Update in
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Human Error – Cognitive Processes and Interventions to Improve Safety. A Global Perspective

Joyce A. Wahr
Correspondence email: jawahr@umn.edu

INTRODUCTION

All humans err. This truth has been self-evident for thousands of years (Sophocles in his Greek tragedy Antigone writes "All men make mistakes") except, perhaps, for healthcare providers whom others, and even the providers themselves, hold as being capable of error-free practice, all evidence to the contrary. Clinicians who make errors have been faced with onerous guilt and shame, with the unproductive result that individuals and institutions involved in preventable adverse events due to human error have hidden these errors, or, worse, placed the blame for the outcome on the patients' condition or on "misadventure." This flawed approach weakened significantly with the publication of "To Err Is Human", with Dr. Leape stating "All humans err frequently. Systems that rely on error-free performance are doomed to fail."[1] This recognition has been bolstered by a much clearer understanding of the inevitability of human error, and the central role the system plays both in errors and in redesigns that can prevent errors, or designs that at least prevent errors from reaching the patient and causing significant harm.

This paper will explore the cognitive foundations of human error, the system vulnerabilities that enable harmful errors, and then explore what options exist to enhance quality and safety in every setting, regardless of national or local resources. It is obvious that the resources available for patient safety differ widely between countries and within a given country. Mid- to low-resource countries often have well-resourced hospitals in the largest cities, while even vital resources (pulse oximetry) can be scarce in rural settings. What is available in Nairobi is different than what is available in rural Kenya: this disparity can exist even in highly resourced countries such as the US. Resources available in a hospital in Minneapolis are greater than those available on the Leech Lake Native American Reservation. Fortunately, there are ways to improve quality and safety in all clinical settings despite these economic realities.

Before delving into the nature of errors, we need to define several terms. Over many years, a wide variety of definitions have been used for the term "error" and similarly much confusion exists around what defines quality and safety.[2,3] While most definitions have a kernel of truth in them, the existing differences make it difficult to compare various studies: for the purpose of this paper the following definitions will be used. Quality refers to the overarching plan for patient management that reduces inter-provider variability and seeks to provide a consistent best practice that is evidence based. Safety refers to failures in either the design of the plan or in the execution of the plan. For instance, quality in elective caesarean section, in well-resourced locations at least, includes use of a bupivacaine spinal with intrathecal morphine, as well as intravenous tranexamic acid for reducing blood loss; a failure of safety is an unintended swap of bupivacaine and tranexamic acid vials such that TXA is administered intrathecally with devastating consequences.[4] The plan was excellent but the execution was flawed. Errors are by definition unintentional, and involve either the use of a flawed plan, or a failure to carry out a planned action as intended.[5] A violation, by contrast, is an intentional, although not necessarily malicious, decision to not follow those practices deemed necessary to prevent harm.[6] The distinction is important because the interventions to prevent violations are very different from those to prevent error; violations, however, are beyond the scope of this chapter but are explored in depth in other resources.[6]

ERRORS

Cognitive-based Errors

All humans use the same cognitive processes to understand and react to the world around them. Although Dr Reason originally approached errors from the types of actions that caused them (skill-based, rule-based, judgement-based)[7], it is more common now to approach errors by what type of

Joyce A. Wahr MD
University of Minnesota
Department of
Anaesthesiology

thinking was used. As elaborated by Daniel Kahenman,[8] humans think in basically two ways (Table 1) – either "fast thinking" (System 1), rapid, subconscious, effortless, automatic. This type of thinking is related to subconscious recognition of a familiar pattern followed by an appropriate and typically also subconscious response to it. Conversely, "slow thinking" (System 2), is conscious, laborious, and effortful – the type of thinking needed when the current situation fits no pattern stored in the subconscious. Both System 1 and 2 thinking are accompanied by fast, subconscious, automatic perceptions of the world around us, perceptions which also can be erroneous, but for the purposes of this discussion, we will assume most perceptions in the operating room are correct, albeit coloured by context.

Over millennia of evolution, the ability to subconsciously process our immediate world, assess for threats and opportunities, and then nearly instinctually perform the appropriate actions have enabled the human race to flourish.[6] As James Reason puts it, "humans are furious pattern matchers"[7] – subconsciously assessing the current situation, and "matching" it to a memory of a similar situation and then applying solutions that have worked in the past. For infants and children, each pattern or situation is new, but as they explore and grow, similar situations are encountered again and again, and over time these "patterns" become part of their subconscious, whether it is recognizing a familiar building or street corner or performing a well-known task, such as tying shoelaces or intubating a patient. Without being consciously aware of every step of an induction or placement of an intravenous line, anaesthesia providers effortlessly run sequences that have been learned through many repetitions. Pattern matching with the subsequent patterned response is fast and highly efficient – but subject to failures that often are not obvious (except in retrospect!) As noted above, System 1 or "fast" thinking is used relentlessly in our daily actions and is strongly preferred by humans due to the lower cognitive work and ability to multitask (or rapidly task shift). However, when a new situation appears that does not match a pattern stored in our memory, System 2, or "slow" thinking is required. This involves deliberate and conscious working out of the situation from first principles and making sense by using parts of known patterns, then working out an acceptable response. In daily life, humans rarely work just in one realm or the other but switch from fast to slow thinking and then back again, depending on the situation, all while receiving subconscious input (perceptions) about the situation evolving around them. Both types of thinking are associated with errors, but these errors, once understood, can be defended against. Many external devices and safeguards have been developed to protect against these errors, such as bar code medication administration and pin-indexing for volatile gases, but these safeguards are often beyond the financial resources of many hospitals. However, as these errors involve cognitive processes, there are defences that also involve cognitive processes and thus are available to every clinician regardless of external resources.

Errors associated with fast or subconscious thinking relate either to physical errors (Reason's skill-based errors) or subconscious mismatching of patterns (Reason's rule-based errors).[7] Skill based errors involve stumbles or fumbles and occur more often with distractions, disruptions, fatigue, poor lighting or other environmental issues such as noise. Common skill-based errors involve syringe or vial swap whereby the wrong syringe is picked up and injected, or the wrong vial is drawn up into a syringe. Common system vulnerabilities that increase the risk of these errors are look-

Table 1 – Error Types and Possible Interventions

Error type	Error	Example	Intervention in Low Resource	Intervention in high resourced
System 1 (fast thinking) errors: skill based	Vial/syringe swap	Place dopamine in syringe labelled doxapram; pick up the wrong syringe and administer it	No look alike meds; do not place vials alphabetically in med tray; no concentrated meds in anaesthesia cart	Bar-code preparation and administration; no concentrated meds in anaesthesia cart
	Wrong dilution	Diluting 1 mg epinephrine only once not twice (first dilution = 0.1 mg/ml; second 0.01 mg/mL)	Second person check when preparing; if available, pharmacy prepared or prefilled syringes; no concentrated vasoactive meds on cart	Pharmacy prepared or prefilled syringes; no concentrated meds on cart
System 1 (fast thinking) errors: rule based	Wrong rule	Ventilating during CPR	Education to the correct rule	Decision support embedded into electronic health record and ordering systems
	Right rule, wrong situation	Atropine for bradycardia when electrocautery interference is the cause	Education re best practices; collaboration with other team members; cognitive aids	Decision support embedded into electronic health record and ordering systems
System 2 (slow thinking): knowledge based	Mis-diagnosis	Assume hypotension is vasodilation when it is occult blood loss	Communication with surgeon; cognitive aids	Communication with surgeon; cognitive aids

alike vials or ampoules, placing dangerous solutions (hypertonic saline) on the same shelf as the common ones such as dextrose or normal saline, and the relentless pressure to do more and do it more quickly. A common skill-based error is beginning a sequence of steps, being interrupted, and then returning to the sequence but at the wrong place, such as omitting the second dilution when preparing a syringe of dilute epinephrine or phenylephrine. Failure to recognize a dangerous concentration of heparin, epinephrine or insulin is common and represents an error trap – one which has been made with distressing frequency despite being recognized and guidance provided by many safety agencies such as the recommendations for managing high-risk medicines listed by the WHO, The Joint Commission, or the Institute for Safe Medication Practice.[9] Skill-based errors can also involve a break in the performance of a familiar routine, such as retained wires during central line placement or omitting or repeating a step in a medication administration during a case (omitted or duplicate antibiotic doses). It should be noted that there are some errors that appear to be skill-based, such as inability to place a spinal, or putting a Seldinger needle into the carotid artery instead of the internal jugular vein, but these errors are more accurately termed technical errors. These errors are failures to carry out a plan as intended, but are not related to cognitive processes, but rather represent situations when the patient's anatomic complexity or anomalies exceed the provider's skill or experience. While technical errors can certainly harm patients, prevention efforts are different from those used to reduce skill-based errors (see Interventions and Safeguards below).

Rule-based errors occur when an existing pattern is "matched" erroneously. Daniel Kahneman won a Nobel prize for his work on the behaviour of decision making, particularly when decision making behaviours don't seem to be rational.[8] He postulated that these decisions represent cognitive "shortcuts" that make decision making easier such as the "rule" to give atropine when the heart rate is 20. He termed these shortcuts "heuristics", and they are what Reason called rule-based decisions. Heuristics reduce cognitive work but open the door to Reason's rule-based errors and to cognitive biases[10] which can influence the choice of a diagnosis. Rule-based errors can involve the use of an outdated rule, use of the right rule at the wrong time, or use of the wrong rule for the situation.

Ventilating a patient during cardiopulmonary resuscitation is an example of an outdated rule. Current guidance around resuscitation efforts is focused only on chest compressions – ventilation occurs with chest compression alone making bag-mask or mouth to mouth ventilation unnecessary and possibly detrimental (decreasing the effectiveness of chest compressions). Diagnostic errors are often due to erroneous pattern matching (choosing the wrong rule) such as believing the cause of chest pain to be myocardial infarction, when the real cause is a dissecting aortic aneurysm. Application of a good rule in the wrong situation also is a rule-based error, such as giving atropine to treat extreme bradycardia when the actual cause is electrocautery interference with a pacemaker. Diagnostic or rule-based errors may occur due to inadequate training, experience, or outdated knowledge, but can occur even when the provider is very well trained and experienced – often due to cognitive biases.[10] The availability heuristic refers to the fact that our subconscious will naturally pick the "pattern" that is the most available, whether because it is the one seen most often, or the one seen most recently – chest pain in the emergency room is most often myocardial infarction and much less often is a dissecting thoracic aneurysm. The "pattern" that is most available to our subconscious is the one that comes to mind, and is often complicated by another bias, that of confirmation, where our minds interpret new evidence as confirming our chosen diagnosis. Loss aversion bias refers to the fact that we humans fear loss more than we value gain, and can make it harder to accept that our current diagnosis might be wrong. Cognitive biases can influence either subconscious or conscious thinking and can be difficult to correct even when one is aware of them.

As noted above, errors include a failure to design an appropriate plan, even when the situation is correctly understood. Failure in devising a good plan can result from cognitive biases as noted above, poor application of first principles or logic, inadequate knowledge of best practices, inadequate time to consider alternative plans, and inadequate monitoring as the situation evolves and requires a change in the original plan.

System-based Errors

A frustrating aspect of safety is that the same error seems to be made again and again, despite recognition of the problem and attempts to correct it. Any error made by one provider is likely to be made by other providers - that is, certain common situations make errors more common, such as look-alike vials, or poor equipment design. Reason describes this situation: "The same situation keeps producing the same errors . . . even though quite different people are involved. That surely indicates we are dealing with error prone circumstances rather than error prone people. We are dealing with error traps."[11] Often these "traps" cannot be corrected by individual effort, but require system redesign and changes. Common examples of system vulnerabilities include:

- Production pressure to do more in a shorter time frame can lead to distraction, omission of critical double checks, failure to follow safety guidelines (labelling all syringes)
- Non-standardised concentrations of high-risk medications (e.g., insulin, epinephrine, norepinephrine)
- Non-standardised processes for any aspect of healthcare delivery
- Frequently changing medication suppliers with consequent look-alike vials or ampules
- Stocking of unusual preparations in usual locations (hypertonic saline stored with normal saline)
- Inadequate staffing, leading to working while fatigued or ill, production pressure and chaotic situations
- Failure to deal with disruptive and disrespect between and within hospital disciplines[12]
- Failure to correct providers who habitually violate policies (physicians and hand hygiene)
- Weak safety culture (missing the traits of high-reliability organisations)[13]

- Choosing weak interventions such as retraining over more robust ones such as forcing functions (bar code medication administration and automatic dispensing cabinets)
- Disconnect between leaders view of "work as prescribed" versus the frontline knowledge of "work as done"[14]
- Inadequate tools or systems (central line carts to reduce central line infections)[15]

Communication-based Errors

Communication errors do not strictly fall into either System 1 or 2 thinking, but are likely the most common contributing factor to errors made anywhere in the hospital.[16-19] Communication failures can be due to wrong time (information give too late), result from information directed to the wrong individual or group (wrong audience), be due to wrong or unclear content and wrong purpose (issues not resolved), or to omission of critical facts.[20] Operating room teams often use slang or jargon that can be wrongly interpreted by someone new to the group. Even standard names and numbers can be misunderstood or misheard (hearing fifty instead of fifteen, or eleven instead of seven). ORs also tend to be noisy places, where communication is not only lost in the noise, but muffled by masks. Communication failures occur often in the hand-over of a patient's care from one individual or group to another, both within the operating room and from the OR to the recovery unit and then to the ward.[21] Furthermore, information about a patient degrades across the continuum of care – if an allergy is omitted in the first handover, it will be omitted with each subsequent handover together with the omissions of that latest handover.[22]

These handovers occur frequently in the operating room, as one provider relieves another for a break or lunch, and then at the end of the day, as a night shift relieves the day shift providers. Short mid-case handovers do not seem to carry significantly risk, but still frequently involve omitted information about last narcotic or antibiotic dosing with subsequent duplication by the provider providing relief. Terminal handovers which occur as the primary day team turns care over to a relieving team, may be more dangerous, with several studies showing an increased mortality in patients whose anaesthesia care involved a terminal handover versus those that did not.[23] Relying solely on memory without a checklist to prompt recall results in many more omissions than when a protocol or checklist is used.[24,25]

All of the errors noted above can occur more frequently when a provider is fatigued, a situation that seems inevitable given the need to provide anaesthesia services 24 hours a day, 7 days a week. Simulation studies as well as real-life studies show that fatigue slows reaction time and reduces accuracy.[26,27] One noted study showed that 18 hours of wakefulness slowed reaction time as much as drinking alcohol.[28] Many providers cite situations where they made an error or nearly made an error when fatigued.[29,30] One could argue that adverse events occurring due to provider fatigue represent violations rather than errors:[6] however, if the fatigue is due to a necessity to care for sick patients due to limited resources, the "violation" is both necessary and appropriate. An experienced clinician will, however, recognize fatigue in themselves, and alert their teammates to the danger and ask for double checks during critical periods (coming off bypass) or tasks (measuring out insulin dose).

INTERVENTIONS AND SAFEGUARDS

Local Incident Reporting Systems and Safety Culture

It should be recognized that, because we all think alike, the errors we commit are also alike. These are the "error traps" noted above, and should not be explained by blaming the error-maker as "careless" or "error prone."[31] These error traps represent situations where anyone could easily make this error, and therefore a system redesign is the best way to eliminate a vulnerability. Hazards and vulnerabilities differ considerably between hospitals depending on local culture ("the way we do things here"), equipment (pulse oximeters available everywhere or not), staffing and training of the staff, and so on. Failure to recognize hypoxia is much more likely to happen in a recovery unit that does not have pulse oximeters than in one that does.

Since vulnerabilities are local, the best way to identify and correct these local issues is a local incident reporting system that allows individuals to report their errors or near misses without fear of blame, shame, or punishment.[32,33] Incidents that are reported should be approached with curiosity and compassion and analysed with a view to what system hazard allowed the incident to occur. Interventions proposed to reduce these hazards should be examined to be certain that they can achieve the desired goal, and with an understanding that interventions such as re-education or re-training are very weak, and often are not effective (Table 2).[6] Stronger interventions such as redesigning dangerous processes (requiring a second person check of insulin or heparin concentrations and doses) or using structured communication techniques are more useful. Strongest of all are forcing functions, such as the pin-indexing of gas canisters,

Table 2 – Effectiveness of Interventions to Improve Safety

Weaker Actions	Warnings and labels New procedures, memoranda, policies Training, re-education Additional study or analysis
Intermediate Actions	Checklists or cognitive aids Redundancy Enhanced communication techniques such as speak-back, three-way communication Decision support embedded in computer order entry systems (can over-ride) Improved labelling of medications Elimination of look-alike, sound-alike medications Separation of dangerous medications from routine medications (hypertonic saline) Elimination of concentration medications from anaesthesia carts
Strong Actions	Forcing functions (pin-indexing of gas tanks, unique small-bore connectors for neuraxial route, anaesthesia machines with anti-hypoxic gas mixture function) Standardization of equipment New device usability testing prior to purchase

or computer-based hard stops when a medication is ordered in the face of a pre-existing allergy, or an erroneous dose is entered into a smart pump. Unfortunately, weak interventions are inexpensive and easy to implement, while strong interventions are often costly and may require an extensive change in manufacturing, as exemplified by the new unique small-bore connectors, designed to eliminate wrong route errors. As noted above, resource constrained hospitals may not be able to afford the strongest interventions; this does not mean that they should not employ the weaker ones but that there should be an awareness of the strength of every intervention.

A strong local safety culture is key to reducing errors and requires overt support from top leadership. Although there are inexpensive ways to improve safety, virtually all of them cost something, even if it is simply working at a (slower) pace that allows for double checking, or refusing to be rushed, i.e., resisting production pressure. Without a strong commitment from the top executives of any institution, grassroots efforts are likely to fail. There are nearly always those who resist change, even if it is simple such as implementing the WHO Safe Surgery Saves Lives checklist, and strong leadership is required to establish the expectation that these preop checklists and briefings are an expectation, not a suggestion.[34] Hospital leadership also needs to ensure that reported incidents are met with curiosity and demonstrate a culture of accountability where unintentional errors are met with system and process redesigns, but intentional violations are met with accountability.

Over time, a strong commitment to safety by hospital leadership will change safety culture. This has been demonstrated by entities such as aviation, the military and the nuclear power industries who are known for their ability to perform complicated and dangerous functions without error (high-reliability industries).[35] These entities have characteristics in common, and these traits can be implemented in any hospital at little cost. These habits can also be practiced by individuals in their day-to-day work. The first is a preoccupation with failure, or always being alert to where the next patient is likely to be hurt. This approach can uncover hidden error traps that have become accepted as "how things get done" even if it is a dangerous approach. Another trait is closely related to the first and is sensitivity to operations – the leaders are aware of what goes on at the front lines, so that they can understand what work conditions might make healthcare delivery more dangerous (look alike vials, bar code scanners that do not work, work arounds that are required to get things done but that make it more dangerous.) Leaders need to understand the work as it is really done, not as they imagine it is getting done, or as workers report that it is getting done.[14] This requires leadership rounds in the ORs or on the wards to hear from frontline workers and understand local hazards. A third trait follows the same theme, deference to expertise, i.e., asking front-line workers, who know the job well, what can be done to make it safer.

Policies, Procedures, Standardised Order-Sets

As noted in Table 2, policies and procedures tend to be weak interventions in reducing errors, but by setting a standard way that different processes are done both identifies for all the accepted best practice and allows recognition of an error more quickly. Computerized standardised order sets can include checks such as always including an order for a blood glucose to be done an hour after insulin is ordered. In high resource settings, these safeguards can be built into a computerized provider order entry; in low resource setting, more manual checks can be instituted, such as a process to hang a sign on a patient's bed reminding all that a blood glucose should be checked at such and such a time. Care maps can be written that spell out the evidence based best practice for a given condition. As noted above, in high resource setting, anaesthesia for a caesarean delivery would include a spinal with bupivacaine; in low resource settings with no trained anaesthesia providers, the dose of ketamine can be clearly noted together with what monitors are required.[36]

Technology

In high resource institutions, a multitude of technical safeguards are available, such as bar code medication preparation and administration devices that will scan the label of a vial and print a correct syringe label that can be scanned during administration to provide visual (medication name displayed on computer screen) and audible (name announced) clues that the syringe is the one intended for administration. Scanned medications can then trigger a best practice alert to confirm weight-based dosing or dose adjusted for renal function.[37] Bar coded medication administration (BCMA) is widely adopted in high resource hospitals on the wards, but not yet in all procedural areas: there is clear evidence that BCMA does improve medication safety in anaesthesia and should be implemented everywhere it is affordable.[38,39] Pharmacy prepared or pre-filled medications eliminate the errors associated with provider prepared syringes or infusions, particularly when dilution is required, as well as removing concentrated medications from individual anaesthesia carts. Pre-filled syringes eliminate one possible error category, that of vial swap, which is especially important in the current environment with on-going medication shortages which bring new appearing labels for a given medication. Smart pumps can be pre-programmed with medication "libraries" such that when a pump has the medication name entered only appropriate dose ranges are allowed ("guard rails"). These electronic libraries can be easily updated by the pharmacists as needed.

These technical safeguards may not be available in our low to middle resource institutions, but alternative safeguards are available, albeit somewhat weaker in preventing error. These include a quiet distraction free location to prepare medications for the next case. Perhaps the most important intervention is using a two person check for preparation of a high-risk medication such as verifying with another provider or nurse the concentration of the insulin in the vial and the correct dose drawn up; doing double-dilution of phenylephrine or epinephrine with another provider and doing multiple syringes at one time; quietly stating the name of the medication to oneself while reading the label syringe just prior to administration. In general, mindfully inviting the conscious brain to oversee the unconscious actions will reduce errors.

Cognitive Safeguards

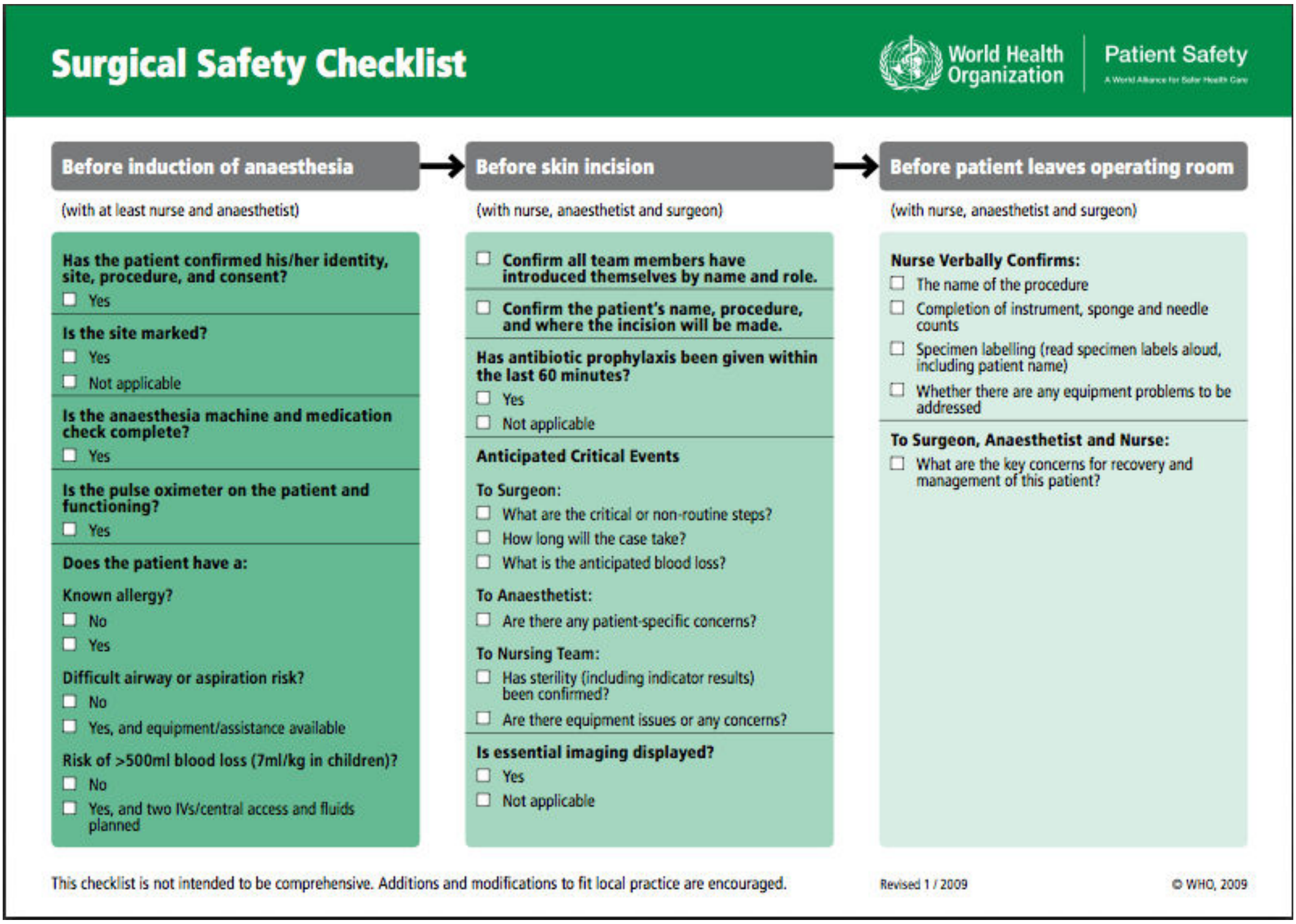
As noted above, unconscious biases play a significant role in cognitive errors, whether those be making a diagnosis or choosing a plan of action. Although the decisions are often made subconsciously (fast thinking or "intuition")[8], the conscious mind can be trained to "oversee" these subconscious decisions to examine them for possible biases or flaws. In the case of diagnoses, a provider can train themselves to always list at least 3 possible diagnoses other than the one that immediately springs to mind; always consider the diagnosis that would be the most dangerous and consciously work through a process to exclude each diagnosis. Similarly, when choosing a medication to treat a diagnosis, consciously ask if this is the best medication or plan of action. Involving a colleague in the decision-making process brings another point of view and involves someone who will not have the same stored memories, who will have a different "availability heuristic." The saying that "two heads are better than one" refers to the fact that another provider may recognize different elements or view the situation differently. Hearing from all members of the team provides many points of view and may bring to light information known to one but not to others that can help uncover errors. In the OR, announcing a deteriorating situation ("I am having trouble with the patient's pressure) can bring to light new information (surgeon admits that more blood is being lost than expected).

A simple means to prevent skill-based errors is a brief pause before initiating a sequence or to confirm at the end of a sequence that all steps were completed; this allows the conscious mind to verify that the intended action is correct and/or was done correctly. Skill-based errors are more common when the cognitive workload is high (managing multiple issues at the same time) or when distractions are present. Extraneous conversations, phones ringing, staff announcing questions to be decided ("does the next patient require an arterial line?") or problems to be solved ("the blood bank does not have blood available for the next case"). Time pressure and working against the clock can lead to shortcuts that result in steps being skipped or safety checks are not completed.

Communication Safeguards

These safeguards are not costly and can be implemented in even the most resource limited hospitals. Restricting conversation in the OR to that pertaining to the case goes a long way to reducing noise, as does limiting the number of people in the OR. Communication protocols can be implemented without expense other than training or education. The protocols include directed communication,

Figure 1– World Health Organization Safe Surgery Checklist (Available at https://www.who.int/teams/integrated-health-services/patient-safety/research/safe-surgery/tool-and-resources; accessed July 7, 2023)



Surgical Safety Checklist

World Health Organization | Patient Safety — A World Alliance for Safer Health Care

Before induction of anaesthesia → **Before skin incision** → **Before patient leaves operating room**

Before induction of anaesthesia

(with at least nurse and anaesthetist)

Has the patient confirmed his/her identity, site, procedure, and consent?
- ☐ Yes

Is the site marked?
- ☐ Yes
- ☐ Not applicable

Is the anaesthesia machine and medication check complete?
- ☐ Yes

Is the pulse oximeter on the patient and functioning?
- ☐ Yes

Does the patient have a:

Known allergy?
- ☐ No
- ☐ Yes

Difficult airway or aspiration risk?
- ☐ No
- ☐ Yes, and equipment/assistance available

Risk of >500ml blood loss (7ml/kg in children)?
- ☐ No
- ☐ Yes, and two IVs/central access and fluids planned

Before skin incision

(with nurse, anaesthetist and surgeon)

- ☐ **Confirm all team members have introduced themselves by name and role.**
- ☐ **Confirm the patient's name, procedure, and where the incision will be made.**

Has antibiotic prophylaxis been given within the last 60 minutes?
- ☐ Yes
- ☐ Not applicable

Anticipated Critical Events

To Surgeon:
- ☐ What are the critical or non-routine steps?
- ☐ How long will the case take?
- ☐ What is the anticipated blood loss?

To Anaesthetist:
- ☐ Are there any patient-specific concerns?

To Nursing Team:
- ☐ Has sterility (including indicator results) been confirmed?
- ☐ Are there equipment issues or any concerns?

Is essential imaging displayed?
- ☐ Yes
- ☐ Not applicable

Before patient leaves operating room

(with nurse, anaesthetist and surgeon)

Nurse Verbally Confirms:
- ☐ The name of the procedure
- ☐ Completion of instrument, sponge and needle counts
- ☐ Specimen labelling (read specimen labels aloud, including patient name)
- ☐ Whether there are any equipment problems to be addressed

To Surgeon, Anaesthetist and Nurse:
- ☐ What are the key concerns for recovery and management of this patient?

This checklist is not intended to be comprehensive. Additions and modifications to fit local practice are encouraged.

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where the speaker always begins by using the receiver's name (or names) and not going further until the intended recipient is paying attention. Speak-back communication is well recognized to reduce communication errors and is mandatory in many high-risk industries such as the military, commercial aviation, and nuclear power plants. Speak-back is also known as three-way: the speaker states the concern or instruction using the name of the intended receiver, the receiver then repeats back the instructions, and the speaker states "that is correct" or corrects any misunderstanding. Use of the NATO alphabet (Alpha, Bravo, Charlie, Delta, etc) provides clarity for patient names and medications. Other conventions can be used but the NATO alphabet uses names that are each unique in sound as opposed to the common "d as in dog" which could easily be "b as in bog". Numbers that sound alike such as fifteen and fifty should be clarified as "fifteen, that's one-five".

Although not strictly structured communication, preoperative briefings reduce communication failures by making sure that all OR team members have the same information about the case to be done, what equipment will be needed, and what the risks are. The World Health Organization Safe Surgery Checklist (Figure 1, which can be accessed at https://www.who.int/teams/integrated-health-services/patient-safety/research/safe-surgery) has been shown to reduce surgical mortality by 30%. The pre-induction section includes identification of patient, procedure, site of surgery and consent; anaesthesia safety check (machine, suction, etc.), pulse oximeter on patient and functioning, and review of allergies, risk of blood loss, and difficult airway. The time out is the "brief" and includes introduction of the team members by name, once again confirmation of patient, procedure and location of surgery, anticipated critical or risky steps, antibiotic given, and a question about any concerns anyone has. Finally, before leaving the OR at the end of the case, the procedure intended and the one actually done are confirmed, needle and sponge counts are confirmed, specimens removed are appropriately labelled, and any concerns for recovery and postoperative management. Although it seems lengthy, multiple studies have shown that this checklist and briefing can be done in about 2 minutes, a very small time investment to gain a 30% reduction in patient deaths!

Simulation – High- and Low-Fidelity

Many high resource hospitals, especially those that are academic, have sophisticated simulation laboratories with "high-fidelity" that use manikins and sophisticated monitor displays to allow teams to practise the approach to rare but high risk crisis situations. These simulations can improve the speed with which teams manage crises and improve adherence to best practice protocols for many emergencies.[40] These laboratories can be expensive and are typically beyond the resources of many hospitals even in high resource countries. Low fidelity simulation, however, is low cost, and can be implemented by virtually any team. Many labour and delivery units on a regular basis pull a team together when the work-load is low, and draw a crisis situation from a jar such as prolapsed cord. The team then identifies what steps need to be done and in what order they should be completed, practise identifying a leader for the crisis, and work through which roles are required and who should take on that role.

Barriers to Implementation of Safeguards

Cost is one of the greatest barriers to implementing safeguards, as the strongest preventative measures are typically the most expensive. However, even very low-cost interventions are often not implemented (speak-back communication), most often due to human nature and an unwillingness to 1) accept that all of us will make errors; 2) an unwillingness to openly report errors, and then 3) an unwillingness to "be told what to do." We all have our preferred ways of doing things, and strongly resist that another way may be better or safer. Physicians often demand "autonomy" but we need to accept that the "right" to our autonomy should not and cannot be placed above the patient's right to receiving evidence based best practices as well as the safest practices. Safer care of our patients is possible – we simply must do it.

CONCLUSIONS

- Humans are furious pattern matchers and the subconscious processes involved lead to specific errors such as skill and rule based; when no appropriate patterns match, humans must resort to slow, effortful and conscious decision making where errors commonly arise from inadequate information or knowledge, and cognitive biases
- Interventions to improve safety include:
    - Top leader involvement in comprehensive safety programmes (non-punitive incident reporting systems, root cause analyses, unit walk arounds, establishing a just culture).
    - Technology such as electronic health records, with best practice alerts, standardised order sets and decision support, bar code medication administration, smart infusion pumps are strong interventions to improve safety.
    - Non-technical skills such as team training, use of standardised communication protocols and checklists and briefings are also powerful elements of a safety culture.
- Significant barriers to achieving patient safety include lack of transformational leadership, an unwillingness to financially invest in safety teams, adequate staffing and technology, and the personality traits that lead to a hero mentality or a refusal to adopt safety behaviours.

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