack of trained assistance at induction and throughout anaesthesia process;
- ... anaesthetist helping with application of tourniquet to aid theatre efficiency;
- ... staff over-stretched. To avoid any delays in the through-put in the list, the patient was brought into the anaesthetic room while still operating on the previous one, with only one anaesthetist working. Another anaesthetist was asked to come from other theatre to take over the care of patient in the theatre. The main anaesthetist started the care of the said patient.

Theatre design

- ... anaesthetic room small/narrow- allows probably one anaesthetist (from the head end) to keep an eye on the monitors – could have helped if the anaesthetic room design was better and bigger;
- ... ASA 3 case scheduled for day-case theatres with inadequate drug stocks;
- ... thiopentone in a central store so not immediately available for mixing.

Distraction

- ... a complicated day, with complex cases, list changes (patients and order) and we had swapped theatre to do this case...
- ... recent bereavement (anaesthetist);
- ... surgeon had agreed early start with anaesthetist the day before, but team were half an hour late sending because waiting for estates staff to repair equipment (which should have been done after early finish previous day). The pointed discussion audible from theatre as anaesthetist was drawing up was reported by him to be distracting, as was the presence of a brand new FY1. In a break with normal routine, the ODA had given him remifentanyl and morphine instead of remifentanyl and fentanyl;
- ... anaesthetist said he was busy in the anaesthetic room drawing up some antibiotics for the next case when the patient moved;
- ... rushing through the list. Issues in recovery with previous patient. Staff changeover;
- ... solo anaesthetist. Late start of busy list with difficult cases;
- ... patient was hypotensive, the vaporiser was turned off, then desaturated which became the focus of the anaesthetists attention – diagnosing and managing an endobronchial intubation in a prone patient at high risk of accidental extubation. The patient had previously had an accidental extubation under general anaesthesia in the prone position.

Tiredness

- ... anaesthetist had a 2-week old baby at home. The procedure was at night.

Guidelines

- ... although we have a transfer guideline which includes guidance on sedation it is not explicit that the patient must have an effective form of sedation provided. The transfer checklist provided as part of this guideline was not used.

Other

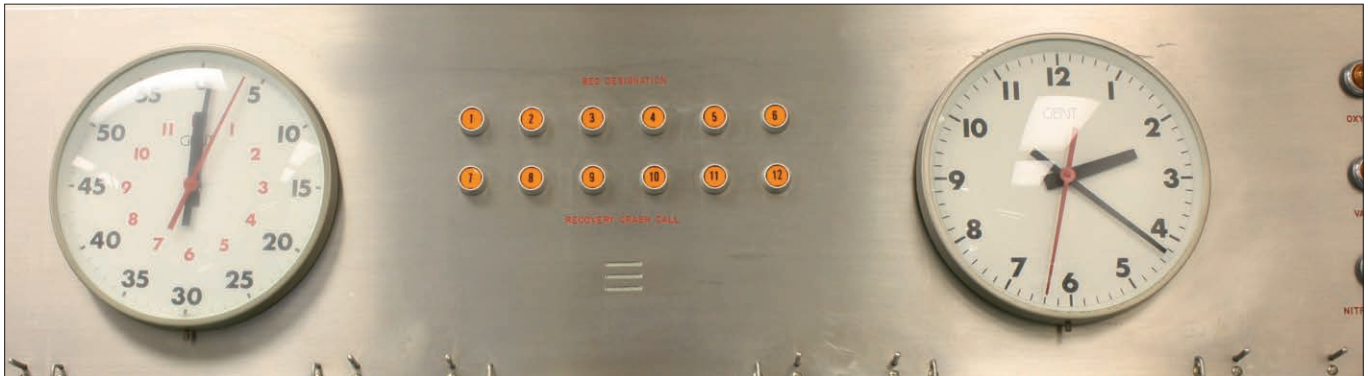
- ... the anaesthetist who performed the operation has limited UK experience, however he/she had overseas experience;
- ... failure to have cannula/arm on display at all times.

All or most of the 'human factors' listed above 'COULD' have some relevance...

DISCUSSION

- 23.41 HF is considered separately in many individual chapters, directly or in passing. Here we make some more broad comments. Similarly many chapters have recommendations relating to HF.
- 23.42 NAP5, despite its limitations in terms of detection of HF, has enabled a greater analysis of latent factors than many previous reports on AAGA, which have tended to focus solely on the final 'action errors'.
- 23.43 As NAP5 and NAP4 share methods in terms of HF analysis, some comparison between projects is relevant. Overall, HF was detected as a contributory or causal factor in NAP5 more often, and as a mitigating factor less often, than in NAP4. While the distribution of contributory factors had similarity between projects (patient and education/training being prominent in both) there were also notable differences (although medication was predictably higher in NAP5, so too was work/environment and task). Quality of care was judged 'poor' in NAP5 almost exactly as often as in NAP4. Finally, HF in NAP5 included issues around airway assessment and management as contributors to AAGA, showing overlap between the two projects.
- 23.44 It is notable from the vignettes, reporters' comments and chapter excerpts included in this chapter that latent factors play an important part in the genesis of action errors leading to AAGA. Indeed almost every factor listed in para 23.21 is identifiable in reports to NAP5.
- 23.45 In the case of drug errors leading to AAGA (see Chapter 13, Drug Error) latent factors were identified in every case. These contributory factors and their potential solutions should be considered both by organisations seeking to prevent drug errors leading to AAGA, and in investigations of such events.
- 23.46 Organisational contributory factors were prominent in reports of AAGA to NAP5, and included staffing, theatre scheduling, busy disorganised lists and communication (all 'threats' in the HFIT model). These raised concerns over safety culture in some cases and indicate that AAGA should not simply be considered to be caused by human errors.
- 23.47 Individual contributory factors that were prominent in reports were education, judgement (decision making) and distraction ('threats' and 'situation awareness' in the HFIT model).
- 23.48 Rushing – whether caused by organisational or individual failings – was prominent in the genesis of some cases of AAGA. Prevention of AAGA likely requires that the organisational and individual circumstances that lead to rushing are addressed.
- 23.49 In Chapter 13 (Drug Error) 'the authors reported "recurring themes in the details of the cases were mention of staff shortages and a pressured environment with 'busy' lists. Some hospital policies for the storage and preparation of drugs appeared misguided and themselves were contributory to error. ...Distractions during critical moments can have very serious consequences. ...Other anaesthetists and circulating nurses are the most common causes of distractions. In terms of individual conduct, it seemed that a lack of vigilance and having several similar sized syringes on the same drug tray may be contributory."
- 23.50 Checklists are a method to improve reliability of complex or time-sensitive tasks. In Chapter 8, Induction, a very simple ABCDE checklist is proposed to address what we term the 'Mind the Gap' problem – which describes failure to maintain anaesthetic drug concentrations soon after induction, and which may be caused by any one of a large number of organisational or individual HF. This and other checklists – for instance, those to be used at emergence in paralysed patients, or prior to transferring critically ill patients – might be developed and tested.
- 23.51 Technology may also be used to reduce error/harm from HF. For example, studies have demonstrated that monitoring of end-tidal anaesthetic concentrations (ETAC) can be as effective as specific depth of anaesthesia monitors (BIS) in the prevention of AAGA (Avidan et al., 2011; Mashour et al., 2012). However, this was best achieved when ETAC alarms were activated, audible and backed up by a text message to the anaesthetist alerting them to the alarm (Mashour et al., 2012). Chapter 8 (Induction) notes "that it was surprising that several reports of AAGA during maintenance were associated with vapouriser problems that went undetected, despite end-tidal monitoring."
- 23.52 Anaesthetic machines are now available with smarter anaesthetic gas delivery and monitoring. These include anaesthetic gas delivery systems that guarantee a specified ETAC, and these may have a role in future prevention of AAGA.
- 23.53 Similarly some machines now have 'single touch' operations that will pause fresh gas and volatile administration but only for a brief period (e.g. one minute) and need only a single touch to restart it. This might reduce the risk of volatile omission after events such as patient repositioning or difficult airway management.

Time pressures and rushing contributed to drug errors and other slips causing AAGA



- 23.54 Technical solutions such as drug scanning systems that may reduce HF-caused drug errors (timing errors, syringe swaps etc) are also available, but require further development and research. Investment would also be required to see their widespread introduction into practice.
- 23.55 Solutions do not always need complex technology and, as an example, drug errors due to confusion between ampoule appearances would likely be reduced by improved communication between theatre and pharmacy departments and drug suppliers. This could be extended to national efforts to set minimum standards for drug packaging and ampoule labelling and, even a colour scheme similar to that currently used for anaesthetic syringe labelling.
- 23.56 In addition to technical solutions, anaesthetists (and those who manage them) need to accept that they are all prone to making errors and should therefore, develop robust individual mechanisms to protect their patients, themselves and their colleagues. The anaesthetist needs to recognise their vulnerability to errors of judgement, knowledge and memory, and that their vulnerability is likely to be increased by tiredness, distraction, hunger etc. All need to contribute to developing environments, equipment and systems of work which minimise the risk of error, and which enable errors to be detected and remedied before harm results.
- 23.57 Human factors – or even simple ‘humanity’ – have a role to play in mitigating the effects of AAGA when it occurs. When AAGA occurred, the response of carers at the time AAGA was taking place (explanation and reassurance – or lack of it) and afterwards (empathy, apology and support – or lack of it), appeared to impact on patient experience and the longer term sequelae. In Chapter 13 (Drug Error) for example, the authors stated “After

an error had happened, the patient experience appeared greatly influenced by anaesthetic conduct. In some cases, hurried efforts were made to reverse paralysis without attending to the patient’s level of consciousness, while in others, reassurance of the patient and ensuring comfort was prioritised. In the latter group, it seemed that patients, on understanding events, appeared to have considerably more benign experiences and fewer or no sequelae.”

IMPLICATIONS FOR RESEARCH

Research Implication 23.1

The extent to which Human Factors play a part in the genesis, experience and sequelae of episodes of AAGA could usefully be further explored using HF research methodology. Large registries such as the ASA Awareness registry and that proposed by NAP5 would be useful starting points.

Research Implication 23.2

The apparent overlap between the role of human factors described in NAP5 and those previously described in NAP4, suggests that the themes discussed are generic. Further research into HF leading to AAGA will therefore likely be potentially relevant to a wider area of anaesthetic practice.

Research Implication 23.3

Further research into human error (active failures) in the genesis of AAGA events should also focus on broader contributory factors (latent failures).

Research Implication 23.4

Further research would be valuable to determine which of the several HF classifications and models for investigating healthcare patient safety incidents is or are best suited specifically to the investigation of AAGA events.

Research Implication 23.5

Further research into innovative methods to reduce both latent factors and action errors that increase the risk of AAGA would be of value. This might include investigation of: (a) the role of checklists in improving reliability of care delivery; (b) the impact of technologies (such as drug scanners, anaesthetic machine alarms and anaesthetic gas delivery systems) in reducing the risk of AAGA, and (c) whether individuals can learn 'safer practice'.

Research Implication 23.6

Qualitative research might examine how best to manage the tension between the drive to increase operating theatre productivity whilst maintaining the quality and safety of anaesthesia.

RECOMMENDATIONS**RECOMMENDATION 23.1**

All anaesthetists should be educated in human factors, so they can understand their potential impact on patient care and how environments, equipment and systems of work might impact on the risk of, amongst other things, AAGA.

RECOMMENDATION 23.2

Investigation of and responses to episodes of AAGA – especially those involving drug error – should consider not only action errors, but also the broader threats and latent factors that made such an event more or less likely.

REFERENCES

- Avidan MS, Jacobsohn E, Glick D, et al. BAGRECALL Research Group: Prevention of intraoperative awareness in a high-risk surgical population. *New England Journal of Medicine* 2011;**365**:591–600.
- Brennan TA, Leape LL, Laird NM, et al. Incidence of adverse events and negligence in hospitalized patients. Results of the Harvard Medical Practice Study I. *New England Journal of Medicine* 1991;**324**:370–76.
- Cook TM., Woodall N, Frerk C. Major complications of airway management in the UK: results of the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society: Part 1: Anaesthesia. *British Journal of Anaesthesia* 2011;**106**: 617–31.
- Cooper J, Newbone R, Long C, McPeck B. Preventable anesthesia mishaps: a study of human factors. *Anesthesiology* 1978;**49**:399–406.
- Errando CL, Sigl JC, Robles M, et al. Awareness with recall during general anaesthesia: a prospective observational evaluation of 4001 patients. *British Journal of Anaesthesia* 2008;**101**:178–85.
- Flin R, Fioratou E, Frerk C, Trotter C, Cook TM. Human factors in the development of complications of airway management: preliminary evaluation of an interview tool. *Anaesthesia* 2013;**68**:817–25.
- Gawande A. *Better. A Surgeon's Notes on Performance*. Profile Books, London 2007.
- Gordon R, Mearns K, Flin R. Designing and evaluating a human factors investigation tool (HFIT) for accident analysis. *Safety Science* 2005;**43**:147–71.
- Gupta KJ, Cook TM. Accidental hypoglycaemia caused by an arterial flush drug error: a case report and contributory causes analysis. *Anaesthesia* 2013;**68**:1179–87.
- Kohn LT, Corrigan JM, Donaldson MS. *To Err Is Human. Building a Safer Health System*. Committee on Quality of Health Care in America. Institute of Medicine. National Academies Press, Washington, D.C (2000). www.nap.edu/openbook.php?isbn=0309068371 (accessed 23 April 2014)
- Lawton R, McEachan RR, Giles SJ, Sirriyeh R, Watt IS, Wright J. Development of an evidence-based framework of factors contributing to patient safety incidents in hospital settings: a systematic review. *British Medical Journal Quality & Safety* 2012;**21**:369–80.
- Mashour GA, Shanks A, Tremper KK, Kheterpal S, Turner CR, Ramachandran SK, Pictou P, Schueller C, Morris M, Vandervest JC, Lin N, Avidan MS. Prevention of intraoperative awareness with explicit recall in an unselected surgical population: A randomized comparative effectiveness trial. *Anesthesiology* 2012;**117**:717–25.
- National Quality Board. Human Factors in Healthcare: A Concordat from the National Quality Board. National Quality Board 2013 www.england.nhs.uk/wp-content/uploads/2013/11/nqb-hum-fact-concord.pdf (accessed 23 April 2014).
- NPSA Seven Steps to Patient Safety: A Guide for NHS Staff. National Patient Safety Agency, 2004. Available from www.nrls.npsa.nhs.uk/resources/?entryid45=59787 (accessed 20 April 2014).
- Paech MJ, Scott KL, Clavisi O, Chua S, McDonnell N. The ANZA Trials group. A prospective study of awareness and recall associated with general anaesthesia for Caesarean section. *International Journal of Obstetric Anesthesia* 2008;**17**:298–303.
- Reason J. Understanding adverse events: human factors. *Quality & Health Care* 1995;**4**:80–9.
- Reason JT. *Managing the risks of organizational accidents*. Ashgate Aldershot Publishing 1997.
- Reason J. Human error: models and management. *British Medical Journal* 2000;**320**:768–70.
- Sandin RH, Enlund G, Samuelsson P, Lennmarken C. Awareness during anaesthesia: a prospective case study. *Lancet* 2000;**355**:707–11.
- Sari AB, Sheldon TA, Cracknell A, et al. Extent, nature and consequences of adverse events: results of a retrospective case note review in a large NHS hospital. *Quality & Safety in Health Care* 2007;**16**:434–39.
- Sebel PS, Bowdle TA, Ghoneim MM, Rampil IJ, Padilla RE, Gan TJ, Domino KB. The incidence of awareness during anesthesia: A multicenter United States study. *Anesthesia & Analgesia* 2004;**99**:833–39.
- Vincent C, Taylor-Adams S, Stanhope N. Framework for analysing risk and safety in clinical medicine. *British Medical Journal* 1998;**316**:1154–57.
- Vincent C, Neale G, Woloshynowych M. Adverse events in British hospitals: preliminary retrospective record review. *British Medical Journal* 2001;**322**:517–19.
- Wilson RMCL, Runciman WB, Gibberd RW, et al. The quality in Australian healthcare study. *Medical Journal of Australia* 1995;**163**: 458–71.