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Neonatal nurses' experiences with generative AI in clinical decision-making: a qualitative exploration in high-risk nicus

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Abstract

Background Neonatal nurses in high-risk Neonatal Intensive Care Units (NICUs) navigate complex, time-sensitive clinical decisions where accuracy and judgment are critical. Generative artificial intelligence (AI) has emerged as a supportive tool, yet its integration raises concerns about its impact on nurses' decision-making, professional autonomy, and organizational workflows.

Aim This study explored how neonatal nurses experience and integrate generative AI in clinical decision-making, examining its influence on nursing practice, organizational dynamics, and cultural adaptation in Saudi Arabian NICUs.

Methods An interpretive phenomenological approach, guided by Complexity Science, Normalization Process Theory, and Tanner's Clinical Judgment Model, was employed. A purposive sample of 33 neonatal nurses participated in semi-structured interviews and focus groups. Thematic analysis was used to code and interpret data, supported by an inter-rater reliability of 0.88. Simple frequency counts were included to illustrate the prevalence of themes but were not used as quantitative measures. Trustworthiness was ensured through reflexive journaling, peer debriefing, and member checking.

Results Five themes emerged: (1) Clinical Decision-Making, where 93.9% of nurses reported that AI-enhanced judgment but required human validation; (2) Professional Practice Transformation, with 84.8% noting evolving role boundaries and workflow changes; (3) Organizational Factors, as 97.0% emphasized the necessity of infrastructure, training, and policy integration; (4) Cultural Influences, with 87.9% highlighting AI's alignment with family-centered care; and (5) Implementation Challenges, where 90.9% identified technical barriers and adaptation strategies.

Conclusions Generative AI can support neonatal nurses in clinical decision-making, but its effectiveness depends on structured training, reliable infrastructure, and culturally sensitive implementation. These findings provide evidence-based insights for policymakers and healthcare leaders to ensure AI integration enhances nursing expertise while maintaining safe, patient-centered care.

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Keywords Generative artificial intelligence, Neonatal nursing, Clinical decision-making, Cultural context, Professional practice, Saudi Arabia

Introduction

Neonatal nurses operate at the forefront of healthcare's most challenging environments, providing life-critical care to newborns in high-risk Neonatal Intensive Care Units (NICUs) [1, 2]. In these settings, precise and timely clinical decision-making is essential, as even minor interventions can profoundly affect survival and long-term developmental outcomes [3]. Traditionally, these decisions relied on nurses' clinical expertise, professional judgment, and adherence to established protocols [4]. However, with the rapid digital transformation of healthcare, artificial intelligence (AI) has emerged as a transformative tool, reshaping how patient data is interpreted and care recommendations are generated [5]. Recent advancements in AI, particularly generative AI, have introduced sophisticated systems capable of producing innovative and context-specific solutions [6, 7]. Unlike earlier AI tools that primarily classified data patterns or provided standard alerts, generative AI can analyze complex datasets, propose tailored care strategies, and identify real-time risks that may deviate from established guidelines [8, 9]. For example, in NICUs, generative AI can predict the likelihood of neonatal sepsis by detecting subtle changes in heart rate variability, suggesting ventilation adjustments based on real-time respiratory data, or recommending feeding protocols for infants with rare metabolic conditions [10, 11]. These applications enhance diagnostic accuracy, optimize workflows, and reduce human error [12, 13]. However, their integration into high-stakes environments raises questions about how frontline nurses perceive, trust, and utilize these tools alongside their professional judgment and experiential knowledge [14, 15].

AI in clinical decision-making specifically refers to using these advanced technologies to support healthcare professionals in analyzing patient data, predicting outcomes, and guiding interventions [16, 17]. In NICUs, where even the slightest delays or inaccuracies can have critical consequences, generative AI can act as a computational partner to neonatal nurses, complementing their expertise while mitigating cognitive workload [18, 19]. Despite this potential, the adoption of AI raises concerns about its reliability, transparency, and ethical implications, particularly in environments where human oversight is paramount [20]. AI in high-stakes environments like NICUs raises fundamental questions about how frontline nurses experience, interpret, and integrate this technology into their decision-making processes [21, 22]. Despite advancements in perinatal and neonatal care, global neonatal mortality remains a significant concern, with approximately 2.3 million newborns dying within the first 28 days of life in 2022 [23]. Preterm birth complications continue to be the leading cause of death among children under five [24]. In Saudi Arabia, neonatal mortality rates have declined from an estimated 12.2 per 1,000 live births in 1990 to around 3.1 per 1,000 in 2022 [25, 26]. However, the burden of neonatal morbidity and the complexities of caring for premature and critically ill infants persist, presenting significant challenges for NICU teams nationwide [27].

While global healthcare systems have increasingly adopted AI to improve quality, safety, and efficiency, the literature on AI in clinical practice has largely focused on technical performance indicators, such as predictive accuracy or cost-effectiveness [28, 29]. While important, these metrics fail to address how frontline healthcare professionals, particularly nurses, interact with and experience these technologies [30]. Nurses, who play a pivotal role in continuous patient care, are often the first to notice subtle changes in neonates' conditions [31]. Their ability to integrate AI-generated insights with experiential knowledge is crucial for ensuring that these tools complement rather than compromise patient safety [32, 33]. However, research exploring nurses' experiences with AI in NICUs is limited, particularly in qualitative terms, leaving a critical gap in understanding how generative AI influences their clinical reasoning, communication, and decision-making [34–36]. A significant research gap exists in understanding the nuanced experiences of neonatal nurses with generative AI in clinical decision-making, particularly in the cultural and institutional context of Saudi Arabia [37–39]. While AI applications in neonatal care have been explored, most studies have emphasized quantitative metrics or physician perspectives, leaving nurses' voices underrepresented [40].

Furthermore, the hierarchical decision-making structures and rapid digitalization within Saudi healthcare systems have not been sufficiently examined [38]. Without an in-depth understanding of how nurses in high-risk NICUs perceive generative AI's role, reliability, and limitations, there is a risk of adopting technology that does not align with local clinical realities or nursing workflows [41, 42]. Despite growing evidence on AI's technical capabilities, there is limited insight into how neonatal nurses who provide continuous bedside care perceive, interpret, and integrate AI recommendations into their high-risk clinical workflows [33, 43, 44]. Existing scholarship often prioritizes physician perspectives or broader quantitative metrics, overlooking the nuanced, real-time decision-making processes that nurses undertake [45].

Since neonatal nurses in Saudi Arabian NICUs operate under unique cultural, organizational, and familial dynamics, understanding their experiences is critical to ensuring that generative AI supports, rather than undermines, patient safety and professional autonomy [33, 46]. By centering neonatal nurses' voices, this study responds to an unaddressed need in the literature, offering context-specific insights that can guide responsible AI implementation and policy development.

This study explores how neonatal nurses experience the integration of generative AI into clinical decision-making and nursing practice in high-risk NICUs. Specifically, it examines how nurses reconcile AI-generated recommendations with clinical judgment, establish trust in AI outputs, and navigate organizational, cultural, and practice-related factors influencing AI adoption. The primary research question guiding this study is:

Q: How do neonatal nurses working in high-risk NICUs experience the use of generative AI in their clinical decision-making processes?

The objectives of this study were threefold:

- To qualitatively explore how neonatal nurses in high-risk NICUs perceive, interpret, and integrate generative AI recommendations into their clinical decision-making, emphasizing their lived experiences, professional judgment, and the cultural and ethical dimensions of AI use in neonatal care.
- To identify organizational, educational, clinical, and cultural factors such as training adequacy, workload distribution, safety protocols, and institutional AI norms that facilitate or hinder the effective adoption of generative AI in neonatal nursing practice.
- To explore and describe neonatal nurses' lived experiences and perceptions regarding how generative AI influences their clinical workflows, professional autonomy, patient interactions, and ethical considerations in care delivery.
- To provide experience-informed insights and contextual recommendations for clinicians, administrators, policymakers, and technology developers, contributing to responsible, ethically sound, culturally sensitive, and practice-oriented AI integration in neonatal critical care.

By addressing these objectives, this study provides critical insights into the integration of advanced computational tools in NICU settings. Understanding how nurses engage with generative AI will inform the design of user-friendly, transparent, and ethical AI systems that respect professional judgment, improve patient outcomes, and align with cultural and institutional contexts. Ultimately, this research seeks to guide the responsible and human-centered implementation of AI in neonatal care, ensuring that it augments rather than replaces the expertise and advocacy of neonatal nurses.

In conclusion, this qualitative investigation addressed the urgent need to understand how neonatal nurses experienced generative AI in clinical decision-making within Saudi Arabia's high-risk NICUs. Focusing on their perspectives filled a critical gap in the literature, offering guidance on how to integrate advanced computational tools in a way that respected professional judgment, improved patient outcomes, and aligned with cultural and institutional contexts. Through this lens, the study provided a foundation for more informed and ethically grounded adoption of AI in one of healthcare's most sensitive and life-critical areas.

Theoretical framework

This study is anchored in an integrative theoretical framework that synthesizes Complexity Science [47], Normalization Process Theory (NPT) [48, 49], and Tanner's Clinical Judgment Model [50]. Complexity Science conceptualizes the high-risk NICU as a complex adaptive system characterized by emergent behaviors, non-linear interactions, and dynamic relationships between technological, social, and organizational elements, highlighting how generative AI introduces new interaction patterns that influence workflows and care protocols [51, 52]. Normalization Process Theory (NPT) extends this understanding by offering a structured approach to exploring how new technologies, such as generative AI, are operationalized and embedded into clinical practice [53]. NPT focuses on four core mechanisms: coherence (sense-making), cognitive participation (relational work), collective action (operational work), and reflexive monitoring (appraisal work) to explain how neonatal nurses adopt and normalize technology into their routines [54]. Tanner's Clinical Judgment Model complements these perspectives by grounding the analysis in the cognitive and experiential processes of nursing [55]. This model highlights how nurses notice, interpret, respond, and reflect, integrating algorithmic insights from generative AI with their clinical expertise and professional judgment [56]. Tanner's framework ensures that AI supports, rather than replaces, the critical thinking essential for high-stakes neonatal care [57].

To illustrate the convergence of these three frameworks, Fig. 1 shows how Complexity Science (orange boxes), Normalization Process Theory (NPT) (green boxes), and Tanner's Clinical Judgment Model (blue boxes) interact within high-risk NICU settings. Complexity Science underpins the dynamic, adaptive environment in this diagram by highlighting elements such as complex adaptive systems, emergent behaviors, and non-linear interactions. NPT's four core mechanisms, coherence, cognitive participation, collective action,

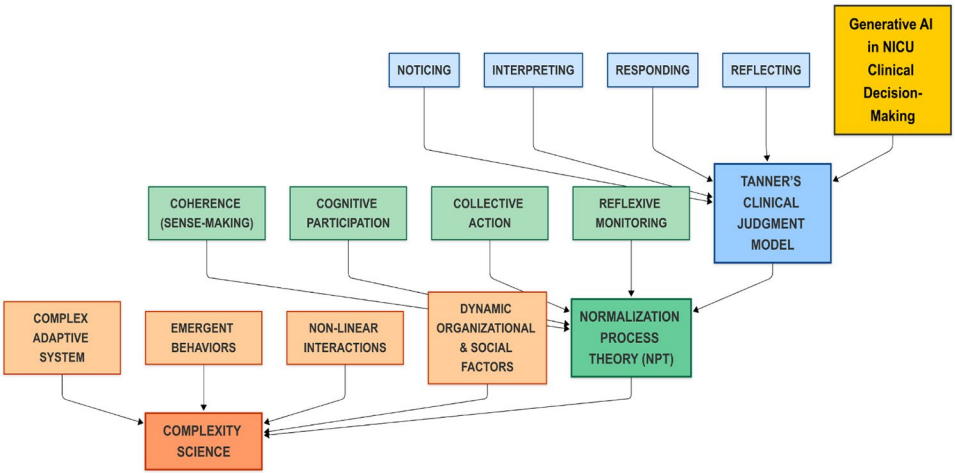

Fig. 1 Theoretical Framework for Neonatal Nurses' Use of Generative AI in Clinical Decision-Making

and reflexive monitoring, are depicted in the middle layer, emphasizing how new technologies like generative AI are embedded and normalized in daily practice. Meanwhile, Tanner's Model sits at the top, encompassing noticing, interpreting, responding, and reflecting as the core stages of clinical judgment for individual nurses. In designing this study, we applied Complexity Science by selecting multiple high-risk NICUs that capture the dynamic nature of neonatal care. NPT guided our interview questions and focus group prompts, exploring how nurses make sense of AI (coherence), engage with it (cognitive participation), implement it in practice (collective action), and evaluate its effectiveness (reflexive monitoring). Simultaneously, Tanner's Model drove our coding and interpretation by mapping participant narratives to the four stages of clinical judgment. These frameworks shaped our data collection (e.g., open-ended questions probing sense-making and professional judgment) and analysis (e.g., organizing emergent themes around systemic, team-based, and individual cognitive factors). Consequently, the theoretical foundation framed our conceptual understanding of AI adoption in high-risk NICUs and directly influenced how we gathered, coded, and interpreted the qualitative data.

Materials and methods

Research design

This study employs an interpretive phenomenological research design guided by van Manen's (1990) hermeneutic approach [58, 59], to investigate neonatal nurses' lived experiences with generative AI in clinical decision-making within high-risk NICUs. This methodology enables an in-depth exploration of both the immediate, embodied experiences of working with AI and the deeper meanings nurses assign to these interactions, using an iterative hermeneutic analysis process [60, 61]. The design incorporates temporal dimensions of experience, Saudi Arabian healthcare's cultural and organizational contexts, and alignment with Tanner's Clinical Judgment Model to ground the findings in neonatal nursing practice's cognitive and experiential processes. To ensure methodological rigor, the study includes reflexive journaling and peer debriefing, addressing potential biases related to AI in healthcare and strengthening the trustworthiness of the findings [62].

Settings

The study was conducted between March 2024 and October 2024 in four high-risk Neonatal Intensive Care Units (NICUs) located in the Eastern Region of Saudi Arabia. The NICUs were purposively stratified by hospital type and size, comprising one large specialist pediatric hospital, one large general hospital, one medium-sized specialist pediatric hospital, and one medium-sized general hospital. This stratification enabled an examination of variations in neonatal care delivery and resource allocation across distinct clinical settings. Each NICU functions as a referral center for complex neonatal cases, equipped with advanced medical technologies and supported by interdisciplinary healthcare teams. Operating under a family-centered care model, these units emphasize parental involvement in clinical decision-making to optimize neonatal outcomes and support family well-being. The diverse clinical environments provided a robust framework for investigating the integration of generative artificial intelligence into neonatal nursing practice. By exploring institutional factors and resource dynamics across different hospital types and sizes, this study offers critical insights into the contextual determinants that shape the adoption of innovative technologies in high-stakes neonatal care settings.

Sample

This study utilized purposive sampling to recruit neonatal nurses with direct experience using generative AI in high-risk NICUs. Participants met the following inclusion criteria: active nursing licensure in Saudi Arabia, a minimum of two years of high-risk NICU experience, direct interaction with generative AI tools in clinical decision-making, and fluency in either Arabic or English. To capture a broad range of perspectives, maximum variation sampling was employed, ensuring representation from both private and public hospitals. This approach reflected the complex adaptive systems framework, capturing diverse organizational contexts and workflows. Data collection continued until saturation, yielding a sample of 33 participants across various roles, including staff nurses, charge nurses, and unit coordinators. This sampling strategy aligned with the study's theoretical foundation, including Complexity Science and Tanner's Clinical Judgment Model. It enables a detailed exploration of how nurses normalize AI technologies within distinct institutional settings and integrate them into their clinical judgment processes. The decision to recruit 33 neonatal nurses was informed by established qualitative research principles, particularly those related to data saturation. Saturation is reached when subsequent interviews and focus groups yield no new codes or themes [63]. In our study, thematic redundancy became evident after analyzing data from 28 participants, and five additional participants were included to confirm that no further insights emerged. This iterative approach ensured that the sample size was sufficient to provide a rich, in-depth account of nurses' experiences with generative AI. We documented our saturation assessment through a systematic monitoring process using a saturation grid that mapped emerging themes against participant interviews. After the 28th interview, we observed complete thematic redundancy across all major coding categories, with subsequent interviews only reinforcing existing patterns rather than contributing new insights. Our coding team independently verified this saturation point through separate analysis, confirming theoretical sufficiency had been achieved.

Data collection tools

Data collection utilized semi-structured interviews and focus group discussions to explore neonatal nurses' experiences with generative AI in high-risk NICUs. The interview guide was developed based on the study's theoretical framework, incorporating elements from Complexity Science, Normalization Process Theory (NPT), and Tanner's Clinical Judgment Model. Individual interviews were conducted in a private setting to ensure confidentiality and encourage open dialogue. These interviews used open-ended questions to delve into nurses' personal experiences, perceptions of AI reliability, and the contextual factors influencing AI integration into their clinical practice. Focus group discussions, comprising 5–7 participants with diverse roles, served as a complementary method to individual interviews by capturing collective perspectives and fostering dialogue on team-level interactions with generative AI. These discussions provided insights into how nurses communicated, collaborated, and made clinical decisions influenced by AI-generated recommendations, enriching the understanding of organizational dynamics.

Both data collection tools were reviewed by an expert panel specializing in neonatal nursing, qualitative research, and AI integration to ensure content validity. Pilot testing was conducted with two neonatal nurses to refine the tools for clarity and relevance. Data collection was carried out in participants' preferred language, Arabic or English, and all interviews and focus groups were audio-recorded with informed consent. Field notes were taken to document non-verbal cues, contextual details, and initial observations, further enriching the dataset. Semi-structured interviews allowed participants to share personal, detailed reflections on their use of generative AI, fostering candid discussions around sensitive or complex topics. Focus groups, in contrast, captured the collective and interactive dimensions of AI adoption by enabling participants to validate, expand, or challenge each other's perspectives in a group setting. This two-pronged approach provided complementary insights: individual interviews elucidated each nurse's internal decision-making processes, while focus groups illuminated team-level dynamics, negotiation of AI recommendations, and the shared sense-making that occurs within NICU environments. The interview and focus group protocols were systematically designed to address our research objectives. Questions exploring organizational structures, training experiences, and cultural contexts directly supported our aim to identify factors influencing AI adoption. Similarly, inquiries about clinical judgment processes, workflow adaptations, and role transformations generated rich data regarding AI's impact on nursing practice. This methodological alignment ensured our qualitative approach could capture both explicit and tacit dimensions of nurses' experiences with AI in high-risk NICUs. The full questionnaire used for data collection, including interview and focus group questions, is available in Supplementary File 1.pdf.

Ethical approval

for this study was obtained from the King Faisal University Ethics Committee under the reference number KFU-2024-ETHICS2926. The study adhered to the principles outlined in the Declaration of Helsinki to ensure the ethical conduct of research involving human participants.

Approval was secured prior to the commencement of data collection, ensuring compliance with all institutional and national ethical guidelines. Participants were provided with detailed information about the study's objectives, procedures, and their rights, including the right to withdraw at any time without consequences. Written informed consent was obtained from all participants before their involvement in the study.

All data were de-identified using numeric codes, and any potentially identifying information was removed from the transcripts to maintain confidentiality. Audio recordings, transcripts, and field notes were stored on secure, password-protected servers, with hard copies locked in cabinets within restricted-access offices, ensuring data security. Reflexive journaling was employed to document researchers' assumptions, and peer debriefing sessions were conducted regularly to address potential biases, particularly given the sensitive nature of AI in clinical decision-making. Confidentiality and anonymity were maintained by de-identifying all data and securely storing records. Measures were taken to ensure that participants felt comfortable sharing their experiences, particularly given the sensitive nature of their professional roles and the integration of new technologies in their practice.

Procedure

This study employed a systematic approach guided by its phenomenological design and the integrative theoretical framework encompassing Complexity Science, Normalization Process Theory (NPT), and Tanner's Clinical Judgment Model. Ethical approval was obtained from the King Faisal University Ethics Committee prior to initiating data collection in March 2024. Nursing administrators facilitated recruitment in the four participating NICUs, who distributed information packets explaining the research objectives, participant rights, and confidentiality safeguards. Interested nurses meeting the inclusion criteria were invited to provide written informed consent before participating. Data collection commenced with semi-structured individual interviews, each lasting approximately 45–60 min. These interviews took place in private rooms within the NICU facilities during non-clinical hours to ensure participant comfort and minimize interruptions. Interviews were conducted by bilingual researchers in Arabic or English, depending on the participant's preference. The interview guide, informed by Complexity Science, NPT, and Tanner's Clinical Judgment Model, began with broad, open-ended questions such as "Can you describe your experiences with generative AI in your clinical practice?" to elicit lived experiences and contextual insights. Subsequent, more focused questions were shaped by the theoretical framework: Complexity Science guided inquiries into how AI influenced the dynamic and adaptive nature of NICU workflows; NPT illuminated how nurses understood, engaged with, and integrated AI tools into their routines; and Tanner's Model informed probes into how participants noticed, interpreted, and responded to AI-generated recommendations.

Following the completion of all individual interviews, focus group discussions were held to explore collective dynamics and shared interpretations. Groups of 5–7 participants, drawn from a range of professional roles (e.g., staff nurses, charge nurses, unit coordinators), were assembled to capture diverse viewpoints and experiences. Each focus group, lasting around 90 min, was facilitated by two researchers, one leading the conversation and the other documenting non-verbal cues and group interactions. These discussions, also informed by the theoretical framework, examined how nurses collectively made sense of AI recommendations (NPT), navigated organizational complexities (Complexity Science), and reflected on the quality of their clinical judgments supported by generative AI (Tanner's Model). To maintain methodological rigor, researchers kept reflexive journals to record methodological decisions, initial impressions, and evolving interpretations, ensuring awareness of potential biases and alignment with the theoretical framework. Regular team debriefings allowed for the ongoing refinement of data collection strategies, ensuring that emerging patterns remained theoretically grounded. All interviews and focus groups were audio-recorded, transcribed verbatim, and, when necessary, professionally translated from Arabic into English.

To minimize interpretive biases associated with cross-language research, we implemented a dual-review process. First, all Arabic transcripts were professionally translated by certified translators experienced in medical terminology. Then, bilingual research team members compared the translated transcripts against the original Arabic audio recordings to ensure semantic and contextual fidelity. Any discrepancies were resolved through consensus discussions among the translators and researchers. Additionally, member-checking sessions were conducted with participants to validate the accuracy of the translated findings, further reinforcing the credibility of the cross-language data. Member checking was employed to validate the authenticity and accuracy of transcripts, allowing participants to confirm that the recorded data and preliminary interpretations faithfully represented their experiences. Ethical considerations were maintained throughout, with data de-identified during transcription and securely stored in password-protected files.

Data triangulation and quality assurance

This study employed rigorous methods to ensure the trustworthiness and credibility of the findings through data triangulation and robust quality assurance measures. Triangulation was achieved by collecting data from multiple sources, including individual interviews and focus group discussions, to capture a comprehensive and nuanced understanding of neonatal nurses' experiences with generative AI in clinical decision-making [64]. This approach allowed for the cross-verification of insights across different contexts and interactions, enhancing the depth and reliability of the data. To further ensure quality, the study adhered to established standards for qualitative research. Reflexivity was maintained throughout the research process, with researchers keeping reflexive journals to document methodological decisions, emerging themes, and potential biases [65]. Regular debriefing sessions were conducted among the research team to discuss preliminary findings critically, refine data collection strategies, and ensure alignment with the study's theoretical framework and phenomenological design [66]. Member checking was used as a key validation strategy. Participants were invited to review their transcripts and provide feedback on the accuracy of the recorded data and preliminary interpretations [67]. This iterative process ensured that the findings accurately reflected participants' experiences and perspectives. Transcriptions of audio-recorded interviews and focus group discussions were reviewed for accuracy, and certified translators translated Arabic transcripts into English. Dual-review processes were employed to validate translations, minimizing the risk of misinterpretation.

Data analysis

Data were analyzed using Braun and Clarke's (2006) [68], thematic analysis framework. Following verbatim transcription, two researchers independently immersed themselves in the data through repeated readings to ensure a comprehensive understanding of the participants' narratives. Initial codes were generated inductively, capturing significant statements and patterns related to nurses' experiences with generative AI in clinical decision-making. Our coding process followed Braun and Clarke's six-phase approach systematically. After familiarization, we developed initial codes using line-by-line analysis, generating 187 unique codes. During the third phase, we grouped these codes into potential themes through an iterative process of comparing, contrasting, and clustering. These preliminary themes were then reviewed against the coded extracts and entire dataset, resulting in a thematic map with five overarching themes. In the fifth phase, we refined theme definitions and names through team discussions, ensuring each captured distinct aspects of nurses' experiences. The final phase involved selecting representative quotes and preparing the analytical narrative.

To ensure inter-rater reliability, both researchers coded the transcripts independently and then compared their codes, resolving discrepancies through collaborative discussions. After calculating Cohen's kappa ($\kappa = 0.88$), we addressed any persistent coding discrepancies through iterative consensus discussions. In cases where disagreements remained unresolved, a third researcher familiar with the study aims but not involved in the initial coding reviewed the contested excerpts and provided an independent assessment. This process further strengthened the credibility of our qualitative findings. This iterative coding process facilitated the development of a final thematic framework that accurately reflected the complexity of the nurses' experiences. The analysis was guided by the study's theoretical underpinnings, Complexity Science, Normalization Process Theory (NPT), and Tanner's Clinical Judgment Model, ensuring that the integration of generative AI into clinical decision-making was interpreted through multiple analytical lenses.

Trustworthiness was enhanced through several strategies: credibility was achieved via prolonged engagement with the data, independent coding, and member checking with participants to verify the accuracy of the themes; dependability was ensured by maintaining a detailed audit trail of the coding and theme development process; confirmability was strengthened through reflexive journaling by the researchers, documenting their reflections and potential biases throughout the analysis; and transferability was supported by providing rich, detailed descriptions of the themes and the study context. Additionally, simple counts and percentages were employed to represent the prevalence of certain themes, enhancing the clarity and accessibility of the findings for readers. Data saturation was confirmed as no new themes emerged after analyzing 28 interviews out of the total 33. Ultimately, the analysis yielded five overarching themes and their subthemes, which elucidated how generative AI influenced clinical judgment, professional identity, organizational dynamics, cultural factors, and the adaptive strategies nurses employed to overcome implementation challenges. These thematic insights provide a robust and context-sensitive understanding of neonatal nurses' lived experiences with AI in high-risk NICUs, forming the foundation for the study's results.

Results

Overview of the participants

Using purposive sampling with maximum variation criteria, this qualitative study encompassed 33 neonatal nurses from four high-risk NICUs in the Eastern Region of Saudi Arabia. As detailed in Table 1, the sample demonstrated diverse professional and demographic characteristics

Table 1 Demographic and professional characteristics of study participants ($N = 33$)

Characteristic	*n* (%)
Gender	
Female	29 (87.9%)
Male	4 (12.1%)
Age Range (years)	
25–30	8 (24.2%)
31–35	12 (36.4%)
36–40	9 (27.3%)
> 40	4 (12.1%)
Professional Role	
Staff Nurse	20 (60.6%)
Charge Nurse	8 (24.2%)
Unit Coordinator	5 (15.2%)
Years of NICU Experience	
2–5 years	7 (21.2%)
6–10 years	14 (42.4%)
> 10 years	12 (36.4%)
Education Level	
Bachelor's Degree	25 (75.8%)
Master's Degree	7 (21.2%)
Doctoral Degree	1 (3.0%)
AI Training Received	
Formal Training	28 (84.8%)
No Formal Training	5 (15.2%)
Years of Experience with AI Systems	
≤ 1 year	20 (60.6%)
> 1 year	13 (39.4%)
Shift Pattern	
Day	10 (30.3%)
Night	10 (30.3%)
Rotating	13 (39.4%)
Previous Specialties before NICU	
None	20 (60.6%)
Pediatrics	8 (24.2%)
Adult ICU	5 (15.2%)
Hospital Setting	
Public	19 (57.6%)
Private	14 (42.4%)

Note: Chi-square tests (χ^2) were conducted to examine associations between hospital settings (public/private) and categorical variables. No significant associations were found (all $p > 0.05$), suggesting a comparable distribution of participant characteristics across settings. The mean age of participants was 34.7 years (SD = 5.8), and the mean NICU experience was 8.9 years (SD = 4.2)

essential for capturing comprehensive perspectives on generative AI integration in clinical practice. The sample size achieved theoretical saturation, as evidenced by the redundancy of themes in later interviews, aligning with established qualitative research guidelines. Female nurses constituted the majority (87.9%, $n = 29$), aligning with regional workforce demographics. The age distribution centered predominantly in the early to mid-career range, with 36.4% ($n = 12$) aged 31–35 years. Professional roles spanned the organizational hierarchy, including staff nurses (60.6%, $n = 20$), charge nurses (24.2%, $n = 8$), and unit coordinators (15.2%, $n = 5$).

The participants exhibited substantial clinical expertise, with 78.8% ($n = 26$) having more than five years of NICU experience. Educational qualifications were predominantly at the bachelor's level (75.8%, $n = 25$), complemented by those with advanced degrees (24.2%, $n = 8$). Notably, while most participants (84.8%, $n = 28$) had received formal AI training, the majority (60.6%, $n = 20$) had less than one year of direct experience with AI systems. The sample was well-distributed between public (57.6%, $n = 19$) and private (42.4%, $n = 14$) healthcare settings, with no statistically significant differences in key variables between sectors ($p > 0.05$). This demographic profile facilitated a rich examination of generative AI implementation across varying levels of expertise and institutional contexts.

Key themes identified

Following Braun and Clarke's (2006) six-step framework [68], the thematic analysis of the interview and focus group data revealed five overarching themes and corresponding subthemes that illuminate how neonatal nurses experience and integrate generative AI in their clinical practice. Data saturation was achieved after 28 interviews, with subsequent interviews confirming the established thematic structure. The analysis involved three independent researchers who achieved an inter-rater reliability coefficient of 0.88 (Cohen's kappa). The themes were validated through member checking with 25% of participants and peer debrief sessions with experienced qualitative researchers. These themes reflect the multifaceted nature of AI adoption in high-risk NICUs, encompassing clinical decision-making processes, professional practice evolution, organizational dynamics, cultural influences, and implementation challenges. Each theme emerged from a systematic analysis of participant narratives, providing comprehensive insights into the complex interplay between technological advancement and nursing practice in critical care settings.

The thematic framework presented above emerged from the rigorous qualitative analysis and represented the core experiences of neonatal nurses working with generative AI in high-risk NICUs. To fully appreciate the depth and significance of these findings, each theme warrants detailed examination through the lens of participant narratives and theoretical frameworks. The following discussion explores how these themes manifest in daily practice, illuminating the complex interplay between human expertise, technological innovation, and organizational context in critical care settings. Through this detailed analysis, we can better understand how generative AI shapes nursing practice while acknowledging

Table 2 Themes, subthemes, and their frequencies in this study (*N* = 33)

Themes and Subthemes	Frequency *n*(%)
1. Clinical Decision-Making Process with AI	
1a. Integration of AI Recommendations with Clinical Expertise	31 (93.9%)
1b. Evolution of Critical Thinking in AI-Enhanced Environment	29 (87.9%)
1c. Risk Assessment and Safety Considerations	30 (90.9%)
2. Professional Practice Transformation	
2a. Shifting Role Boundaries and Responsibilities	28 (84.8%)
2b. Adaptation to AI-Enhanced Workflows	27 (81.8%)
2c. Professional Identity in the AI Era	29 (87.9%)
3. Organizational and Systemic Factors	
3a. Infrastructure and Resource Requirements	32 (97.0%)
3b. Training and Competency Development	30 (90.9%)
3c. Policy and Protocol Integration	28 (84.8%)
4. Cultural and Contextual Influences	
4a. Saudi Healthcare System Dynamics	31 (93.9%)
4b. Family-Centered Care with AI Integration	29 (87.9%)
4c. Cultural Considerations in AI Adoption	27 (81.8%)
5. Implementation Challenges and Solutions	
5a. Technical and Practical Barriers	32 (97.0%)
5b. Strategic Solutions and Workarounds	30 (90.9%)
5c. Future Development Needs	28 (84.8%)

Note: Percentages represent the proportion of participants who discussed each subtheme during interviews and focus groups. Multiple references by the same participant were

the cultural and systemic factors that influence its adoption and implementation.

Discussion of themes and subthemes

This section comprehensively analyzes the five overarching themes and their corresponding subthemes, each supported by frequency data (see Table 2) and multiple participant quotations. Although qualitative research values depth over breadth, reporting the frequency of participants referencing a given concept offers an additional layer of transparency. Furthermore, integrating Complexity Science, NPT, and Tanner's Clinical Judgment Model provides a robust theoretical scaffold, ensuring that these findings are both empirically grounded and conceptually informed.

Theme 1: Clinical decision-making process with AI

This theme reflects how nurses incorporate generative AI outputs into their clinical reasoning, refine their critical thinking patterns, and maintain a vigilant stance on patient safety. High frequency counts here underscore the central role that AI plays in shaping nurses' clinical judgments.

1a. Integration of AI recommendations with clinical expertise

A substantial majority of nurses (31/33, 93.9%) indicated that AI outputs supplement, rather than supplant, their clinical expertise. Instead of passively following algorithmic suggestions, they used these insights as prompts to scrutinize and refine their decisions. This approach ensured that technology informed but did not dictate their professional judgments.

> *When the AI flags potential respiratory distress, I don't just change settings blindly. I check the baby's color, muscle tone, and response. The AI points me in a direction, but I still make the call. (P22)*

> *I see the AI as a second opinion. It suggests a course of action, but I always ask myself: 'Does this align with what I'm seeing and feeling?' It never overrides my experience. (P07)*

> *Sometimes, the AI confirms what I'm already suspecting, and other times, it challenges me to reconsider. Either way, it ensures I'm never complacent. (P29)*

The nurses' accounts highlight a balanced integration of data-driven tools and human skills. By critically evaluating AI recommendations against their own observations and clinical understanding, they preserved their autonomy and safeguarded patient care quality. Rather than diminishing their role, AI facilitated more thoughtful, context-sensitive decisions that enhanced, rather than replaced, their expert judgment.

1b. Evolution of critical thinking in an AI-enhanced environment

Nurses all nurses (29/33, 87.9%) highlighted how AI integration has transformed their critical thinking processes. Rather than relying solely on established protocols, they reported that AI prompts a deeper level of analysis, encouraging them to question, explore, and justify their decisions. This shift reflects the emergence of a more investigative and anticipatory approach to clinical reasoning, driven by the nuanced insights AI provides.

> *Before AI, I followed standard guidelines almost reflexively. Now, I ask: 'Why is the AI suggesting this?' It pushes me to look deeper and justify my decisions. (P11)*

> *The AI can highlight subtle trends I might have missed. Instead of feeling threatened, I use it as a learning tool, refining my diagnostic reasoning. (P19)*

> *It's made me more analytical. I'm no longer just*

reacting; I'm anticipating and interpreting. The AI helps me think in layers, not just steps. (P03)

These reflections illustrate how AI fosters a more analytical mindset among nurses, shifting their focus from reactive to proactive decision-making. By identifying patterns or trends that might otherwise go unnoticed, AI challenges nurses to broaden their perspectives and refine their diagnostic reasoning. This dynamic interaction not only enhances their clinical judgment but also cultivates a culture of continuous learning and adaptability in neonatal care.

1c. Risk assessment and safety considerations (30/33, 90.9%)

Patient safety emerged as a critical priority, with nearly all nurses (30/33, 90.9%) emphasizing the importance of verifying AI outputs to prevent over-reliance on technology. Participants underscored the need to balance trust in AI's capabilities with a healthy degree of skepticism, ensuring that all recommendations are rigorously validated against clinical observations and collaborative input.

If the AI suggests a sepsis alert, I still confirm with the infant's vitals, consult a colleague, and review the chart. I never take it at face value. (P06)

Safety comes from balancing trust and skepticism. The AI is a tool, not an authority. I ensure every recommendation is grounded in real-world evidence. (P10)

I appreciate early warnings, but I'm careful not to let the AI lull me into a false sense of security. I remain vigilant and double-check everything. (P25)

These accounts highlight nurses' cautious and deliberate approach to integrating AI into their practice, ensuring that its outputs enhance rather than compromise safety. By consistently cross-checking AI-generated alerts with patient data and peer consultations, nurses maintain vigilance and guard against overconfidence in automated systems. This practice reinforces their role as the final decision-makers, safeguarding the integrity of neonatal care and minimizing potential risks.

These findings align with Tanner's Clinical Judgment Model, as nurses 'notice' AI alerts, 'interpret' algorithmic signals alongside patient cues, and 'respond' by either endorsing or adjusting the proposed action. Complexity Science principles are evident in the nonlinear interplay between human reasoning and machine guidance. NPT's coherence mechanism emerges as nurses integrate AI into their cognitive frameworks, making sense of its outputs and understanding its role within complex NICU care.

Theme 2: Professional practice transformation

Nurses described evolving professional identities and workflows as they embraced AI-driven insights. Their roles expanded from task-oriented functions to more integrative, consultative positions, reflecting a transformative effect on daily practice.

2a. Shifting role boundaries and responsibilities

The integration of AI into clinical practice has shifted traditional role boundaries, with 28 of 33 nurses (84.8%) reporting a transformation in their responsibilities. AI-enabled insights have empowered nurses to move beyond task execution, positioning them as key contributors to decision-making processes. This evolution allows nurses to advocate for interventions and engage more actively in shaping care strategies.

I used to carry out orders. Now, I'm often the one suggesting interventions based on AI insights. It's empowering to have a voice backed by data. (P30)

It feels like I'm evolving from a bedside caregiver to a clinical strategist. The AI highlights possibilities I present to the team. (P13)

Before AI, I was mostly monitoring. Now, I'm actively shaping decisions and offering suggestions that sometimes lead to the care plan. (P02)

These accounts underscore how AI fosters a more consultative and strategic role for nurses, enabling them to bridge the gap between data and clinical application. By leveraging AI insights, nurses transition from passive implementers to proactive decision-makers, contributing meaningfully to care plans. This shift not only enhances their professional autonomy but also strengthens the collaborative dynamic within interdisciplinary teams.

2b. Adaptation to AI-enhanced workflows

The integration of AI into clinical practice required significant workflow adjustments, as reported by 27 of 33 nurses (81.8%). Participants described initial challenges, including learning new systems and reprioritizing tasks. Over time, however, they adapted to these changes, finding ways to seamlessly incorporate AI into their routines and optimize their efficiency without compromising care quality.

At first, it felt like an interruption—another system demanding my attention. Over time, I've synchro-

nized it with my workflow, making it feel like a natural extension of my practice. (P17)

Now, I spend less time on rote tasks and more on interpreting data. It's more mentally demanding, but I feel more engaged and effective. (P28)

I've learned shortcuts and patterns in the AI's interface. Instead of resisting, I embraced these changes, and it's streamlined my shift. (P14)

These experiences demonstrate the adaptability of nurses as they integrate AI into their practice. While initially perceived as an additional burden, AI eventually became a valuable tool for streamlining workflows and enhancing focus on complex decision-making. By learning to use AI effectively, participants transitioned from resistance to empowerment, leveraging its potential to optimize both efficiency and clinical impact in the NICU.

2c. Professional identity in the AI era

The majority of participants (29/33, 87.9%) reflected on how the integration of AI has reshaped their professional identities. Nurses described an evolving role that requires balancing the empathetic, human-centered essence of nursing with the analytical rigor demanded by AI-enhanced decision-making. This fusion of caring and computing has created a more complex and enriched professional identity, allowing nurses to embrace both traditional and modern aspects of their practice.

I'm still the nurse who soothes a worried parent, but now I'm also the one interpreting predictive analytics. It's a richer, more complex identity. (P01)

I've learned that caring and computing aren't opposites. My humanity guides how I use AI. Together, they enhance patient care. (P24)

I've become comfortable with both touch and technology. The AI doesn't erode my professional identity; it expands it. (P20)

These narratives highlight the dynamic evolution of professional identity in the AI era. Nurses see themselves not just as caregivers but also as interpreters of advanced analytics, blending human compassion with technological precision. Far from undermining their roles, AI has added new dimensions to their practice, fostering a sense of empowerment and adaptability. This synergy of empathy and data underscores the resilience and versatility of nursing professionals as they navigate the complexities of a digitally enhanced healthcare environment.

NPT's cognitive participation and collective action components are evident as nurses redefine their professional roles and collaborate around AI insights. Complexity Science appears in the emergent behaviors and adaptations that arise from integrating a novel tool into established professional norms. Tanner's Model extends here as nurses reflect on their evolving roles, integrating algorithmic insights into their experiential knowledge and judgment processes.

Theme 3: Organizational and systemic factors

Beyond individual skill and judgment, participants emphasized the importance of organizational structures, resources, and policies. These systemic elements govern how effectively AI can be implemented and sustained.

3a. Infrastructure and resource requirements

Infrastructure and resources emerged as critical enablers of effective AI integration, with nearly all participants (32/33, 97.0%) emphasizing the importance of stable systems, reliable connectivity, and sufficient staffing. Nurses noted that even the most advanced AI systems become unreliable or unusable in the absence of robust technical and human resource support, directly impacting their ability to provide high-quality care.

A top-notch AI system means nothing if the network keeps dropping. Robust infrastructure ensures we can trust the data we see. (P14)

I feel confident when I know there's IT support at hand. Without it, the AI can become a source of frustration rather than insight. (P26)

Staffing matters. If we're short-handed, even the best AI can't be fully leveraged. You need people to interpret and act. (P08)

These accounts underscore the foundational role of infrastructure in leveraging AI's potential. Reliable systems, IT support, and adequate staffing ensure that nurses can focus on interpreting AI insights rather than troubleshooting technical issues or compensating for workforce shortages. Without these elements, the efficiency and reliability of AI in clinical practice are significantly compromised, highlighting the importance of organizational investment in creating a supportive environment for AI integration.

3b. Training and competency development

A majority of participants (30/33, 90.9%) highlighted the essential role of training in enabling effective use of AI in clinical practice. They emphasized that understanding the logic and limitations of AI systems fosters trust

and confidence, transforming initial skepticism into a productive collaboration. Comprehensive and ongoing education was seen as critical for ensuring that nurses remain competent and adaptable as AI technologies continue to evolve.

> *After we had a proper workshop, I stopped seeing the AI as a black box. Knowing how it works builds trust. (P20)*

> *Continuous education keeps me updated. As the AI evolves, so must my understanding and skills. (P02)*

> *Training demystified the algorithm. Now, I'm less skeptical and more confident, using it as a partner rather than an enigma. (P09)*

These reflections demonstrate that training is pivotal to the successful integration of AI in clinical workflows. Educational initiatives empower nurses to engage with AI as informed users by demystifying how algorithms operate and clarifying their limitations. This ongoing learning process builds confidence and strengthens the partnership between human expertise and machine intelligence, ensuring that AI enhances rather than disrupts clinical decision-making.

3c. Policy and protocol integration

A significant majority of participants (28/33, 84.8%) emphasized the importance of clear policies and protocols for effectively integrating AI into clinical practice. These structured guidelines were described as essential for standardizing responses to AI alerts, reducing ambiguity, and fostering consistent decision-making across teams. Participants highlighted that having a well-defined framework also enhanced their confidence in using AI tools.

> *We have a protocol for responding to AI alerts, which removes guesswork and ensures fairness in decision-making. (P10)*

> *Without formal policies, each nurse might interpret alerts differently. Protocols align us, improving teamwork and consistency. (P11)*

> *Knowing the hospital's stance on AI gives me confidence. I'm not just improvising; I'm following an agreed-upon framework. (P15)*

These insights illustrate how formalized policies and protocols stabilize the integration of AI. By eliminating individual variability in interpreting AI recommendations, such guidelines promote fairness, consistency, and collaboration among nursing teams. Clear organizational stances on AI usage empower nurses to make informed decisions within a trusted framework, ensuring that AI enhances rather than complicates clinical workflows.

Complexity in Science is evident as organizations must balance multiple interdependent factors within a dynamic system, such as technology, staff, and policies. NPT's collective action and reflexive monitoring are reflected as teams and institutions assess, refine, and normalize AI use. Tanner's Model benefits from a stable organizational environment, ensuring nurses can effectively apply their judgment when interacting with AI-driven recommendations.

Theme 4: Cultural and contextual influences

Cultural norms, family involvement, and the Saudi Arabian healthcare context shaped how nurses and families perceived and engaged with AI technologies.

4a. Saudi healthcare system dynamics

Nearly all participants (31/33, 93.9%) reflected on the influence of Saudi Arabia's healthcare system dynamics on AI adoption. They emphasized the role of hierarchical structures, where deference to senior physicians shapes how AI recommendations are implemented. Participants also highlighted the impact of national digital health initiatives, which provide momentum and support for integrating AI into clinical practice as part of broader modernization efforts in the healthcare sector.

> *Our system values senior physician input. Even if the AI suggests something insightful, I must present it respectfully, acknowledging our hierarchy. (P03)*

> *Saudi Arabia's national push for digital health support makes us more willing to embrace AI. It feels like we're part of a larger modernization effort. (P30)*

> *Understanding the healthcare landscape here helps me navigate AI adoption. It's not just a tool; it's part of a broader national vision. (P19)*

These reflections demonstrate how the Saudi healthcare system's unique structural and cultural features shape the adoption of AI. While hierarchical traditions require careful navigation of AI-driven recommendations, the nation's strategic commitment to digital health fosters openness to innovation. This dual dynamic positions AI not only as a tool for individual practice but also as a cornerstone of a larger vision for healthcare transformation in Saudi Arabia. Nurses' ability to integrate AI effectively reflects their adaptability within this evolving landscape.

4b. Family-centered care with AI integration

A significant majority of nurses (29/33, 87.9%) emphasized the importance of maintaining family trust and involvement in care while integrating AI. Participants noted that families often expressed curiosity or concern about the role of AI, requiring nurses to explain its function as a supportive tool rather than an autonomous decision-maker. Through education and reassurance, nurses worked to ensure families understood that human expertise remained central to clinical decisions.

> *Parents ask how we 'knew' to intervene early. Explaining the AI's monitoring reassures them that we're proactive and attentive. (P09)*

> *Some families worry we rely too heavily on 'machines.' I tell them we still make the final decision, guided by human expertise. (P15)*

> *Involving families in understanding the AI helps build trust. They appreciate that we're using every tool available to safeguard their baby. (P25)*

These accounts highlight the critical role of family-centered communication in AI integration. By involving families and transparently explaining AI's supportive role, nurses were able to build trust and alleviate concerns about overreliance on technology. This approach underscores the importance of maintaining strong human connections in neonatal care, ensuring that advanced tools like AI complement, rather than overshadow, the compassionate and collaborative aspects of nursing practice.

4c. Cultural considerations in AI adoption

A majority of participants (27/33, 81.8%) noted that local cultural beliefs and values significantly shaped the adoption and acceptance of AI in clinical practice. Nurses highlighted that while there is respect for technological advancements, there is also an expectation that these tools align with cultural norms and enhance, rather than replace, traditional care practices. This gradual process of trust-building reflects the interplay between innovation and cultural sensitivity.

> *People here respect technology but want to be sure it aligns with our values. Over time, consistent results build cultural acceptance. (P05)*

> *Cultural comfort isn't instant. Seeing AI support better outcomes gradually fosters trust within our community. (P24)*

> *We must present AI as enhancing, not replacing, our traditional care approaches. That balance respects cultural expectations. (P22)*

These insights underscore the importance of framing AI as a tool that complements and respects established cultural values. By demonstrating consistent and positive outcomes, nurses can foster trust and acceptance of AI within their communities. This culturally sensitive approach ensures that AI is seen as an enhancement to care, reinforcing traditional nursing roles while integrating technological advancements in a manner that aligns with local expectations.

Complexity Science highlights how cultural and contextual factors create a unique ecosystem shaping AI adoption. NPT's coherence component emerges as participants and families make sense of AI within their sociocultural framework. Tanner's Model, traditionally focused on individual clinical judgment, is broadened to acknowledge that context and culture inform how nurses notice, interpret, and respond to AI cues.

Theme 5: Implementation challenges and solutions

Despite recognizing AI's potential, nurses grappled with technical and practical hurdles while also devising strategies and envisioning future improvements.

5a. Technical and practical barriers

Nearly all participants (32/33, 97.0%) reported encountering technical and practical barriers during AI integration, underscoring the imperfections of current systems. Nurses highlighted challenges such as alert fatigue, system glitches, and connectivity issues, all of which could disrupt workflows and patient care. These barriers necessitated constant vigilance and adaptive strategies to ensure uninterrupted clinical operations.

> *Too many alerts can be overwhelming. I have to prioritize which ones to address immediately. (P11)*

> *A glitch last week cut off our data feed for hours. It reminded me that I can't rely solely on AI; I need a backup plan. (P19)*

> *It's not always smooth. Sometimes, the system lags, and I have to revert to traditional methods. We need robust reliability. (P03)*

These experiences highlight the critical need for reliable, well-supported AI systems in clinical environments. Frequent interruptions or excessive alerts can undermine AI efficiency and trust, requiring nurses to rely on backup plans or traditional methods. Addressing these technical and practical issues is essential to ensure AI enhances, rather than hinders, care delivery. Robust infrastructure, user-friendly designs, and streamlined alert systems are pivotal to overcoming these challenges and realizing AI's full potential in neonatal care.

5b. Strategic solutions and workarounds

A majority of nurses (30/33, 90.9%) described implementing strategic solutions and workarounds to mitigate the challenges posed by AI integration. Participants emphasized the value of teamwork, structured approaches like checklists, and peer consultation to ensure that AI was used effectively and efficiently. These adaptive strategies helped them navigate initial disruptions and maximize the technology's potential.

We created a checklist for handling AI alerts, ensuring a consistent and calm response. (P06)

If I'm unsure, I quickly confer with a senior nurse. Combining human insight with AI's suggestions makes decisions stronger. (P22)

Over time, we've learned to filter the noise. We share tips and strategies, turning AI from a hurdle into a help. (P28)

These strategies demonstrate nurses' proactive and collaborative efforts to successfully integrate AI into clinical workflows. They transformed AI from a potential obstacle into a supportive tool by standardizing responses with checklists, seeking peer input, and sharing practical tips. This collective adaptability highlights nursing teams' resilience and capacity to refine and optimize AI usage to enhance patient care.

5c. Future development needs

Many participants (28/33, 84.8%) highlighted the need for future improvements in AI systems to better align with clinical workflows and patient needs. Suggestions included incorporating context-aware capabilities that factor in patient history, seamless integration with electronic health records (EHR), and designing user-friendly interfaces to enhance accessibility and adoption. These enhancements were critical to maximizing AI's effectiveness and usability in neonatal care.

If the AI considered patient history and not just current vitals, its recommendations would feel more personalized. (P01)

We need smoother integration with our EHR. Ideally, AI insights should appear seamlessly within our existing workflow. (P24)

A more user-friendly interface would help. If using AI feels natural, adoption will be faster and more effective. (P26)

These reflections underscore the importance of advancing AI technology to meet the nuanced needs of clinical practice. Context-aware systems that personalize recommendations, seamless EHR integration, and intuitive interfaces could significantly improve the efficiency and practicality of AI in neonatal settings. Addressing these developmental priorities would ensure that AI becomes a more natural and effective component of nurses' workflows, enhancing both care delivery and adoption rates in high-stakes environments.

Complexity Science explains how nurses respond adaptively to emergent problems, developing innovative solutions as part of a dynamic care environment. NPT's reflexive monitoring appears in their iterative evaluation of AI's utility and the subsequent fine-tuning of implementation strategies. Tanner's Model is evident in how nurses refine their noticing, interpreting, and responding skills as they navigate technological challenges and identify pathways for improvement.

Overview of key themes

The thematic analysis revealed a complex interplay among five major themes that illustrate how neonatal nurses experience and integrate generative AI in high-risk NICU settings. These themes form an interconnected framework that demonstrates the multifaceted nature of AI adoption in clinical practice. The "Clinical Decision-Making Process with AI" emerged as a foundational theme, with the highest average frequency (90.9%) across its subthemes, highlighting how nurses balance algorithmic recommendations with clinical expertise. This theme connects directly to "Professional Practice Transformation" (84.8% average frequency), showing how nurses' roles evolve as they incorporate AI into their practice. The success of AI integration is substantially influenced by "Organizational and Systemic Factors" (90.9% average frequency), which provides the infrastructure and support necessary for effective AI implementation. This organizational foundation interacts with "Cultural and Contextual Influences" (87.9% average frequency), particularly within the Saudi healthcare system, where cultural norms and family-centered care shape AI adoption. Implementation Challenges and Solutions" (90.9% average frequency) spans across all other themes, representing how nurses actively engage in problem-solving and adaptation to optimize AI use in clinical practice. This theme demonstrates the dynamic nature of AI integration and the importance of continuous improvement in technological systems and clinical workflows.

Discussion

The findings of this study provide a detailed and nuanced understanding of neonatal nurses' experiences with generative AI in clinical decision-making within high-risk

NICUs. This discussion interprets the results in the context of existing literature, critically evaluates their significance, and offers insights into how generative AI influences nursing practice, organizational dynamics, and cultural contexts. The discussion synthesizes participants' narratives with theoretical frameworks and aligns the findings with prior research, highlighting areas of agreement and divergence while presenting informed interpretations.

The five themes identified in this study directly address our primary research question regarding how neonatal nurses experience generative AI in clinical decision-making. Theme 1 (Clinical Decision-Making Process with AI) reveals nurses' integration of AI recommendations with professional expertise as complementary rather than substitutive. Theme 2 (Professional Practice Transformation) illuminates the evolution of professional identities and workflows in AI-enhanced environments. Theme 3 (Organizational and Systemic Factors) identifies the institutional infrastructure essential for meaningful AI adoption. Theme 4 (Cultural and Contextual Influences) demonstrates how Saudi healthcare structures and family-centered care create a distinctive context for AI integration. Finally, Theme 5 (Implementation Challenges and Solutions) captures nurses' adaptive responses to technical barriers. Together, these interconnected themes comprehensively address our research objectives by exploring nurses' perceptions of AI, identifying contextual factors influencing adoption, and describing AI's influence on nursing practice within this specific cultural context.

The study revealed that nurses used AI as a complementary tool, balancing algorithmic recommendations with clinical expertise. This approach mirrors findings by Sezgin (2023), who reported that healthcare professionals often use AI to validate rather than dictate decisions [69]. However, Zhai et al. (2024) raised concerns about the potential over-reliance on AI in high-stakes settings, warning that such dependency could undermine human expertise [70]. The contrasting findings could be attributed to differences in institutional training and infrastructure. The participants in this study had access to formal AI training (84.8%), which likely equipped them to evaluate and integrate AI outputs critically, mitigating the risks. This underscores the importance of education and context in shaping how AI is adopted and utilized in clinical environments. Despite these strengths, the reliance on qualitative data may have influenced the prominence of certain narratives, potentially overlooking nuanced instances where AI recommendations were either over-relied upon or rejected without sufficient evaluation.

While AI serves as a valuable decision-support tool, its increasing reliance in high-risk environments like NICUs raises ethical concerns regarding algorithmic bias, decision opacity, and overdependence on automation [71]. AI models are trained on datasets that may not fully represent diverse neonatal populations, potentially leading to disparities in diagnostic accuracy and treatment recommendations [72]. Moreover, the opacity of some AI-driven predictions can make it challenging for nurses to interpret and critically assess algorithmic outputs, heightening the risk of automation bias. This concern aligns with recent critiques by Hassija et al. (2024) [73], who caution that AI may introduce a "black-box effect," where clinical staff accept AI-generated recommendations without fully understanding the underlying rationale. Our findings suggest that nurses who received formal AI training were more likely to challenge and verify AI suggestions, reducing this risk. However, further research is needed to determine how structured AI literacy programs influence nurses' long-term trust, skepticism, and critical engagement with AI-generated insights.

While our findings align with prior research highlighting AI's role as a clinical aid rather than a replacement for expertise [74], key divergences emerged in nurses' adaptation patterns and decision-making autonomy across different healthcare contexts. Unlike studies in Western healthcare systems, where AI is often introduced as a physician-centric tool [75], our results show that neonatal nurses in Saudi Arabian NICUs played an active role in shaping AI adoption and integrating it into collaborative decision-making models. This discrepancy may stem from the family-centered care model prevalent in Saudi Arabia, where nurses act as mediators between AI-generated recommendations, physicians, and families. Additionally, while Crigger et al. (2022) reported concerns about AI undermining clinical autonomy, our participants perceived AI as an augmentative rather than a controlling force [76]. This difference may be attributed to the structured AI training programs implemented in our study settings, which empowered nurses to use AI critically rather than dependently. These findings suggest that institutional readiness and cultural context play a critical role in shaping how AI is perceived, utilized, and trusted in neonatal care.

The transition from task-oriented responsibilities to consultative roles empowered nurses to take on more strategic positions in decision-making. This aligns with Przegalinska et al. (2025), who highlighted AI's potential to augment professional expertise [77]. However, participants also described challenges such as increased cognitive workload and disruptions to workflows. These findings parallel those of Borges do Nascimento et al. (2023), who documented similar difficulties during the early phases of AI integration in healthcare [78]. Notably, gender dynamics may have influenced how these professional shifts were experienced. With a predominantly

female sample (87.9%), the study reflects broader demographic trends in nursing but may also reveal how gendered expectations shape nurses' adaptability to AI. For example, the traditional perception of nursing as a caregiving profession may amplify resistance to adopting data-centric tools like AI, especially in environments emphasizing empathetic patient care. Exploring these dynamics could provide deeper insights into the interplay between gender and technology adoption in nursing.

Participants underscored the critical role of organizational infrastructure, reliable IT support, and clear policies in facilitating AI integration. This finding aligns with Loureiro et al. (2021), who emphasized systemic investments as essential enablers of technological adoption [79]. However, the study also highlighted significant gaps, such as alert fatigue and system glitches, which disrupted workflows and undermined the perceived reliability of AI systems. These challenges are consistent with Papagiannidis et al. (2023), who identified technical issues as common barriers to effective AI implementation [80]. The study could more explicitly address the practice-policy gap by examining how organizational and systemic factors translate into actionable recommendations for policymakers. For example, regulations could standardize AI interfaces, minimize alert fatigue through design improvements, and ensure equitable access to IT support across public and private healthcare settings. This would bridge the disconnect between AI's technical potential and its real-world application in critical care environments.

The cultural context of Saudi Arabia shaped how nurses and families interacted with AI. The influence of hierarchical decision-making structures aligns with Alotaibi and Federico (2017), who noted that deference to senior physicians is a defining feature of Middle Eastern healthcare [81]. However, this hierarchy may inadvertently constrain nurses' autonomy in interpreting AI outputs, a dynamic that warrants further exploration. Family-centered care emerged as a pivotal factor in AI adoption. Participants emphasized the importance of educating families about AI's role in decision-making, addressing concerns about over-reliance on technology. This approach reflects culturally sensitive practices [82], but also underscores the dual challenge of managing technological integration alongside traditional caregiving values.

Building on these findings, recent studies have further illuminated AI's evolving role in clinical education and culturally sensitive healthcare. For instance, Elmaoğlu et al. (2023) highlighted how AI tools, including ChatGPT, are redefining professional roles in pediatric health education, a shift that parallels the task-to-consultative transition observed among our participants [83]. Similarly, Coşkun et al. (2024) underscored the importance of digital health literacy and cultural acceptance in AI integration [84], aligning with our theme on the Saudi healthcare system's hierarchical and family-centered context. By incorporating insights from these contemporary works, we reinforce the notion that AI adoption in neonatal care is not solely a technological endeavor but also a cultural and educational one, demanding robust training, supportive infrastructures, and mindful engagement with local norms.

Although AI holds immense potential in enhancing neonatal care, reducing cognitive load, and improving early risk detection, it is not without challenges. Our study underscores that AI's effectiveness depends on the quality of training, the reliability of hospital IT infrastructure, and the level of interdisciplinary collaboration. Without these foundational elements, AI may inadvertently exacerbate alert fatigue, reinforce existing biases, or create workflow inefficiencies [85]. The mixed experiences reported by our participants suggest that AI is not a universally positive or negative tool but one that requires careful contextual adaptation. Future research should explore the longitudinal impacts of AI on nurse autonomy, patient outcomes, and interprofessional decision-making to assess whether the benefits observed in early adoption phases are sustained over time.

The discussion could integrate quantitative results with qualitative insights more effectively to strengthen the analysis. For instance, the high percentage of nurses (93.9%) who reported using AI to enhance clinical decision-making should be contextualized within the qualitative narratives about maintaining vigilance and balancing trust with skepticism. Similarly, the finding that 97.0% of participants identified infrastructure and resource requirements as critical highlights the universal need for systemic investments, which could be explored in greater detail through thematic analysis.

Practical implications

The findings underscore the critical need for comprehensive training programs tailored to neonatal nurses, focusing on developing competencies to critically evaluate and effectively use AI-generated recommendations. Training should demystify algorithms, address their limitations, and build confidence in integrating AI into decision-making. Robust organizational support is equally essential. Investments in reliable IT infrastructure, seamless integration with electronic health records, and user-friendly interfaces are necessary to minimize disruptions and optimize AI's usability. Standardized protocols ensure consistent and effective responses to AI outputs, enhancing clinical workflows. Cultural and contextual factors, particularly in hierarchical healthcare systems like Saudi Arabia, play a pivotal role in AI integration. Strategies should involve educating families about AI's supportive

role to foster trust and acceptance. Additionally, addressing gender dynamics within the predominantly female nursing workforce is critical to understanding how professional identity and caregiving expectations intersect with technology adoption. Aligning AI systems with local cultural values and organizational realities ensures that the transformative potential of AI is realized while preserving the human-centered essence of neonatal nursing care.

In light of these organizational barriers and concerns regarding professional autonomy, we propose that NICUs adopt specialized AI training programs that address both technical proficiency and critical evaluation skills. Furthermore, interdisciplinary collaboration encompassing nurses, physicians, IT specialists, and hospital administrators should be formalized through regularly scheduled forums aimed at harmonizing AI initiatives with clinical workflows. Clear regulatory policies and ethical guidelines are also vital; these would include data governance standards, protocols for algorithm transparency, and frameworks ensuring that AI-driven recommendations are continually reviewed to safeguard patient care quality. Such measures could empower nurses to integrate AI more confidently while maintaining their professional autonomy, ultimately enhancing clinical decision-making and patient outcomes.

Limitations and reflexivity

This study provides valuable insights into AI integration in Saudi Arabian high-risk NICUs, but its context-specific focus may limit the generalizability of findings to different cultural and institutional settings. While some results align with global AI adoption trends, factors such as hierarchical decision-making, family-centered care, and regulatory structures may shape AI integration differently across healthcare systems. Comparative research across diverse regions and institutional models is needed to distinguish universal versus context-specific challenges in neonatal nursing.

The predominantly female sample (87.9%), reflecting the broader nursing workforce demographics, may have influenced how AI adoption was perceived. Gendered professional norms could affect how nurses engage with AI, potentially favoring collaborative and interpretive interactions over autonomous, algorithm-driven decision-making [86]. While this study did not explicitly examine gendered AI perceptions, future research should explore how professional identity and caregiving expectations influence technology adoption and decision-making autonomy in nursing.

As this study relied on semi-structured interviews and focus groups, the findings are shaped by self-reported experiences, which may introduce recall bias and social desirability effects, particularly in group settings where participants might present AI in a more favorable or cautious manner. Although member checking, triangulation, and reflexivity enhanced credibility, observational and mixed-methods approaches could complement this work by objectively assessing how AI is integrated into clinical workflows. Future studies should incorporate real-time documentation or AI-generated decision logs to validate and contextualize nurses' experiences.

Additionally, the study was conducted during the early stages of AI implementation, meaning the findings likely reflect initial challenges rather than long-term adaptations. As AI becomes more embedded in NICU practice, ongoing research should track how nurses' experiences, trust, and professional roles evolve over time. Despite these limitations, rigorous qualitative methodologies, including iterative coding, member checking, and reflexivity, ensured the trustworthiness of the findings, providing a strong foundation for understanding how neonatal nurses integrate generative AI into practice.

Future research directions

Future research should prioritize longitudinal studies to examine how nurses' experiences and practices with AI evolve over time. Such research would provide insights into sustained benefits, emerging challenges, and long-term impacts on patient outcomes and nursing roles. Comparative investigations across varied cultural and institutional settings are critical to identifying universal and context-specific themes in AI adoption. Expanding research to include quantitative studies would further strengthen the evidence base, measuring AI's impact on clinical efficiency, patient safety, decision-making accuracy, and nurse satisfaction. Exploring gender dynamics in AI adoption is another vital direction. Understanding how societal expectations and professional identities influence technology use could inform targeted training and support systems. Additionally, interdisciplinary collaboration involving policymakers, technologists, and clinicians is necessary to address gaps in policy and regulation. This approach would ensure that AI systems align with clinical realities, ethical standards, and data privacy requirements. Finally, a deeper exploration of ethical implications, such as algorithmic transparency, data security, and accountability, is essential. Addressing these concerns will build trust among healthcare professionals and ensure the responsible integration of AI in critical care [33]. By addressing these priorities, future studies can advance the safe, effective, and context-sensitive use of generative AI in neonatal nursing and broader healthcare contexts.

Conclusions

This study provides critical insights into how neonatal nurses in Saudi Arabian high-risk NICUs integrate

generative AI, emphasizing the interplay among technological, organizational, and cultural factors. While AI can enhance clinical judgment and decision-making autonomy, its successful adoption requires more than technical capability. Robust infrastructure, structured training, and culturally sensitive protocols tailored to hierarchical decision-making and family-centered care are pivotal for meaningful AI integration. From a practice perspective, NICU policies should incorporate AI-specific competencies, including simulation-based training that fosters critical appraisal skills and ethical vigilance against automation bias. Interprofessional collaboration is vital to streamline workflows, minimize alert fatigue, and align AI-driven innovations with compassionate, patient- and family-centered care.

Future studies should employ longitudinal designs to observe how nurses' perceptions and practices evolve as AI becomes further embedded in neonatal care. Cross-cultural and quantitative inquiries would help delineate universal versus context-dependent challenges while also measuring patient outcomes and cost-effectiveness. Investigations into AI's impact on nurse–family interactions, professional roles, and interprofessional collaboration would further refine guidelines for sustainable, human-centered AI adoption. Ultimately, balancing technological advancement with human expertise, organizational readiness, and cultural alignment is key to harnessing AI's transformative potential in neonatal nursing. By doing so, healthcare systems can foster safe, effective, and ethically grounded practices that enrich both clinical outcomes and the nurse-patient relationship in high-risk NICU settings.

Supplementary Information

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Supplementary Material 1

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O.M.E.R. conceptualized the study, developed the methodology, conducted the literature search, and wrote the original draft of the manuscript. A.N.A. and A.M.M. assisted with data extraction and conducted the quality assessment of the included studies. N.B.E. and A.A. contributed to the data analysis and interpretation of results, providing critical insights for the discussion. O.M.E.R. and S.I.A. supervised the project, contributed to the study design, and reviewed and edited the final manuscript. All authors have read and agreed to the published version of the manuscript.

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Data availability
Data will be available upon request.

Declarations

Institutional review board statement
The present study was conducted in accordance with institutional ethical standards and received approval from the Standing Committee of Bioethics Research, King Faisal University Ethics Committee (Protocol approval number: KFU-2024-ETHICS2926).

Informed consent
Informed consent was obtained from all participants involved in the study.

Consent for publication
Not applicable.

Clinical trial number
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Competing interests
The authors declare no competing interests.

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