Cognitive Biases and Heuristics in Medical Decision-Making: Mechanisms, Clinical Manifestations, and Debiasing Strategies

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ABSTRACT Cognitive biases–systematic deviations from rational judgment–are implicated in most diagnostic errors in medicine. They arise from heuristics: mental shortcuts that are often beneficial in clinical settings and adaptive in most contexts but produce predictable errors when applied inappropriately. In this review, we integrate cognitive psychology, research on heuristics, dual-process theory, empirical studies of diagnostic error in medicine, and educational research on debiasing interventions to examine the theoretical foundations of cognitive heuristics and biases. Its uniqueness is in the clinical manifestations and mechanisms of the most consequential biases, and the evidence-based debiasing strategies available at the individual and system levels. Heuristics and cognitive biases arise from System 1 reasoning (fast, automatic, pattern-based) and are amplified when System 2 monitoring fails to detect and correct erroneous outputs. Key biases that are analyzed include anchoring bias, availability bias, confirmation bias, premature closure, the representativeness heuristic, overconfidence bias, framing bias, commission and omission bias, status quo bias, loss aversion, ignoring critical information, locking on a preferred alternative, shooting from the hip, and wishful thinking. Each bias has distinct clinical manifestations with documented consequences for diagnostic accuracy and patient safety. Debiasing strategies including checklists, structured reflection, consideration of alternatives, software to identify biases in decision-making, and metacognitive training have demonstrated efficacy in reducing error rates. Cognitive biases in medical decision-making are typically not random failures but structured, predictable phenomena with identifiable mechanisms. Their recognition and mitigation constitute a learnable clinical competency with direct implications for patient safety. Both individual-level training and system-level support are required for meaningful impact.

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Clinical decision-making is fundamentally a process of inference under uncertainty. Physicians gather information that is incomplete, interpret symptoms that are never perfectly specific, and reach conclusions they cannot verify in advance. To navigate this landscape efficiently, physicians rely extensively on heuristics: fast, frugal, pattern-based rules of thumb that provide serviceable answers without exhaustive analysis [1,2]. The use of heuristics is common and often beneficial. Marewski and Gigerenzer [3] argued persuasively that heuristics are ecologically rational. Heuristics exploit the structure of environments in which they evolve and produce accurate outcomes in most cases. The problem arises when a heuristic is applied in a context that does not fit its implicit assumptions, generating a systematic and predictable error: a cognitive bias [1,4]. Heuristics are adaptive processes that generate accurate decisions in most contexts. Biases are the systematic errors that emerge when those processes are applied outside their domain of validity [3,5]. Cognitive biases are consequential in clinical medicine because their effects are not evenly distributed across outcomes. Cognitive failures are present in approximately 74% of diagnostic errors in internal medicine, and diagnostic errors affect an estimated 10–15% of clinical encounters. These figures and their provenance are described by Flugelman and Riskin in a review in this issue of the *Israel Medical Association Journal* (*IMAJ*) [6]. Systematic reviews confirm that biases including anchoring, availability, and confirmation bias each have documented effects on diagnostic accuracy across specialties [7,8], with most errors attributable to cognitive failures rather than knowledge failures [6,9].

This review is the designated home within this issue of *IMAJ* for the catalogue of cognitive biases and for the causal framework relating heuristics to biases. We de-

scribe the mechanisms and clinical manifestations of the most consequential biases, explain how useful heuristics could turn into dangerous cognitive biases, and summarize evidence-based strategies for their mitigation.

KEY HEURISTICS AND COGNITIVE BIASES

Tversky and Kahneman [1,2] defined three primary classical heuristics (representativeness, availability, and anchoring), and a comprehensive set of cognitive biases that govern decision-making under uncertainty, which focused heavily on mathematical probability, economic choices, and core mental shortcuts. More recent cognitive and decision literature, such as Forman and Selly [10], Mintz and DeRouen [11], and general clinical/strategic frameworks, introduced cognitive biases that address procedural, motivational, and goal-oriented organizational traps.

COGNITIVE BIASES AFFECT MEDICAL DECISIONS AND OFTEN LEAD TO ERRORS IN DECISION-MAKING. THEY ARE NOT RANDOM ERRORS BUT SYSTEMATIC, PREDICTABLE DEVIATIONS FROM RATIONAL REASONING.

Classical heuristics and biases

The following list of the seven foundational psychological concepts are most recognized in cognitive research. These concepts represent the bedrock of the early heuristics and the biases research program, which focused heavily on how the mind miscalculates risk, probability, and value [1,2].

1. **Representativeness heuristic and base-rate neglect:** The representativeness heuristic drives probability estimates based on how closely a patient resembles the prototypical case of a disease, often at the expense of base-rate information [1,2]. A patient whose symptoms exactly match the textbook description of a rare disease may receive that diagnosis at the expense of far more probable alternatives. **Clinical example:** A 30-year-old male athlete presented to the emergency department with sharp, pleuritic chest pain that was positional, worsening when lying flat and improving when leaning forward. An electrocardiogram showed mild diffuse ST-segment elevation. The clinical presentation was highly representative of acute pericarditis, and the physician immediately made this diagnosis, initiating high-dose aspirin. However, this representativeness assessment completely suppressed consideration of a pulmonary embolism (PE). Although the presentation is highly prototypical for pericarditis, the physician neglected the base rates. The patient had recently undergone arthroscopic knee surgery and taken a 14-hour flight, putting him at high risk for thromboembolism. The neglect of base-rate risk factors led to a delayed diagnosis of a massive, life-threatening saddle PE, which is only identified when the patient suddenly collapses in the emergency department ward hours later, demonstrating how base-rate neglect produces systematic diagnostic errors when a clinical prototype matches an alternative condition. **Risk to patients:** Representativeness heuristic and base-rate neglect expose patients to acute, catastrophic cardiovascular or respiratory failure [1,7]. In the case of missed pulmonary embolism, the risk of untreated thromboembolic disease is extremely high: clot propagation, progressive right ventricular strain, cardiogenic shock, and sudden death [2]. Clinicians who treat the representative prototype (e.g., pericarditis) with anti-inflammatory medications fail to provide essential life-saving treatments (such as systemic anticoagulation or thrombolysis), leading to sudden, preventable fatal outcomes in otherwise young and healthy patients [8].
2. **Availability bias:** Availability bias arises when the estimated probability of a diagnosis is driven by the ease with which similar cases are retrieved from memory rather than by the patient's actual clinical features [1,12,13]. Dramatic, emotionally salient, or temporally recent cases are more accessible and therefore more available in memory, inflating their estimated frequency. **Clinical example:** A pediatrician who managed two cases of severe, life-threatening pneumococcal meningitis, both requiring pediatric intensive care unit (ICU) admission, became highly sensitized to this catastrophic diagnosis. Over the subsequent week, the pediatrician referred the next five children presenting with common, low-risk febrile illnesses (such as mild viral pharyngitis or simple tension headaches) directly to the emergency department for urgent, invasive lumbar punctures. All five spinal taps returned completely sterile cerebrospinal fluid with normal chemistries. The pediatrician's prior dramatic and emotionally draining encounters with meningitis heavily biased their clinical judgment, driving them to overestimate the baseline probability of meningitis and subject five low-risk pediatric patients to unnecessary procedural trauma and anxiety based on ease of recall rather than objective clinical risk criteria. **Risk to patients:** Availability bias drives significant clinical over-testing, over-treatment, and iatrogenic

harm. By overestimating the likelihood of a recently encountered or emotionally vivid condition, clinicians expose low-risk patients to highly invasive, painful, and unnecessary procedures [12]. In the case of unnecessary lumbar punctures in children, patient risk includes post-dural puncture headaches, procedural pain and anxiety, local hematoma formation, accidental introduction of pathogens into the sterile cerebrospinal fluid causing iatrogenic infection, and the misallocation of hospital resources, which delays care for patients with actual medical emergencies [13].

3. **Anchoring bias:** Anchoring bias is the tendency to fix on a salient initial hypothesis and insufficiently revise it in response to new information [1,14]. Clinically, anchoring typically occurs at the first point of clinical contact: a triage assessment, an emergency department handover, or a referral letter frames the patient before the clinician has independent access to the history. Subsequent information is then processed against this initial anchor, which distorts its interpretation [15].

SUCH BIASES ARISE FROM HEURISTICS, WHICH ARE MENTAL SHORTCUTS THAT ARE ADAPTIVE IN MOST CONTEXTS BUT FAIL UNDER SPECIFIC CONDITIONS.

Clinical example: An 82-year-old woman arrived to the emergency department by ambulance with the paramedic handover listed as a mechanical fall at home, query hip. The receiving medical and surgical team, anchored entirely to an orthopedic and mechanical explanation, immediately ordered pelvic and hip radiographs. When these radiographs returned normal, the team arranged discharge with physiotherapy follow-up, scheduling a clinic visit for 2 weeks later. Critically, no clinician asked why she fell or performed a thorough cardiovascular history. The patient returned 36 hours later via ambulance after a second, more severe collapse at home, resulting in a facial laceration. An electrocardiogram was finally performed and revealed complete (third-degree) heart block, which had caused transient bradycardic syncope. The cognitive anchor was established by the initial triage frame before any clinician had independent access to the patient's clinical history, orienting every subsequent diagnostic decision toward excluding a hip fracture rather than investigating the etiology of the fall itself.
Risk to patients: The primary risk of anchoring bias is the complete omission or severe delay in diagnosing life-threatening, time-critical underlying conditions. In cardiovascular medicine, anchoring on superficial mechanical explanations for falls results in missed opportunities to identify severe bradyarrhythmias, heart blocks, or critical valvular stenosis [7]. This oversight exposed the patient to the high risk of recurrent syncope, resulting in secondary physical trauma (i.e., severe facial lacerations, subdural hematomas, or orthopedic fractures) and, potentially, sudden cardiac arrest or fatal ventricular arrhythmias if the cardiac disease is left untreated [14,15].

4. **Framing bias:** Framing bias describes the systematic change in decision-making that occurs when the same information is presented in different forms, as a gain versus loss, as a percentage versus natural frequency, or as a survival rate versus mortality rate [16]. Tversky and Kahneman [1] established that people are reliably loss-averse: the same option is more acceptable when framed as a 90% chance of survival than when framed as a 10% risk of death.

Clinical example: A general surgeon presented two identical elective cholecystectomy scenarios to different cohorts of patients. For the first cohort, the surgeon framed the surgical outcomes as a 95% probability of a completely successful, complication-free recovery. For the second cohort, the surgeon framed the identical procedure as having a 5% risk of major intraoperative complications, including bile duct injury and bleeding. Despite the underlying mathematical risk being identical, patients in the first group agreed to proceed with the elective cholecystectomy at a rate of 92%, whereas patients in the second group refused the procedure at a rate of 36% (only 64% consent). This scenario illustrates that framing effects significantly distort patient autonomy and the physician's clinical advice during the shared decision-making process, showing how language frames direct treatment choices.
Risk to patients: Framing bias violates the core ethical principle of informed consent and patient autonomy, driving patients and surrogate decisionmakers to make suboptimal therapeutic choices [16]. When a highly beneficial, low-risk procedure is framed negatively (focusing on the 5% complication risk), the resulting high rate of treatment refusal exposes patients to recurrent, painful exacerbations of their disease and major secondary complications (e.g., gallstone pancreatitis, ascending cholangitis, or gallbladder

perforation). Conversely, over-optimistic framing of high-risk procedures can lead patients to consent to interventions they would have otherwise declined, exposing them to unanticipated morbidity and profound postoperative regret [16].

5. **Loss aversion bias:** Loss aversion bias in medicine is the tendency for physicians and patients to feel the pain of a negative health outcome much more deeply than they value an equivalent positive gain, leading to choices that are either overly cautious or, in some settings, inappropriately risky [1,17]. The mechanism is asymmetric weighting: the psychological distress of causing a complication or losing a functional baseline feels roughly twice as powerful as the satisfaction of curing or improving a condition. **Clinical example:** A 68-year-old patient with severe, bone-on-bone knee osteoarthritis discussed options with an orthopedic surgeon. The surgical option (total knee replacement) offered an 85% chance of complete pain relief and mobility restoration but carried a 15% risk of complications such as chronic stiffness, nerve injury, or surgical infection. Because of loss aversion, the patient and physician focused overwhelmingly on the 15% risk of losing their current baseline mobility (a known loss). Even though the probability of major gain (85% cure) vastly outweighed the risk, the dread of a negative change led them to reject surgery and choose to continue futile physical therapy and high-dose nonsteroidal anti-inflammatory drugs (NSAIDs), enduring chronic, debilitating pain that severely degraded their daily quality of life, demonstrating how the psychological weight of a potential loss is far greater than the value of an equivalent gain. **Risk to patients:** Loss aversion bias results in prolonged, severe, and avoidable functional impairment; chronic debilitating pain; and progressive systemic complications from less effective palliative treatments [17]. By focusing disproportionately on the small risk of an active complication rather than the high probability of a complete clinical cure, patients and physicians choose chronic illness over curative interventions. Furthermore, relying on alternative treatments like long-term, high-dose NSAIDs exposes the patient to severe chronic risks, including chronic kidney disease, severe peptic-ulcer hemorrhage, fluid overload, and elevated long-term cardiovascular events, which are often far more statistically probable than the surgical risks they avoided [17].
6. **Status quo bias:** Status quo bias in medicine is an emotional and mental habit whereby doctors, patients, or family members prefer keeping the current treatment plan instead of changing [18]. Key factors driving this preference include risk aversion, fear of regret, and patient or physician behavioral inertia. Physicians often select treatments that require the least active change or that match preset institutional defaults. Changing a stable routine may feel risky, so providers stay with older methods to avoid blame if something goes wrong [19]. **Clinical example:** In a multidisciplinary ICU, a 76-year-old patient with multi-organ failure remained unresponsive on mechanical ventilation and high-dose vasopressor support. Despite clear, documented evidence showing clinical futility, the family and surrogate decision makers resisted transitioning to comfort care. Continuing mechanical ventilation represented the emotional and operational status quo; withdrawing life support felt like taking an active, terrifying step that could directly cause death [18]. The clinical team, experiencing status quo inertia and a desire to avoid conflict, colluded with the family's emotional defense mechanism. They maintained non-beneficial invasive care for weeks, prolonging suffering and delaying a dignified end-of-life process. A second manifestation was seen in outpatient settings, where a physician continued to prescribe an older, brand-name medication to a stable hypertensive patient out of pure habit, ignoring newer, safer, and cheaper generic alternatives, simply because modifying the stable prescription routine felt like unnecessary active effort. **Risk to patients:** Status quo bias causes profound ethical and clinical harm. In acute or intensive care, it directly results in the prolongation of medically futile, highly invasive, and painful interventions, causing severe patient suffering and violating the central medical oath of non-maleficence [18]. It converts a natural, dignified end-of-life process into a highly medicalized, traumatic death. In chronic diseases, status quo inertia traps patients on less effective, poorly tolerated, or financially prohibitive therapeutic regimens, increasing the long-term risk of uncontrolled hypertension, diabetes-related target-organ damage,

THE USE OF HEURISTICS IS COMMON IN CLINICAL DECISION-MAKING, WHERE MEDICAL TEAMS ARE OVERLOADED WITH INFORMATION AND OFTEN NEED TO MAKE ACUTE DECISIONS UNDER PRESSURE.

or severe gastrointestinal and renal toxicities [18,19].

7. **Overconfidence bias:** Overconfidence means rating confidence in one's judgment higher than actual accuracy warrants. It is the cognitive bias with perhaps the most extensively documented clinical consequences [7,8]. It operates by suppressing the monitoring function that would otherwise prompt verification or consultation. Clinicians working under time pressure or fatigue show amplified overconfidence [20]. **Clinical example:** An ophthalmologist with 25 years of clinical experience made a confident clinical diagnosis of standard open-angle glaucoma during a quick slit-lamp examination, immediately initiating standard beta-blocker eye drops. Relying on his long experience, he bypassed automated visual field testing and optical coherence tomography (OCT), feeling that his clinical assessment of the optic disc was infallible. The patient returned 6 months later with progressive visual field deterioration. Additional diagnostic testing finally revealed that the patient had normal-tension glaucoma with progressive optic neuropathy, requiring a much lower intraocular pressure target and systemic cardiovascular evaluation. The clinician's overconfidence suppressed the objective testing and consultation that would have refined the diagnosis, leading to permanent, avoidable visual impairment. **Risk to patients:** The patient risk of overconfidence bias is the permanent, irreversible loss of organ function or sensory capacity due to the clinical bypass of objective diagnostic validation and professional consultation [8]. In chronic diseases like glaucoma, overconfidence results in insidious, silent damage (irreversible visual field loss and blindness) before the diagnostic error is discovered. In acute surgery or intensive care, overconfident reliance on subjective assessments without checking laboratory, radiographic, or physiological data leads to major iatrogenic complications, severe sepsis, delayed returns to the operating room, and elevated inpatient mortality [20].

THE MOST CLINICALLY KNOWN AND CONSEQUENTIAL BIASES ARE WISHFUL THINKING, IGNORING CRITICAL INFORMATION, SHOOTING FROM THE HIP, FOCUSING ON A SINGLE ALTERNATIVE COURSE OF ACTION, ANCHORING, AVAILABILITY, CONFIRMATION BIAS, PREMATURE CLOSURE, AND OVERCONFIDENCE.

BIASES FROM MODERN COGNITIVE AND DECISION-MAKING LITERATURE

Following is a list that includes seven more recently characterized biases that emerged from advanced decision science literature, which are crucial for medical practitioners but are less universally known [10,11]. These concepts evolved from broader psychological, strategic, and clinical decision-making domains (such as international relations, medical triage, and multi-criteria management), focusing on procedural errors, informational filtering, and emotional defense mechanisms.

1. **Premature closure:** Premature closure is the cessation of diagnostic hypothesis generation once a plausible diagnosis has been identified and before alternative diagnoses have been adequately excluded [4,9]. It is widely described as the single most common cognitive error in emergency and internal medicine. It is amplified by time pressure and by anchoring, that is, once the initial hypothesis generates high confidence, the motivation to continue searching is diminished. **Clinical example:** A 54-year-old woman presented to her primary care clinic with new-onset, burning epigastric pain that occurred primarily after meals. The physician prescribed a proton-pump inhibitor (PPI) with a working diagnosis of gastro-esophageal reflux disease (GERD), stopping further diagnostic workup. Over the next month, the patient returned for two follow-up visits reporting that her pain had not improved. At each visit, the physician concluded she had refractory acid reflux and adjusted her medication, first doubling the PPI dose and then switching to a different PPI class. The physician failed to ask about early satiety, difficulty swallowing, or unexplained weight loss, and did not refer her for endoscopy. At a fourth visit, a different covering physician performed a structured diagnostic pause, noted her 4 kg weight loss, and immediately ordered an upper endoscopy. Biopsies confirm advanced, poorly differentiated gastric adenocarcinoma. The initial plausible diagnostic label of GERD halted further diagnostic search, delaying the identification of a life-threatening malignancy. **Risk to patients:** Premature closure represents a severe failure of diagnostic thoroughness, leading to the rapid progression of untreated diseases. By stopping the diagnostic process prematurely, clinicians leave major, life-threatening differential diagnoses completely uninvestigated [4,9]. For patients with undiagnosed malignancies, this causes progressive tumor growth and metastatic spread. In acute settings, premature closure on a diagnosis of muscular strain or GERD in patients presenting with atypical acute cor-

onary syndrome, aortic dissection, or active peptic ulcer disease can lead to massive myocardial infarction, catastrophic aortic rupture, or sudden, life-threatening upper gastrointestinal hemorrhage [21].

2. **Confirmation bias:** Confirmation bias is the tendency to seek, prioritize, and interpret information in ways that confirm preexisting hypotheses, while discounting or reframing disconfirming evidence [15,22]. It is self-sustaining: each piece of confirming information strengthens the hypothesis, increasing resistance to revision. **Clinical example:** A family physician diagnosed a 58-year-old male with lobar pneumonia based on a chest radiograph interpreted as showing a right middle lobe consolidation and initiated a standard course of oral amoxicillin. When the patient returns 5 days later with persistent fever, cough, and mild shortness of breath, the physician attributed the lack of clinical response to antibiotic-resistant atypical pathogens rather than questioning the original diagnosis. The physician prescribed a different, broad-spectrum fluoroquinolone. They interpreted a slight decrease in the patient's subjective fever as confirmation of this secondary hypothesis, while rationalizing his ongoing mild weight loss as loss of appetite due to a stubborn respiratory infection. A central lung mass blocking the bronchus, rather than pneumonia, was finally identified 3 months later when a chest computed tomography (CT) was obtained due to persistent hemoptysis, illustrating how confirmation bias filters and actively misinterprets ongoing clinical data to maintain the initial diagnostic construct. **Risk to patients:** The patient risk of confirmation bias lies in the catastrophic elongation of diagnostic timelines for progressive, malignant, or highly destructive pathologies [15]. By actively filtering, reinterpreting, or ignoring red-flag signs, such as persistent weight loss and hemoptysis, to protect an initial incorrect diagnosis, the clinician allows the underlying disease to advance unchecked [22]. In oncology, this diagnostic delay directly enables local tumor propagation, vascular invasion, and distant metastasis, transforming a potentially curable localized cancer into a terminal, inoperable stage IV disease [22,23].
3. **Commission and omission bias:** Commission bias is the tendency to act even when watchful waiting is the rational choice. It is driven by the discomfort of apparent inaction and by a medico-legal fear of failing to treat [4,19]. It is a primary driver of low-value care, including unnecessary imaging and antibiotic prescription. Omission bias is the converse: the tendency to judge harmful omissions as less culpable than harmful actions, which produces excessive conservatism in high-risk clinical decisions [24]. **Clinical example:** Commission bias was demonstrated when a pediatric emergency resident, highly uncomfortable with the clinical strategy of watchful waiting for a borderline febrile 3-month-old infant, ordered an invasive septic workup including a lumbar puncture, blood cultures, and intravenous antibiotics, despite the patient appearing completely well and meeting low-risk criteria. The psychological discomfort of potential inaction and the fear of litigation outweighed the objective clinical risk of procedural harm. Conversely, omission bias was illustrated when a primary care physician declined to prescribe oral anticoagulation to an 82-year-old female patient with atrial fibrillation and a high risk of stroke (CHA_2DS_2-VASc score of 5). The clinician focused intensely on the active, visible risk of causing a gastrointestinal bleed (commission of harm) from the anticoagulant and instead accepted the far more probable but invisible risk of an ischemic stroke (omission of harm). The patient suffered a massive, preventable embolic stroke 3 months later. **Risk to patients:** The dual risk profile of commission and omission biases results in widespread clinical harm. Under commission bias, patients suffer significant iatrogenic complications from over-investigation and over-treatment, including drug-resistant hospital-acquired infections, procedural organ perforation, allergic drug eruptions, and severe patient anxiety [19]. Under omission bias, patients are denied highly effective, evidence-based preventive therapies. This exposes them to catastrophic, irreversible, and highly preventable medical events, such as massive embolic strokes that lead to permanent hemi-paralysis, global aphasia, cognitive devastation, long-term nursing home dependency, or death [24].
4. **Ignoring critical information:** Ignoring critical information occurs when a clinician, often operating under cognitive load or high-volume conditions, selectively bypasses or fails to integrate

CHECKLISTS, STRUCTURED REFLECTION, DELIBERATE CONSIDERATIONS OF ALTERNATIVES, AND METACOGNITIVE TRAINING ARE EVIDENCE-BASED STRATEGIES THAT MAY REDUCE THE IMPACT OF COGNITIVE BIASES ON WRONG DECISIONS WITHOUT ELIMINATING THE EFFICIENCY BENEFITS OF HEURISTIC REASONING.

essential historical, laboratory, or physiological data that is readily available [10,11]. This bias represents a severe failure of System 2 monitoring, where the brain shunts focus to a narrow, acute problem and completely disregards baseline clinical realities that alter the safety of a therapeutic plan. **Clinical example:** A 64-year-old male with a long-standing history of Stage 4 chronic kidney disease (CKD) presented to a busy urgent care clinic with an acute, excruciating gout flare-up in his left great toe. The primary care physician, focused entirely on alleviating the patient's acute, visible distress and pain, immediately ordered a prescription for high-dose oral indomethacin and a course of ibuprofen. Critically, the physician failed to review the patient's comprehensive electronic health record (EHR) or check his baseline serum creatinine level (which was markedly elevated at 3.2 mg/dl), ignoring his severe underlying renal impairment. This failure to integrate the critical baseline history of CKD led to severe NSAID-induced acute kidney injury on chronic renal failure. The patient was admitted to the emergency department 3 days later with severe metabolic acidosis, hyperkalemia, and fluid overload, requiring urgent hemodialysis and a prolonged ICU stay. **Risk to patients:** The risk of ignoring critical information is the direct, rapid, and severe precipitation of iatrogenic organ failure, drug-drug interactions, and acute metabolic collapse [10,11]. In modern medicine, where EHRs contain vast amounts of patient data, ignoring highly salient history (such as CKD, anticoagulant use, severe drug allergies, or underlying cardiovascular instability) leads clinicians to prescribe highly contraindicated treatments. This failure results in acute-on-chronic renal failure, life-threatening hyperkalemic arrhythmias, catastrophic gastrointestinal hemorrhage, anaphylaxis, or sudden cardiac arrest, turning a simple clinic presentation into an ICU-level emergency [10,11].

5. **Locking on a preferred alternative:** Locking on a preferred alternative describes a strong choice-supportive bias or escalation of commitment, where a clinician selects an initial favorite diagnosis or treatment path early in the clinical encounter and clings to it dogmatically [11]. Even when objective, contradictory evidence emerges, the clinician rationalizes away the disconfirming data and refuses to pivot to other viable options, often leading to delayed treatment and procedural complications. **Clinical example:** A 42-year-old male presented with severe, radiating left calf pain and localized swelling that began shortly after a 12-hour international flight. The clinician immediately suspected deep vein thrombosis (DVT) as the preferred alternative. An emergent lower extremity Doppler ultrasound was ordered and returned completely negative, demonstrating normal, patent venous flow with no evidence of thrombus. Rather than pivoting to alternative diagnoses (such as a ruptured Baker's cyst, popliteal artery entrapment, or a severe gastrocnemius muscle tear), the clinician locked onto the DVT diagnosis, assuming the ultrasound was a false negative. They initiated therapeutic low-molecular-weight heparin (enoxaparin). Two days later, the patient returned with worsening, excruciating calf pain, tense swelling, and progressive foot drop. He was found to have a massive, expanding intramuscular hematoma in the calf that caused acute compartment syndrome, directly precipitated by the unnecessary anticoagulation prescribed for an undiagnosed gastrocnemius muscle tear. The clinician's refusal to pivot from their preferred alternative blinded them to the correct diagnostic path. **Risk to patients:** Locking on a preferred alternative treatment exposes patients to dual risks: the direct, immediate physical harms of an unnecessary and dangerous therapy (such as therapeutic anticoagulation or invasive procedures) and the progressive progression of the undiagnosed, actual disease [11]. In the musculoskeletal system, this bias can lead to severe iatrogenic hemorrhage inside a closed myofascial compartment, causing acute compartment syndrome, permanent ischemic muscle necrosis, and irreversible common peroneal nerve damage (resulting in permanent foot drop) or amputation. Clinging dogmatically to an incorrect preferred hypothesis blocks the critical reasoning required to correct clinical pathways [11].
6. **Shooting from the hip:** This bias describes rapid, impulsive clinical action or diagnostic labeling based on immediate, superficial instinct or gut feeling without gathering basic clinical facts, conducting a physical examination, or waiting for essential data. It is an extreme, unmonitored System 1 reaction that bypasses critical safety checklists and clinical protocols under high-pressure conditions [25]. **Clinical example:** An emergency department physician on a chaotic, high-volume night shift was handed the case of a 58-year-old male who was extremely

agitated, diaphoretic, and hyperventilating. Recalling a highly similar, dramatic case of severe panic disorder they successfully treated earlier that day, the physician shoots from the hip and immediately ordered a high dose of intravenous midazolam to calm the patient, completely bypassing a basic physical examination, vital sign measurement, or an electrocardiogram (ECG). Within 10 minutes of sedative administration, the patient's respiratory drive fails, and they went into cardiac arrest. An emergent resuscitation and ECG reveal the patient's underlying pathology was actually a massive acute myocardial infarction with cardiogenic shock. The impulsive shoot from the hip decision catastrophically masked the cardiac symptoms and induced systemic vasodilation and respiratory depression that precipitated a preventable cardiac arrest. **Risk to patients:** Shooting from the hip carries an immediate, high risk of acute clinical mortality and severe, irreversible iatrogenic injury [25]. By completely bypassing basic clinical safety protocols such as checking vital signs, conducting a brief physical examination, or performing an ECG, clinicians execute highly dangerous interventions. Masking an acute myocardial infarction, aortic dissection, or severe hypoxia with powerful sedatives, paralytics, or vasoactive drugs removes the patient's physiological compensation mechanisms, transforming a highly treatable medical emergency into a fatal, irreversible event within minutes [25].

7. **Wishful thinking:** Wishful thinking is the subconscious tendency of a clinician to overestimate the probability of a benign, easily treatable outcome over a terminal, highly complex, or infectious illness because they are emotionally invested in the patient's well-being or wish to avoid a difficult conversation, procedure, or diagnostic reality [13]. **Clinical example:** A general practitioner who maintained a warm, supportive relationship with a beloved elderly patient for over 20 years evaluated her for a persistent, dry, hacking cough, mild weight loss, and progressive fatigue. Deeply attached to the patient and subconsciously dreading the prospect of a terminal oncological diagnosis, the physician attributed her symptoms to a stubborn post-viral bronchitis combined with age-related deconditioning. The physician prescribed repeated courses of cough suppressants, antihistamines, and high-dose vitamins, repeatedly reassuring both the patient and themselves that she was simply taking longer to recover. Out of wishful thinking, the physician delayed ordering a chest CT scan for nearly 6 months, hoping the symptoms would spontaneously resolve. When the chest CT was eventually performed due to progressive hemoptysis, it revealed advanced, inoperable stage IV lung adenocarcinoma with widespread bony metastases, missing a critical diagnostic window for early systemic staging and targeted palliative therapy. **Risk to patients:** Wishful thinking creates a severe diagnostic blind spot that directly compromises patient survival and quality of life [13]. By delaying essential diagnostic testing (e.g., a chest CT) due to emotional attachment or fear of delivering bad news, the clinician allows an active malignancy or progressive infectious process to advance from a treatable, localized stage to a terminal, metastatic stage. This eliminates the patient's eligibility for curative surgical resections or localized radiotherapy, exposing them to unnecessary systemic disease burden, intractable pain, and a highly compressed life expectancy [13].

HEURISTICS AND COGNITIVE BIASES: THEORETICAL FRAMEWORK

Tversky and Kahneman [1] introduced the systematic study of heuristics in the 1970s, demonstrating that human judgment deviates from normative rationality in structured, reproducible ways. Their framework identified three primary heuristics: representativeness, availability, and anchoring, each associated with a characteristic set of biases. The dual-process model of cognition provides the mechanistic framework through which heuristics generate biases [2,9]. In brief, System 1 processes are fast, automatic, and subconscious, relying on pattern recognition, prior experience, and associative memory, whereas System 2 processes are slow, deliberate, and conscious, involving logical analysis and evidence-based reasoning. Kahneman [2] emphasized that most cognitive errors arise not from System 1 activity per se, but from the failure of System 2 to monitor and override System 1 errors in situations that require it.

THE DOUBLE-EDGED SWORD: WHEN ADAPTIVE HEURISTICS TRANSITION INTO DANGEROUS BIASES

In the daily practice of medicine, heuristics are not merely convenient shortcuts; they are an absolute clinical necessity [3,5]. The modern healthcare environment is characterized by high patient volumes, intense time constraints, clinical interruptions, and information overload. In environments such as the emergency department, the ICU, or a busy primary care clinic, it is cognitively impossible

for a clinician to apply exhaustive, first-principles logic (System 2 reasoning) to every patient encounter. Doing so would lead to rapid cognitive fatigue, administrative paralysis, and a catastrophic backlog of care. Heuristics allow physicians to rapidly recognize patterns, synthesize complex presentations into *illness scripts*, and initiate life-saving interventions within seconds [9,11]. The concept of ecological rationality, as articulated by Marewski and Gigerenzer [3], emphasizes that heuristics are highly effective when the environment matches their implicit assumptions. They exploit the structure of clinical environments to produce accurate decisions with minimal cognitive effort. Heuristic methods are highly adaptive and serve as the cornerstone of clinical expertise, reflecting the intuitive wisdom accumulated over years of clinical experience [5,10].

However, a critical challenge arises because these highly adaptive cognitive shortcuts exist on a knife-edge. The very same heuristic that enables rapid, efficient, and correct decision-making in 99 cases can transition into a dangerous cognitive bias in the 100th case [4,21]. Understanding this transition is essential. The shift from a useful heuristic to a dangerous bias typically occurs at specific, identifiable tipping points:

- *Atypical presentations of common diseases:* When a patient presents with an atypical manifestation of a common condition, or when a rare disease presents with symptoms that mimic a common, benign illness. In these cases, the pattern-recognition heuristic (System 1) misclassifies the patient based on superficial resemblance, leading to diagnostic errors [1,13].
- *Cognitive overload and exhaustion:* When a clinician's cognitive capacity is depleted by high patient volume, prolonged shifts, sleep deprivation, or emotional stress [20,26]. Under these conditions, the cognitive resources required for active System 2 monitoring are severely degraded, leaving System 1 outputs unchecked and uncorrected [2,9].
- *Information fragmentation and disrupted workflows:* When clinical handovers are incomplete, or when busy environments cause frequent interruptions. This disrupts the reflective, linear reasoning of System 2, forcing the clinician to rely on rapid, intuitive judgments that are highly vulnerable to bias [25].
- *Diagnostic momentum:* When an initial diagnostic label is attached to a patient (e.g., at triage or during handover) and gains momentum, creating a path dependency that suppresses alternative hypotheses [4,15].

As Feufel and Flach [5] proposed, the appropriate educational response is not to attempt the impossible task of eliminating heuristic reasoning, but rather to cultivate metacognitive awareness. Clinicians must understand which heuristics they are deploying, and precisely when and where those heuristics are likely to fail, so they can activate reflective System 2 overrides at the critical moment [9,10,21]. This perspective reframes debiasing as a metacognitive competency rather than a prohibition on intuition.

CONTEXTUAL AMPLIFIERS OF COGNITIVE BIAS

Several clinical contextual factors systematically amplify cognitive bias, acting as catalysts that degrade System 2 reflective capacity and force reliance on unmonitored System 1 processing.

Fatigue and sleep deprivation

Choshen-Hillel and colleagues [20] demonstrated, in a large observational study, that physicians prescribed significantly fewer analgesics during night shifts. This finding is consistent with cognitive depletion amplifying risk-avoidance bias under fatigue, which is the tendency to prioritize absolute safety to prevent any chance of a negative result, even when doing so may lead to under-treatment.

Emotional state

Both negative affect (increasing risk aversion and omission bias) and positive affect (increasing overconfidence and optimism bias) alter decision-making systematically. Emotion is not merely an amplifier of the biases catalogued here but a decision variable, with discrete emotions producing distinct and predictable effects; it is treated as such in the review of emotions and medical decision-making in this issue [26].

Time pressure

Compressed decision time truncates evidence gathering, increases reliance on System 1, and reduces System 2 error-checking [4,25]. Egoda Kapuralalage et al. [25] found elevated rates of anchoring and framing biases among emergency department triage nurses under high-volume conditions.

Prior experience with the presenting diagnosis

Recent exposure to a diagnosis, whether as a memorable failure or a series of recent successes, systematically inflates its estimated probability via availability bias, altering baseline probability assessments [12,13].

DEBIASING STRATEGIES

The objective of debiasing is not to eliminate heuristic reasoning, which is efficient and usually accurate, but to deploy it more selectively and to detect when it has produced an error that requires correction [4,5,21]. Our review carries the general taxonomy of debiasing. Other articles in this issue of *IMAJ* develop strategies specific to their own mechanisms.

INDIVIDUAL-LEVEL STRATEGIES

Metacognitive awareness

Training clinicians to monitor their own reasoning processes, to ask: "Which heuristic am I using?" and "In what circumstances does this heuristic typically fail?", is the foundational debiasing competency [21]. Croskerry and colleagues [21] identified metacognitive self-awareness as prerequisite to all other debiasing strategies: recognition of a bias must precede its correction. The mechanism by which monitoring and regulation operate, and the evidence for training them, is the subject of the review of metacognitive effects in this issue of *IMAJ* [27].

Structured reflection and diagnostic pause

Deliberate interruption of the diagnostic process to ask "What else could explain this presentation?" and "What feature of this case is inconsistent with my current diagnosis?" reduces anchoring, premature closure, and confirmation bias [12]. Mamede and colleagues [12] demonstrated that residents prompted to reflect explicitly on their diagnostic reasoning made significantly fewer availability-biased errors on subsequent cases.

Considering alternatives (consider the opposite)

Systematically generating at least one alternative diagnosis before closing, with particular attention to diagnoses that would be most serious if missed, counteracts premature closure and anchoring [4].

Checklists and structured protocols

Standardized diagnostic workflows and checklists reduce the influence of individual biases by ensuring systematic coverage of key features regardless of the clinician's current hypothesis [28]. Team-based structured briefing and debriefing, which has been shown in surgical settings to reduce mortality [28], extends this systematic approach to group decision-making.

SYSTEM-LEVEL SUPPORTS

Clinical decision support systems

Computerized alerts, interaction checkers, and evidence-based guideline prompts reduce memory-dependent biases by externalizing critical knowledge [4,25]. Software that identifies cognitive biases in medical decision-making and provides tips for improvement also holds debiasing potential.

Team-based decision-making

Distributing diagnostic authority across multiple clinicians exploits cognitive diversity to counteract individual biases; structured handover protocols and mandatory second opinions for high-risk decisions formalize this benefit [28]. The conditions under which group decision-making corrects rather than amplifies individual bias are examined in the review of group dynamics and social biases in this issue [29].

Limiting consecutive decision-making hours

Organizational policies that restrict extended overnight shifts without rest reduce bias amplification from fatigue [20].

DISCUSSION AND CONCLUSIONS

Cognitive biases in clinical medicine are not anomalies or failures of individual intelligence. They are the predictable outputs of cognitive architectures that evolved for ecological validity in other environments [3,5]. Their clinical impact is substantial, documented across specialties and clinical settings, and concentrated in the diagnostic process where their consequences are most serious [6,8].

The appropriate response is neither fatalistic acceptance nor the unrealistic goal of bias elimination. The evidence supports a calibrated approach: training clinicians to recognize specific biases and their situational triggers, embedding system-level supports that make key information salient at the moment of decision, and cultivating team cultures in which diagnostic uncertainty is voiced and acted on rather than suppressed.

Several evidence gaps remain. Most studies of cognitive bias in clinical settings are observational or use simulated case scenarios. Fewer demonstrate the effect of debiasing interventions on actual patient outcomes. The relative contribution of different biases to diagnostic error varies by specialty and clinical context in ways that are not yet fully characterized. Artificial intelligence-based

tools that monitor decision-making patterns in real time may eventually provide a systematic check on bias that supplements individual metacognitive training, although such tools carry their own well-documented risks.

The recognition that most diagnostic errors reflect cognitive rather than knowledge failures [6,9] shifts the educational imperative from information delivery to reasoning training. In this review, we argue that this shift is both justified by the evidence and practically achievable. Heuristics are not the enemy of clinical excellence; unrecognized biases are.

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The theory of democratic government is not that the will of the people is always right, but rather that normal human beings of average intelligence will, if given a chance, learn the right and best course by bitter experience.

W.E.B. Du Bois (1868–1963), American sociologist, writer, historian, and Pan-Africanist civil rights activist