A Cognitive Autopsy Approach towards Understanding Diagnostic Failure

Pat Croskerry MD, PhD, FRCP(Edin)

Director, Critical Thinking Program

Division of Continuing Medical Education

Professor of Emergency Medicine

Dalhousie University Medical School

And

Sam Campbell MB BCh, CCFP(EM), FRCP(Edin)

Research Director, Charles V Keating Emergency and Trauma Centre

Queen Elizabeth II HSC, Halifax, Nova Scotia.

Professor of Emergency Medicine

Dalhousie University.

Halifax, Nova Scotia, Canada.

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Abstract: Diagnostic failure has emerged as one of the most significant threats to patient safety, and it is important to understand the antecedents of such failures. A consensus has developed in the literature that the majority are due to individual or system factors or some combination of the two. A major source of variance in individual clinical performance is due to cognitive and affective biases, however, their role in clinical decision making has been difficult to assess partly because they are difficult to investigate experimentally. A significant drawback has been that experimental manipulations appear to confound assessment of the context surrounding the diagnostic process itself. The present qualitative study uses a detailed narrative account of selected actual cases of diagnostic error to explore the effect of biases in the 'real world' emergency medicine (EM) context.

Thirty anonymized EM cases were analysed in depth through a process of root cause analysis that included an assessment of error producing conditions, knowledge-based errors, and how clinicians were thinking and deciding during each case. A prominent feature of the study was the identification of specific cognitive and affective biases – through a process called cognitive autopsy. The cases covered a broad range of diagnoses across a wide variety of disciplines. A total of 24 discrete cognitive and affective biases that contributed to misdiagnosis were identified and their incidence recorded. 5-6 biases were detected per case, and observed on 168 occasions across the 30 cases. Thirteen error-producing conditions (EPCs) were identified. Knowledge-based errors were rare, occurring in only 5 definite instances. The ordinal position in which biases appeared in the diagnostic process was recorded. This study provides a base-line for understanding the critical role that biases play in clinical decision making and sheds light on important aspects of the diagnostic process.

Introduction:

Medical error is now considered a leading cause of death in the United States.[1] Of the wide variety of medical errors, diagnostic failure appears to be a significant if not the most important contributor, occurring in 10-15% of cases,[2] and may be associated with a high degree of morbidity and mortality. It appears that physician's clinical judgment, their cognition, how they think, bears the brunt of diagnostic failure.[3,4] Like all humans, emergency physicians are vulnerable to failures in rationality, and leading cognitive scientists have identified cognitive and affective biases as the major impediment to attaining rationality.[5] Multiple types of biases in EM were described in this journal almost two decades ago.[6] Thus, we might have better insights into the process of clinical decision making if we had a better understanding of the behaviour of biases in real clinical situations. With undifferentiated patient presentations, new doctor-patient interactions, high levels of uncertainty, low signal to noise ratios, and a constantly changing environment the emergency department (ED) has been described as a 'natural laboratory for error',[7,8] and thus an optimal clinical setting in which to study biases and other forms of cognitive failure.

A major difficulty in studies of bias in medicine lies in their experimental (*in vitro*) investigation. The diagnostic process is extraordinarily complex with upwards of about 50 factors involved,[9] adding significant context to any clinical decision that is made. The classic experimental approach in which the impact of specific independent variables (e.g. characteristics of the decision maker, homeostatic challenges in the decision maker such as fatigue, cognitive loading, sleep deprivation, and context) on the dependent variable (diagnostic competence) is assessed requires the control or elimination of as many independent variables as possible. But this process inevitably isolates the diagnostic process from the very properties by which it is characterised in the clinical setting, leading to serious challenges to the external and ecological validity of this approach. As Gruppen and Frohna put it: "*…too often, studies of clinical reasoning seem to take place in a vacuum. A case or scenario is presented to subjects, usually in written form, stripped of any 'irrelevant' noise. The traditional methodology of providing clinical cases that are decontextualized and 'clean' may not be a particularly valid means of assessing the full range of processes and behaviors present in clinical reasoning in natural settings*."[10] Thus. the relevance of such studies towards understanding real-life clinical practice may be seriously questioned.[11,12,13] The common method of studying diagnosis using computer screens that display clinical vignettes deprives the cases of their clinical context, resulting in a limited understanding of what actually happens in clinical practice, yet this is the dominant methodology. A review of studies of cognitive biases and heuristics in medicine found that 77% of 213 studies reviewed were based on hypothetical vignettes.[12] The de-contextualizing that occurs by studying diagnosis in the laboratory setting compromises the ecological validity of such studies. Instead, Wears and Nemeth [14] have proposed abandoning laboratory studies in favour of 'real world' studies that focus on context and on the intuitive processing that experts use. *Post hoc* analyses can be done to reconstruct the clinician's experience at the time of the event, by interviewing the clinician, and by promoting self-awareness and introspective processes. Thus, the phenomenon may be studied *in vivo,* in the actual context in which it occurs. Jim Reason referred to this approach as 'corpus gathering' – the first step in the process of classification of error.[15] The present report explores this approach.

***Method*:**

Clinical cases in which a diagnostic failure occurred, were referred for review to the clinical chief of either of two EDs, with annual censuses of 40,000 and 75 000 visits, respectively. The cases were initially assessed in the context of patient safety, and aimed at shedding light on the origins of diagnostic failure. On review of the case, immediate efforts were made to document as much collateral information as possible, including prevailing conditions in the ED, and to elicit the opinions of clinicians and nursing staff about what was going on during the case. Cases were identified as suitable for inclusion if they demonstrated diagnostic errors and if the emergency physician involved had been willing to engage in an intensive process of ‘cognitive autopsy’,[16,17,18] providing comprehensive detail about the case, and taking part in guided reflection in an attempt to understand their clinical reasoning and decision making through their involvement in the case. Both clinical chiefs were well-versed in cognitive aspects of clinical decision making and were continuously involved in clinical and didactic teaching on the subject.

30 cases were selected in which an adverse diagnostic outcome of some significance had occurred, and where the case represented the standard process of evaluation in an emergency department: Patient presents to the ED → is seen and assessed by one or more physicians → may complete diagnostic imaging and laboratory investigations → is diagnosed → disposition is arranged. Any cases that did not follow this ‘typical’ format were excluded. Thus, cases in which this sequence was changed e.g. a patient had been transferred from another department, or from another hospital into the ED, or seen recently in the same ED, were excluded. Cases were also excluded if they involved missed injuries of minimal consequence such as minor fractures or minor foreign bodies or if they involved mainly procedural errors (e.g. failed intubations, failed central lines, poor application of a cast, poor suturing technique, minor protocol violations).

The selected cases were examined in detail for concurrent error producing conditions (EPCs)[19] and any evidence of cognitive or affective biases, or other notable cognitive failures including knowledge deficits, and logical failures in reasoning. Current definitions of cognitive biases in the medical setting were followed.[20,21] A summative assessment and evaluation of the biases, EPCs, and knowledge deficits was made to determine if any particular patterns emerged. Also, an ordinal position analysis of identified biases was completed to determine if specific biases appeared in any particular sequence in the course of a typical case.

***Results*:**

A wide variety of clinical diagnoses was apparent, reflecting the range of conditions that can be associated with misdiagnosis, may be seen in a general ED (Table 1). There was very little overlap in diagnoses and most disciplines were well represented.

Table 1 about here

Table 2 about here

Figure 1 about here

In all, 24 discrete biases were identified along with their respective frequencies in these 30 clinical cases (Table 2). Typically, there were 5-6 biases per case. *Anchoring* was identified as the most common bias, followed by *confirmation bias*, *diagnosis momentum*, *premature closure* and *unpacking failure*. The order in which biases appeared in the diagnostic process is shown graphically in Figure 1 and their mean ordinal position in Table 2. The total number of occasions on which a discrete bias was identified was 168.

The 30 cases were analysed for other error producing conditions (EPCs) which might have predisposed clinicians and staff to error. Twelve were apparent in which an association between the EPC and an error appeared causative or at least contributory. Fatigue was the most common (Table 3). A total of 28 instances of EPCs were identified, representing potential risk factors for patient safety events (PSEs), and which appeared to contribute to adverse outcomes in some cases. Actual knowledge deficits were uncommon and were identified in only 5 cases (Table 4). Attending Emergency Physicians were responsible for a definite knowledge deficit in 3 of these cases with trainees in the other two.

Table 3 about here

Table 4 about here

Discussion: although a number of studies from most disciplines in medicine have been reported illustrating the impact of particular biases,[22] the accounts have typically been for one or two biases acting in isolation, and usually without significant contextual detail. An exception is a recent study in which multiple biases were studied in a series of high-fidelity clinical simulations.[23] This innovative study design avoids some of the difficulties associated with *in vitro* studies, but thus far these studies are rare. In the future, it may be possible to build more such *in simulo* cases using the supportive detail of cases that have been subjected to cognitive autopsy.

The present study is the first to catalog the behaviour of and potential interaction between significant numbers of biases in their natural clinical setting, together with their juxtaposition to each other, alongside knowledge deficits, EPCs, and workplace conditions prevailing at the time. We might expect that when biases occur they will trigger varying degrees of consequence. At one extreme, clinical behaviour subsequent to the bias may be significantly changed, while at the other there may be minimal or no consequence. As many biases are subconscious, the presence and impact of biases may often simply escape notice, the phenomenon unfolding invisibly. Other consequences may involve inter-relationships between biases e.g. when *anchoring* occurs without adjustment it may subsequently trigger *confirmation bias* which may, in turn generate further error.[24] Anchoring has been associated with delay to diagnosis, as well as *premature closure*,[23] and *overconfidence* may also lead to premature closure.[24] Similarly, if *framing bias* is not recognised and corrected, *ascertainment bias* would be expected such that clinicians come to see what they expect to see i.e. how they were framed in a classic set-up.

Recently, Dror et al have proposed two biases that appear to have such knock-on effects, *snowball bias* and *cascade bias*.[25] With snowball bias: 'as one piece of evidence influences another, then greater distortive power is created because more evidence is affected (and affecting) other lines of evidence, causing bias with greater momentum, resulting in the increasing snowball of bias', while cascade bias 'arises as a result of irrelevant information cascading from one stage to another, e.g., from the initial evidence collection to the evaluation and interpretation of the evidence.' In some respects, both bear similarities to *triage cueing* [26] and *diagnosis momentum*[26] in medicine when, for example, paramedics at the scene, or triage personnel at a later stage, form initial impressions that later turn out to be irrelevant and even misleading. Rang described a similar phenomenon where a false positive result of an unnecessary test led to a cascading 'medical adventure'.[27] Seshia et al [28] describe a potentiated form of bias referred to as *cognitive biases plus* where several cognitive phenomena e.g. cognitive biases, conflict of interest, logical fallacies, and ethical violations, may augment and interact with each other to collectively distort clinical decision making.

All biases reported here were qualified as 'probable' as there is no tangible proof of their occurrence; they are usually invisible. Nevertheless, when clinicians are interviewed, or encouraged to reflect on what they were thinking, it is often possible retrospectively to describe a bias that provides a reasonable explanation for the behaviour that was observed and the events which transpired. While it cannot be stated with certainty that a particular bias was responsible for a particular piece of behaviour, given the detailed descriptions and definitions of specific biases in the literature, strong inferences can often be made such that the likelihood of a particular bias being present can be estimated with reasonable probability. A second caveat is that what may be seen by one observer as a clear case of a particular bias, may be seen differently by another. In the present study, the authors were predominantly responsible for and in agreement with the identification of biases, so the analysis may reflect some degree of bias on their part. However, the cognitive sciences literature is very specific about the properties of individual biases, so if these are well known there should be a reasonable correspondence between them and the behaviour to which they have been applied. A third issue is that some of the biases look very similar to each other. What are the differences, for example, between premature closure, diagnosis momentum, search satisficing and cognitive miserliness? Does an unpacking failure necessarily mean that search satisficing has occurred? There are differences between these bias definitions, but they are subtle and the casual or lay observer may not feel comfortable with the finer points that discriminate them from each other. Even so, if we identify one bias where another would have been more appropriate, such 'taxonomic' errors may not be as important as saying that some sort of cognitive bias was involved in how a case was managed. This would, at least, direct remedial efforts in an appropriate direction.

An additional issue concerns hindsight bias. Importantly, a distinction needs to be made between hindsight and hindsight bias. Hindsight is learning from experience, an essential part of human behaviour, whereas hindsight bias is usually a subconscious tendency to distort the past to make the decision maker appear more or less favourably than they actually were.[29] The benefit of true hindsight is that if relevant information is objectively and knowledgeably assessed, bias may be minimal, and important insights may be gained.

Many physicians have had little experience in purposeful introspection, reflection, insight into, or knowledge of the cognitive failures described in the majority of cases reported here. Typically, when cases of diagnostic failure come to light clinicians often make self-recriminatory judgements and comments such as "Well, I guess I dropped the ball there" or "I screwed that one up", or "What will I miss next?" [30] rather than analysing them in any detail or seeing their potential as opportunities for learning or for adjusting cognitive habits. Mostly, this reluctance appears to be due to a lack of awareness of the nature and extent of cognitive biases and how they impact clinical decision making. This may not be altogether surprising in view of the lack of training in these areas in many current medical curricula. Multiple obstacles to understanding diagnostic failure have been described [31] which, along with the sheer complexity of the process[9] provide some explanation for why diagnostic failure has been under-estimated in the past and has taken so long to move into the spotlight in patient safety.

It has been argued that as errors arising in intuitive (System 1) decision making are due to unconscious processes, they are not available to introspection.[32] While it is true that most System 1 processes are autonomous and outside of conscious control at the time they are triggered, an awareness that they have occurred, however, may develop and be made consciously available through introspection, mindfulness and reflection,[33,34] processes by which cognitive bias mitigation (CBM) can occur.[35] In order to improve our understanding of the diagnostic process, more attention needs to be directed towards its multiple facets, context, and overall complexity.[9]

An important observation from these cases is that biases rarely occur in isolation. It seems likely that once certain biases occur others inevitably follow.

The psychology literature is very clear about the abundance of biases in decision making and the present study provides further support. Overall, the number of times a discrete bias was identified from this collection of cases was 168. Although medical students and other noviciates to the domain of cognitive biases may despair at the sheer number of them, currently estimated in the order of about 200,[36,37] the present finding of only 24 in a comprehensive collection of clinical cases from a complex clinical environment, may provide some reassurance. Thus, although any cognitive bias may occur in clinical medicine, it appears that the actual number that commonly occur may be quite limited. If medical trainees could at least identify these 24 and have some understanding of how they work, it would be a significant step towards attaining awareness and engaging strategies to mitigate their action.[35] This is critically important for developing expertise in clinical decision making.

Although a number of instances of EPCs were identified in the present series it is the author's experience from this and several other EDs that deviance from accepted standards of patient safety is normalised in many departments to the point that they hardly attract attention or comment. Fatigue, stress, intermittent cognitive loading, extended lengths of stay in the ED, interruptions and distractions, rapid task switching and other EPCs have become commonplace and escape notice much of the time. Thus, in ED studies we might expect them to be under-reported. Fatigue was the most common EPC observed here (Table 3). Even when workers might not be subjectively experiencing fatigue, there is mounting evidence that decision fatigue begins to set in after several hours of sustained work.[38, 39, 40, 41, 42, 43, 44] It has been attributed to a decline in executive function, localized in the prefrontal cortex of the brain,[45] likely associated with an increased use of heuristics,[46] and a decline in quality of decision making.[47] In some of the cases reviewed here, fatigue was very clear, but in other cases decision fatigue may have influenced outcome in more subtle ways. Further, sleep deprivation and sleep debt which are commonplace in emergency medicine, are inevitably associated with fatigue in several ways (Figure 2).[48] Handover represents a transition of care from one clinician to another and is known to be a vulnerable point in patient care.[49] Resource Availability Continuous Quality Improvement Trade-Off (RACQITO) is based on the well-known SATO (speed accuracy trade- off) described in the psychology literature. As resources become increasingly limited the quality and safety of care may become more compromised.[24] Corridor consultations in the ED occur when the usual clinician-patient process is not followed e.g. a colleague may ask a physician for a medical opinion or even diagnosis outside of the usual doctor-patient relationship. Such exchanges do not necessarily result in error but frequently do.[50] Notably, system failures were very rare; the only instance was in a case where the radiology technician was unable to transmit images to the ED, which led to delay and suboptimal viewing of the images in another location.

Figure 2 about here

The incidence of knowledge deficits in this study was low. We found unequivocal knowledge deficits in only 3 instances by the attending emergency physician (Table 4). This is consistent with that found in a previous study where they were estimated at about 3%,[51] and confirming the observations of Gruver and Freis over 60 years ago,[52] as well as more recent studies.[53] Commonly, when clinicians realise they have made a mistake and have got past the initial defence mechanisms of denial, distancing, and discounting, a typical self-recriminatory response is to say that they don't know enough.[54] Similarly, when a diagnosis has failed, some patients will say that their doctors did not know enough. Other studies have claimed explicitly that a principal cause of diagnostic failure is a knowledge deficit on the part of the decision maker. In a study of diagnostic adverse events in the diagnosis of dyspnoea, a lack of knowledge was identified as the common denominator.[55] The authors indicated that several knowledge-related factors co-occurred, with physicians either not possessing sufficient knowledge or not applying their knowledge correctly. Although these two possibilities were considered together, there is an important difference between them. It is one thing to misdiagnose a patient due to lack of knowledge about their disease, but quite another to misdiagnose them because the clinician simply did not consider a diagnosis despite knowing its clinic-pathological features in detail. Pulmonary embolus is a good example. It may be mis-diagnosed 50% of the time on initial presentation,[56] even though most physicians are well-aware of its pathophysiology and associated risk factors. The present study shows that across a wide range of significant misdiagnoses, knowledge deficits were relatively rare, and an uncommon cause of diagnostic failure.

In contrast to the paucity of knowledge errors, cognitive biases were abundant and appeared significantly more consequential. As the present study suggests, failing to apply medical knowledge (how to think) because of cognitive biases is far more common and more consequential than a simple lack of medical knowledge (what to think). Thus, a distinction needs to be made between medical knowledge that embraces the traditional content of a medical curriculum which covers a wide range of facts about anatomy, physiology, pathophysiology, and the management of disease, versus a more general knowledge which would include knowledge of cognitive science, in particular, the influence of heuristics and cognitive biases on human decision making. But because medical curricula have traditionally not covered these developments in cognitive science, medical graduates would be expected to have knowledge deficits in these areas, referred to as *sub-personal* errors.[57] These are distinguished from individual *personal* qualities such as carelessness, arrogance, gullibility, naivety, incuriousness, wishful thinking, unwariness and other character traits and attitudes, which Cassam refers to as *epistemic vices,*[57] i.e. things that get in the way of knowledge at a subconscious level. This is also an important distinction as the common usage and understanding of 'bias' inclines more towards its negative aspects i.e. as a vice (and therefore usually more blameworthy) rather than the unconscious, involuntary response that it typically is. It might prove easier to educate clinicians about biases if they were not seen in negative terms.

There is accumulating evidence that cognitive and affective biases are an integral part of clinical decision making, and that the same biases would be expected to impact the decision-making at all levels of the healthcare system,[28] including healthcare leadership.[58] Inevitably, patient safety is potentially threatened whenever decision making takes place. Recent consensus statements have firmly identified that recognising the limits and biases of human cognition is a foundational concept to improve diagnostic quality and safety, as is the use of reflection, surveillance, and critical thinking to mitigate their detrimental effects throughout the clinical encounter.[59]
The strategy proposed here for studying clinical decision making, the cognitive autopsy, goes beyond the parameters of conventional root cause analysis. It is important for those conducting a cognitive autopsy to have a solid grounding in the cognitive science that underpins clinical decision making, with especially a detailed knowledge of the common cognitive biases, as well as an understanding of the physiological processes that underlie fatigue, stress, sleep deprivation and cognitive loading in clinical decision making.

Limitations:

The cases explored do not represent a consecutive case series from a single ED, and do not represent every misdiagnosis made in the respective EDs. The incidence and combinations of cognitive biases that we found are not necessarily those that represent the general frequency of occurrence of bias related misdiagnosis. Although we report the incidence of biases identified in our exploration, our goal was not to quantify the incidence in practice as much as to explore their occurrence in a section of cases where misdiagnosis was clearly identified.

It might be argued that knowing the outcome of a case may have distorted the evaluation of the quality of decision making and over-emphasized the consequences of any biases identified in particular cases (hindsight bias and outcome bias). It might also be argued that we are only looking at a subset of cases selected for poor outcomes where harm and near-misses occurred. We are unable to identify that bias caused a misdiagnosis simply from looking at the outcome, so we do not believe that the cases were selected because of a higher probability of cognitive bias compared to other causes of misdiagnosis.

We also do not know what characterizes cases with significant biases that did not lead to diagnostic failure. Yet, as with 'black- box' recorders from aviation accidents, there is much to be learned from error analysis where harm or a near miss occurred. As Reason notes, this preliminary step of corpus gathering, [15] gathering data about the context, ambient conditions, and the behavior underlying common cognitive biases may, at least, allow appropriate focus in future experimental studies. Further, although bias was associated here with negative outcomes, we acknowledge that bias is not universally negative, and in some situations may actually improve outcome. A bias towards taking an over-inclusive history, and doing a more complete physical examination in psychiatric patients counteracts a prevailing tendency to under examine them; a bias towards considering the 'worst case scenario' no-matter how unlikely is often appropriate, and a bias to go to the apparently sicker patient first is the reasonable basis for triage, even though this could result in harm to another waiting patient.

Neither do we have much information on the denominator in this equation of failures, although we do know that about 85% of the time clinicians arrive at the correct diagnosis. This might mean that biases may not be so prevalent as the numerator suggests, or that when they occur, they go unnoticed or are inconsequential. While the true incidence of biased decision making is not known, given the prevalence of cognitive biases in all domains of human activity, we suspect it is the latter. Given that diagnostic failure is associated with high degrees of morbidity and mortality, and is among the most consequential of PSEs, perhaps some latitude should be allowed for focusing on the numerator. Nonetheless, our overriding goal remains the mitigation of diagnostic failure; the present *in vivo* approach, in avoiding the distortions that may result from experimental studies, at least provides some insight into what may be happening in the real world of clinical medicine.

We excluded cases where the process was not limited to a simple format, such as cases referred from other sites or seen recently in the same ED. While such cases should be studied in their own right, the rationale for this exclusion was the assumption that previous work-up might distort the basic process. We wanted to study the sequence of events for a typical *de novo* patient going through the ED.

Conclusions: the present report has focused on cases involving diagnostic failure that were collected for review in the context of patient safety. While the causes of diagnostic failure are well-known: system failures, deficits in knowledge, ambient working conditions, the calibration of physicians thinking, and possibly other unspecified conditions, we have not previously developed a sense of the relative proportions of each. The primary objective of the present study was to delineate those causes with a view to future prevention

With a working knowledge of cognitive and affective biases, we were able to conduct a cognitive root cause analysis of real clinical cases, at the same time recording error producing and ambient conditions, and possible knowledge deficits, in the outcomes. Despite a literature on the relative paucity of knowledge-based errors, we were still surprised to find so few, testimony to the general efficacy of medical training as well as the clinical effort of practitioners. Equally surprising was the finding of so many cognitive and affective biases.

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Figure 1: Graphic presentation of 24 biases in temporal order.

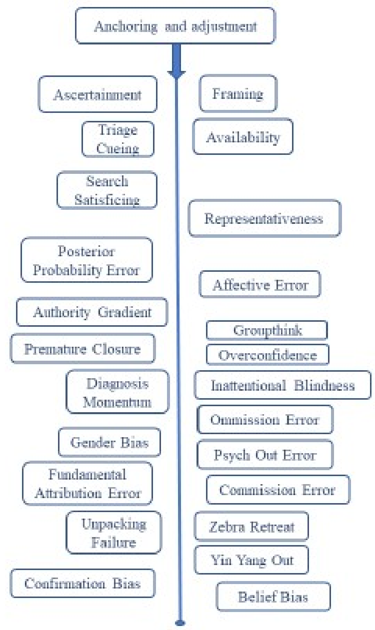

Figure 2. Contributory factors in decision fatigue

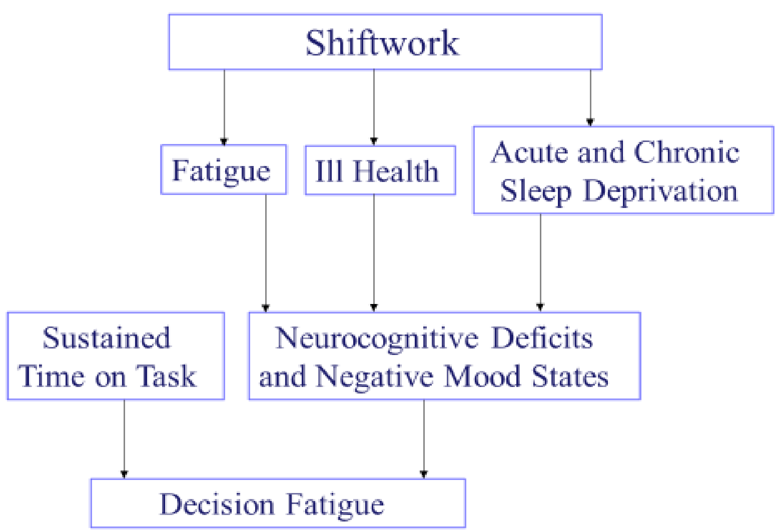

Table 1 Diagnoses initially missed in 30 cases.

Diagnosis
Salicylate overdose
Upper respiratory tract infection
Pulmonary embolism
Cauda equina syndrome
Subarachnoid hemorrhage
Methanol toxidrome
Non Specific Abdominal pain (over-diagnosed as meningococcemia and then appendicitis)
Skull fracture and penetrating brain injury
Guillain– Barré syndrome
Temporal lobe epilepsy
Aspiration pneumonia
Ectopic pregnancy
Imperforate hymen
Acute inferior myocardial infarct
Ludwig’s angina
Intercarpal ligament injury
Aseptic meningitis
Splenic trauma
Retinal detachment
Hand fractures
Comminuted scapular fracture

Traumatic pneumothorax

Giant pulmonary bullae

Medication overdose

Alcoholic gastritis

Tricyclic overdose

Acute inferior myocardial infarction

Herpes zoster ophthalmicus

Renal colic

Hypoglycemia

Table 2. Biases in the 30 cases. Frequency and ordinal position

Bias	*No.*	*Mean Ordinal Position*
Anchoring and adjustment	16	1.69
Confirmation bias	10	5.10
Diagnosis momentum	10	4.30
Premature closure	10	3.89
Unpacking failure	10	4.70
Search satisficing	9	3.00
Affective influence	8	3.50
Ascertainment	8	1.88

Framing	8	1.87
Fundamental attribution error	8	4.63
Triage cueing	8	2.25
Psych- out error	8	4.50
Availability	7	2.14
Posterior probability error	7	3.43
Omission error	6	4.50
Representativeness	6	3.33
Commission error	5	4.60
Groupthink	5	3.80
Overconfidence	5	3.80
Authority gradient	3	3.67
Inattentional blindness	3	4.00
Belief bias	2	6.50
Gender	2	4.50
Yin– yang out	2	6.00
Zebra retreat	2	5.00

Table 3. Error Producing Conditions (EPCs).

Rank#	*Condition*	Frequency
1	Fatigue	7
2	Sleep deprivation	4
3	High stress situation	3
4	Corridor consultation	3
5	Handover/transition of care	2
6	Time pressure	2
7	RACQITO*	2
8	Cognitive overload	1
9	Rapid task switching	1
10	Poor feedback	1
11	System (technical) failure	1
12	Time delay error	1

*RACQITO is resource availability-continuous quality improvement-trade off.[24]

Table 4. Analysis of knowledge deficits in 30 clinical cases.

Knowledge deficit	*Comment*
A resident did not appear to be aware that a normal chest X-ray does not exclude pulmonary embolus (PE).	He appeared to conclude PE was absent on the basis of the CXR
Emergency physician (EP) was not aware that protracted vomiting could result in a petechial rash of the head and neck. He attributed the rash to another cause (meningococcemia).	He acknowledged that he didn't know of the relationship between raised intra-thoracic pressure and injury to superficial blood vessels.
The EP failed to recognise the appearance of imperforate hymen, mistaking it for an emerging fetal head	The EP said he was aware of the condition of imperforate hymen but had never seen a case of it, nor had he ever seen a photo of it.
A clinical clerk did not examine the patient's eyes in a case of herpes zoster involving the face and nose.	He was not aware that ophthalmic involvement had to be excluded in a herpetic rash of the face
The EP did not include a renal stone on the differential diagnosis of a	The EP admitted that he was unaware that up to 50% of patients

patient with Crohn disease and abdominal pain	with Crohn disease have renal stones which likely resulted in him not putting it on the differential.