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MIND THE BIAS: MAPPING AND MITIGATING COGNITIVE ERRORS ACROSS THE EXPANDED NEWBORN SCREENING PATHWAY

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ABSTRACT – Expanded newborn screening (ENBS) has substantially improved the early identification of inherited metabolic diseases, enabling timely interventions that have transformed the prognosis of many affected infants. However, the effectiveness of ENBS relies on a complex multidisciplinary pathway extending well beyond laboratory analysis, involving healthcare professionals with diverse roles as well as families who must understand, interpret, and respond to screening information. At every stage of this process, cognitive biases and heuristics may influence perception, judgment, communication, and decision-making, potentially affecting diagnostic accuracy, follow-up, and family experience. This narrative case-based work examines the role of cognitive biases throughout the ENBS pathway, from parental information provided during pregnancy and dried blood spot collection to laboratory interpretation, communication of positive or uncertain results, confirmatory testing, dietary management, and long-term clinical follow-up. Particular attention is devoted to the different professionals involved – including nurses, midwives, laboratory scientists, metabolic physicians and dietitians – as well as to the cognitive processes that may shape parental understanding, information seeking, and healthcare decisions after positive screening results. The work also discusses practical examples of common cognitive biases encountered in ENBS and explores evidence-based strategies to mitigate their impact, including reflective practice, standardized communication, multidisciplinary collaboration, and cognitive debiasing interventions. Recognizing the influence of cognitive biases represents an important opportunity to strengthen diagnostic reasoning, improve communication with families, reduce avoidable errors, and promote more equitable and patient-centered newborn screening programs.

Keywords: Cognitive bias, ENBS, Medical decision making, Families, Metabolist, Dietitian, Nurse.

INTRODUCTION

Expanded Newborn Screening (ENBS) is a comprehensive, integrated, and multidisciplinary secondary prevention program aimed at the population-wide early detection of rare congenital disorders, including metabolic and genetic conditions, in newborns. By integrating screening, confirmatory diagnosis, timely therapeutic intervention, and long-term follow-up, ENBS seeks to improve clinical outcomes and reduce disease-related morbidity and mortality[1,2]. ENBS involves a complex multistep process requiring the coordinated efforts of numerous healthcare professionals, including pediatricians, nurses, psychologists, dietitians, and laboratory specialists, as well as multiple interactions with families throughout the screening pathway. These interactions occur during the provision of information about ENBS, blood spot sample collection, recall procedures, confirmatory testing, and subsequent clinical follow-up. Each stage of the screening process involves decisions and judgments by both healthcare professionals and families, which may be influenced by cognitive biases and heuristics.

Cognitive biases are systematic and predictable deviations from rational judgment arising from heuristic information processing[3,4]. Widely studied across psychology and medicine, these biases are known to affect diagnostic reasoning, risk assessment, and clinical communication[5].

In healthcare, these biases can significantly influence clinical reasoning, with potential significant consequences on diagnostic accuracy, patient communication, and healthcare outcomes.

When discussing this pedagogical theory, one cannot fail to mention Daniel Kahneman and, in particular, his seminal 2011 work ‘Thinking, Fast and Slow’[6]. According to Dual-Process Theory, clinical reasoning relies on two interacting systems: a fast, intuitive, heuristic-based system (System 1) and a slower, analytic, effortful system (System 2)[7,8]. While System 1 enables efficient pattern recognition, it is also particularly vulnerable to cognitive biases, especially under conditions of uncertainty and time pressure.

Applying the Dual-Process Theory to the medical context, some authors[9] have argued that System 1 is more likely involved in generating multiple diagnostic hypotheses and pattern recognition of clustered symptoms; conversely, System 2 plays a central role in the systematic search for additional information from a history and physical or lab exams.

More than 100 biases have been identified and described in the literature, but only some are specifically related to the medical field. The majority pertain to patients’ or clinicians’ therapeutic choices, whereas only a few focus on diagnostic reasoning[10].

In healthcare, evidence indicates that cognitive biases are a major contributor to diagnostic failures; they can distort diagnosis, risk assessment, and communication, leading to mismanagement or delays[11,12] and cause patient harm in healthcare facilities[13,14]. Cognitive biases seem to be implicated in over 50% of diagnostic errors in ambulatory care[15] and up to 83% of physician-reported cases, with failures of judgment (rather than lack of knowledge) being the primary cause in most malpractice claims related to misdiagnosis[16-18]. Healthcare professionals often underestimate how much such mental shortcuts shape their decisions, which helps explain the persistence of cognitive-process failures despite growing medical expertise and technology.

To date, however, no studies have systematically explored how, when, and for whom cognitive biases may affect the Expanded Newborn Screening (ENBS) pathway.

Awareness of cognitive biases is critical in the context of ENBS for metabolic and genetic disorders because true positives and false positives often cause parental anxiety[19-21], while false negatives can delay treatment; furthermore, cognitive biases can influence each actor’s decisions.

Previous studies have examined cognitive biases in several clinical contexts, including the emergency department[17,22], intensive care unit[23], oncology[24], internal medicine[25], chronic diseases[26], vaccination hesitancy[27], laboratory results interpretation[28], and child physical abuse[29].

The ENBS represents a particularly compelling setting in which to examine these mechanisms. It combines a highly standardized diagnostic workflow with emotionally salient decision points while engaging multiple stakeholders – including pediatricians, laboratory biochemists, metabolic specialists, nurses, and families – who collectively contribute to a process of distributed cognition[30,31]. This complex sociotechnical environment creates multiple opportunities for cognitive biases to influence clinical reasoning, communication, and decision-making across the screening pathway, from the interpretation of biochemical results to confirmatory testing, diagnostic disclosure, and long-term follow-up.

This study employs a narrative, case-based qualitative design to map the primary cognitive biases that may affect decision-making and communication across the ENBS pathway. The objective was not to estimate prevalence or causal effects, but to develop a clinically grounded conceptual framework that illustrates how cognitive biases operate in real-world ENBS scenarios and how their impact may be mitigated.

METHODS

Cognitive biases were identified through a narrative review of the psychological and medical literature on heuristics and biases in clinical decision-making. Biases were selected based on three criteria: (a) relevance to healthcare contexts, (b) plausibility of occurrence within ENBS workflows, and (c) potential impact on diagnostic reasoning, communication with families, or clinical management. The final set of biases reflects those most frequently discussed in the literature and most applicable to ENBS, as identified by the authors' multidisciplinary team.

For each cognitive bias, one vignette was developed to illustrate realistic scenarios occurring at different stages of the ENBS pathway and involving different stakeholders (metabolic specialists, nurses, laboratory scientists, dietitians, and families). Vignettes were constructed by the authors based on their clinical and research experience in neonatal screening, metabolic medicine, and health psychology. All cases are fictional but are intended to reflect common or plausible clinical situations.

All clinical vignettes were independently reviewed by a multidisciplinary panel of expert clinicians, including metabolic specialists, dietitians, nurses, laboratory scientists, and clinical psychologists. Experts assessed each vignette for clinical plausibility, internal coherence, and relevance to real ENBS practice. Revisions were made iteratively until consensus was reached regarding the accuracy and educational value of each scenario.

The analytic process consisted of mapping each vignette to specific cognitive biases and examining their potential impact on clinical reasoning, communication, and workflow. The analysis was conducted collaboratively by the authors and resulted in stakeholder-specific thematic groupings presented in the following sections.

In Table 1, we list the selected cognitive biases that may affect the ENBS process, and in the following sections, we present stakeholder-specific scenarios – metabolic specialists, nurses, clinical biochemists, dietitians, and families – in which these biases and reasoning errors are illustrated and their potential impacts analyzed.

Table 1. Cognitive biases and heuristics involved in the ENBS process.

Representativeness heuristic	A mental shortcut whereby the likelihood of an event is judged by how closely it resembles the typical features of its parent category or prototype.
Framing effect bias	The way information is framed affects how individuals (clinicians and parents alike) receive and process it.
Negativity bias	It is the tendency to accord greater emotional and cognitive weight to negative events than to neutral or positive events of equal intensity.
Anchoring bias	The tendency to rely too heavily on an initial reference point (whether numeric or contextual) when making subsequent judgments or decisions, even if that anchor is irrelevant.
Availability heuristic	The tendency to judge the probability or importance of an event by how readily examples of it come to mind, often leading to over-weighting recent, frequent, or emotionally salient instances.
Bandwagon effect	The tendency to adopt certain beliefs, behaviors, or styles because many others are doing so.
Confirmation bias	The tendency to seek out, interpret, and remember information in a way that confirms one's pre-existing beliefs or expectations, while overlooking or downplaying contradictory evidence.
Overconfidence effect	The tendency to display confidence in your own judgements that exceeds the actual accuracy of those judgements, manifesting as overestimation of performance, overplacement relative to others, or unwarranted precision in one's beliefs.
Attribution bias (fundamental attribution error)	The tendency to explain others' behaviour or outcomes chiefly in terms of their dispositions or intentions, while underestimating situational or contextual factors.

Continued

Table 1 *(continued).* Cognitive biases and heuristics involved in the ENBS process.

Routine bias (automation)	The tendency to follow familiar routines automatically, even when changing circumstances call for a different approach. This is not a classic bias but reflects the neglect of vigilance after many similar tasks.
Hindsight bias	The tendency, after an event has occurred, to overestimate the extent to which the outcome could have been foreseen. It is colloquially known as the "I knew it all along phenomenon."
Premature closure	The tendency to stop considering alternative diagnoses once an initial plausible explanation is reached, leading to incomplete evaluation and potential diagnostic errors.
Outcome bias	The tendency to judge the quality of a decision by its eventual outcome rather than by the information and reasoning available when it was made.
Status quo bias	Preference for maintaining existing practices, even when new information suggests change is warranted.
Certainty effect (zero-risk bias)	The tendency to prefer options that completely eliminate a specific risk, overweighting outcomes that are certain relative to those that are merely probable, even when the probabilistic option would produce a greater overall reduction in expected harm.
Curse of knowledge bias	Tendency to assume that others have the same level of expertise or know-how as we do. We forget what it was like to be new to something and how difficult it was to learn.
Dunning-Kruger effect	The tendency of clinicians with insufficient knowledge or experience to overestimate their diagnostic competence, leading to excessive confidence in incorrect clinical judgments

METABOLIC SPECIALISTS

Metabolic specialists are physicians – typically pediatricians with specialized training in inherited metabolic diseases and metabolic genetics – who receive and interpret abnormal ENBS results. They are responsible for the timely clinical assessment of the newborn, the initiation and interpretation of confirmatory investigations, coordination of the diagnostic and therapeutic pathway within a preventive medicine framework, and the clear communication of diagnostic findings and management plans to both the multidisciplinary clinical team and the infant's family. As the primary communicators of true positives, false positives, or variants of uncertain significance (VUS), metabolic specialists guide families through each subsequent step. These tasks demand the management and interpretation of complex biochemical data, occasionally nonspecific clinical signs, and evolving prognoses, all of which contribute to a high cognitive load. Consequently, metabolic specialists must remain vigilant to a range of cognitive biases, including anchoring bias, confirmation bias, framing effect, availability bias, overconfidence, and attribution bias (see Supplementary Table 1 for clinical examples), especially when communicating uncertain results to parents.

Clinical reasoning may also be compromised by implicit gender-related biases[32,33]. Recently, Lenzini et al[34] described a woman's perspective on inherited metabolic diseases, suggesting that some disparities in approach may be related to clinicians' or patients' gender, including symptom interpretation, diagnostic process, and the prioritization of further testing. Some of these differences can be explained by cognitive biases, specifically stereotyping, attribution, and anchoring biases.

Owing to stereotyping bias, clinicians may implicitly associate particular symptoms with a given gender, leading to under- or over-investigation. For example, an adolescent girl with a urea cycle disorder with subtle neurocognitive or somatic symptoms might have those signs hastily attributed to anxiety or an eating disorder, delaying appropriate metabolic investigations and timely treatment. By contrast, owing to attribution bias, the same clinical picture may be explained differently depending on the patient's sex: symptoms in males are more readily ascribed to biological causes, while similar symptoms in females are more likely to be viewed as psychosocial or emotional. For example, mild neurological signs in a male child may prompt immediate neurological testing, whereas similar signs in a female child may first prompt assessment of family dynamics or emotional health, thereby delaying metabolic work-up. Owing to anchoring bias, initial gendered assumptions can lock clinicians' thinking in place and make them less responsive to new or contradictory evidence. For example, developmental delays in girls may be normalized or dismissed for longer, whereas similar concerns in boys might prompt earlier investigation, a pattern that delays diagnosis and intervention for affected girls.

NURSES AND MIDWIVES

Nurses and midwives play a pivotal role in ENBS by collecting newborn dried blood spot samples and often serving as the first point of contact for parents, whether to explain the screening procedure or to communicate the need for repeat sampling or preliminary positive results. Although empirical evidence specifically addressing cognitive biases among nurses and midwives in the ENBS setting remains limited, a recent scoping review[35] of nursing decision-making found that nurses are susceptible to cognitive biases, particularly confirmation and anchoring biases, similarly to physicians. In addition, the highly standardized and repetitive nature of newborn screening may increase susceptibility to complacency bias, while several other cognitive biases may also influence clinical judgment and communication in this professional group (Supplementary Table 2).

BIOCHEMISTS, GENETICISTS (LABORATORY SPECIALISTS)

Clinical biochemists, geneticists, and laboratory scientists perform the biochemical and molecular analyses underpinning ENBS and conduct confirmatory investigations when required. Their responsibilities include selecting appropriate confirmatory tests and interpreting borderline biochemical findings or genetic variants, both of which are essential for establishing an accurate diagnosis and guiding subsequent clinical management. As with other professionals involved in the screening pathway, these judgments are susceptible to cognitive biases (Supplementary Table 3), which may influence test selection, data interpretation, and the reporting of laboratory findings.

DIETITIANS

Within ENBS, dietitians play a pivotal role in translating biochemical and clinical findings into individualized dietary management plans, particularly for disorders such as phenylketonuria (PKU). However, clinical decision-making in this setting often occurs under conditions of diagnostic uncertainty and emotional pressure from families, making dietitians susceptible to cognitive biases that may influence nutritional assessment, treatment recommendations, and patient counseling[36]. Several cognitive biases relevant to dietetic practice in ENBS are summarized in Supplementary Table 4.

FAMILIES RECEIVING POSITIVE OR FALSE-POSITIVE ENBS RESULTS

Parents and family members are central stakeholders in the ENBS pathway, and the service should be grounded in their informational and emotional needs. On receiving a positive or borderline screening result, families undergo rapid emotional and cognitive processing; even when a result later proves to be a false positive, the experience can remain intensely distressing[20,21,37]. In such high-stress, uncertain moments, fast, intuitive System 1 thinking tends to dominate, making parents particularly vulnerable to heuristics and biases (Supplementary Table 5). These processes influence how families seek, interpret, respond to, and later remember information, so recognizing them is essential for clinicians and other health professionals who must tailor clear, empathetic communication and decision-support.

A related and frequently overlooked consequence is the psychosocial and logistical burden of caring for a child with an inherited metabolic disorder, which often falls disproportionately on mothers[38,39]. Clinicians' assumptions about caregiving roles can implicitly reinforce this imbalance and obscure the needs of other family members. For example, owing to gender-role expectations bias, healthcare professionals may default to addressing mothers more directly, providing instructions and follow-up recommendations primarily to them, even when fathers or other caregivers are actively involved. Similarly, affective bias can lead clinicians to offer more emotional support to mothers, thereby under-recognizing paternal stress or involvement. Fathers who show signs of emotional fatigue may be less likely to be offered psychological support and may feel less authorized to voice their difficulties. Finally, confirmation bias may lead clinicians to interpret maternal fatigue in a way that confirms their expectation that such symptoms are a normal consequence of caregiving, rather than considering the possibility of significant psychological distress or caregiver burden. As a result, reports of persistent sleep deprivation may be acknowledged without further assessment or referral for supportive services.

MITIGATION STRATEGIES: TRAINING AND EDUCATIONAL INTERVENTIONS

ENBS is a clinical context in which integrated collaboration among professionals can help develop a broader perspective on decision-making processes, thereby correcting most cognitive biases. Although evidence regarding the effectiveness is limited, instruction in metacognition, reflective practice, cognitive bias awareness, and interdisciplinary collaboration has been proven to improve diagnostic accuracy and emotional support for families in healthcare settings[12,14,40,41]. At the individual level, teaching healthcare staff to slow down, reflect, and use decision aids or checklists can reduce the impact of bias[42]. Cognitive bias awareness is the first step to mitigating them[42]. Education and training programs can help clinicians (and families) become aware of common heuristics and adopt strategies to counteract them. For clinicians, curricula increasingly include modules on clinical reasoning and cognitive bias. A recent scoping review found that targeted training can improve healthcare providers' recognition of biases[43]. Existing training focuses on increasing awareness and self-reflection about explicit and implicit biases and their harmful effects on patient care[44], as well as on acquiring strategies to manage biases in real-time, promoting perspective-taking to understand patients' unique viewpoints and challenges and to regulate emotions that can contribute to biased decisions[12].

Training should be tailored to the clinician's level of experience. For junior or less experienced clinicians, educational interventions should emphasize structured decision-making frameworks to reduce inappropriate deference to authority and promote confident, evidence-based decision-making. For senior clinicians, training should focus on peer case review, reflective practice, and deliberate reconsideration of diagnostic conclusions despite extensive experience, while reinforcing the consistent use of evidence-based tools and clinical algorithms even when intuitive judgment suggests an alternative course of action.

Educational interventions for healthcare professionals should be designed to fit the demands of busy clinical practice. Short, case-based workshops on common heuristics and cognitive biases, complemented by microlearning modules, can increase awareness while providing practical strategies to recognize and mitigate cognitive traps. Simulation-based training, particularly for communicating uncertain or distressing results and managing challenging specimen collection scenarios (e.g., dehydrated or very small neonates), allows practitioners to develop calibrated responses in realistic clinical settings. In addition, confidence-calibration exercises – where clinicians record their diagnostic confidence and subsequently compare it with actual outcomes – can improve metacognitive awareness, reduce overconfidence, and enhance clinical judgment over time.

Mitigating cognitive errors across the ENBS pathway requires a deliberate shift from ad hoc, intuition-led practice to predictable, data-driven processes. The imperative for system-level solutions was set out in the seminal patient-safety reports and has been reinforced by work on diagnostic error: moving from individual heroics to reliable systems reduces avoidable harm[45,46]. At a service level, this means designing workflows so that routine judgments are supported by objective rules and decision aids rather than left to memory or momentary impressions. Simple, standardized procedures that set out the steps from initial screen to confirmatory testing and, where appropriate, treatment, make practice repeatable and reduce scope for individual judgment to be distorted by recent experiences or emotional states.

Equally important is the principle of "designing for the human factor": accept that people are fallible and build prompts, checks, and rapid feedback into everyday tasks. This can be achieved, for example, through structured reporting templates that require clinicians and laboratory staff to record alternative explanations, the degree of certainty, and explicit next steps, or through Laboratory Information Management System/Electronic Health Record prompts that flag equivocal results and require a short justification before escalation[47]. By making the expected steps visible and unavoidable in the record, multidisciplinary teams reduce the chance that a single striking data point will dominate decision-making.

Furthermore, low-cost usability interventions and "nudges" can sustain behavioral change[48]. Visual reminders in collection areas, brief on-screen prompts in the Electronic Health Record, default follow-up schedules, and ready-to-use reporting templates reduce cognitive load and make the right action the easy action[49]. Implementation should start small: one protocol, one teach-back requirement, one audit loop, and scale up iteratively, engaging frontline staff in co-design so that measures fit real workflows rather than adding burdensome tasks.

System changes may include deliberate procedural "pause points" and short checklists that serve as cognitive forcing functions, encouraging reflective, analytical review before irreversible actions[50-52]. Short time-outs (introduced before irreversible actions such as admission or major dietary changes) create space for verification, to check whether other causes have been considered, and to seek a second opinion when appropriate. These pause points work best when coupled with mandatory quality checks at critical junctures (for example, an objective checklist for blood-spot adequacy at collection and a pre-sign-off review in the laboratory). In practice, a brief, structured pause codified into the pathway will interrupt premature closure and anchoring and prompt a short multidisciplinary check for borderline or high-consequence findings.

Communicating with families should be regarded and delivered as a clinical intervention: how information is transmitted directly affects parental understanding, emotional response, and subsequent health actions, not merely the "soft" side of care[19,21,53].

When clinicians communicate unexpected or provisional results to families, they should begin with an empathetic acknowledgment of the family's likely distress, then provide balanced context and a clear, time-bound plan of next steps (what will be tested, when, and who will contact them). Protocols for delivering difficult news, such as the SPIKES framework, support opening with empathy and following a structured sequence to reduce harm and improve comprehension[54].

The way in which screening results are framed has an important influence on parental understanding and decision-making. Clinicians should avoid isolated or alarmist wording and instead emphasize the provisional nature of the findings while clearly explaining the subsequent diagnostic pathway. Risk communication should rely on simple absolute risks or natural frequencies, supported where appropriate by visual aids, as these formats improve comprehension and reduce misinterpretation compared with vague or relative expressions[55].

Because patients and families commonly forget much of what they are told in a single consultation, providing a one-page written or visual summary that recapitulates the result, the planned next steps, and a named contact improves retention and allows families to review information when they are less emotionally aroused. Empirical work documents poor recall of medical information and supports the routine use of written takeaways to reinforce verbal explanations[56]. Services should provide multimodal, clinician-vetted information such as brief leaflets, icon arrays, translated materials, and short videos.

Finally, the teach-back method – in which caregivers are asked to explain or demonstrate the care plan in their own words – is an evidence-based communication strategy recommended by major healthcare organizations and supported by systematic reviews[57] demonstrating improvements in patient comprehension, adherence, and safety. Documenting the use of teach-back can also help verify that information has been accurately understood rather than merely acknowledged[57].

More broadly, adopting a family-centered approach can help reduce the likelihood that parents' understandable anxiety will contribute to unnecessary or disproportionate interventions[58]. For families experiencing high levels of distress, timely psychosocial support from a clinical psychologist or other qualified mental health professional may provide additional benefit by facilitating coping, improving communication, and supporting informed decision-making.

The goal is not to eliminate heuristics (necessary and efficient tools for navigating a complex and overloading environment), but to normalize the idea that healthcare staff, like other individuals, are cognitively biased and to promote a culture of cognitive transparency. By combining awareness, education, structured checks, teamwork, and effective communication strategies, healthcare staff and families can reduce reasoning and decision-making errors and emotional distress during the ENBS process.

CONCLUSIONS

Cognitive biases have the potential to influence every stage of Expanded Newborn Screening, from specimen collection and laboratory interpretation to clinical decision-making and communication with families. Although clinical experience and pattern recognition remain indispensable in the diagnosis of rare diseases, they do not protect clinicians from systematic errors in reasoning. On the contrary, experience may reinforce predictable cognitive vulnerabilities – including anchoring, availability, and confirmation bias – that can contribute to over- or under-investigation, unnecessary interventions, avoidable parental distress, and inefficient use of healthcare resources. Reducing the impact of cognitive bias requires a multifaceted approach that combines evidence-based communication, structured clinical workflows, and targeted educational interventions. Balanced communication of provisional screening results, teach-back techniques, standardized decision-support tools, diagnostic pause points, second-opinion review of high-impact or borderline cases, and regular audit with feedback represent complementary strategies that strengthen clinical reasoning while reducing reliance on intuition alone. Educational initiatives – including case-based learning, simulation, microlearning, and confidence-calibration exercises – can further promote metacognitive awareness and reflective practice. To maximize effectiveness, these interventions should be pragmatic, integrated into routine clinical workflows, and co-designed with frontline healthcare professionals. This work is based on fictional but expert-validated clinical vignettes and therefore provides a conceptual and educational framework rather than empirical evidence. Future research should evaluate the effectiveness of these mitigation strategies within real ENBS programs, investigate how families understand and respond to risk communication, and determine whether behavioral interventions – such as framing, salience, or priming – can improve comprehension, reduce distress, and support shared decision-making[59,60]. Ultimately, recognizing cognitive bias as an inherent feature of human decision-making rather than an individual failing is fundamental to improving the quality and safety of Expanded Newborn Screening. By integrating behavioral science with clinical expertise, ENBS programs can strengthen diagnostic accuracy, improve the family experience, and enhance the effectiveness and reliability of early detection of inherited metabolic disorders.

Expanded newborn screening has transformed the early detection of inherited metabolic diseases; reducing cognitive bias represents the next step toward improving the quality, consistency, and safety of this complex diagnostic pathway.

Artificial Intelligence-Assisted Technologies:

An artificial intelligence (AI)-based large language model (ChatGPT) was used solely to assist in drafting selected clinical vignettes and improving the language and readability of the manuscript. The AI system was not used for study design, data collection, data analysis, interpretation of results, or scientific decision-making. All AI-generated content was critically reviewed, revised, and verified by the authors, who assume full responsibility for the accuracy and integrity of the final manuscript.

Authors' Contributions:

Study conception and design: M.B., S.R.; writing – original draft: M.B., S.R.; writing – review and editing, manuscript preparation: S.R., S.Ga., V.C., M.C.F., R.P., C.B., S.Gi., K.P., A.C., G.L., M.B.

Availability of Data and Material:

Data sharing is not applicable to this article, as no datasets were generated or analyzed during the current study.

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The authors declare that they have no conflicts of interest to disclose.

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