Nurse Education Today 153 (2025) 106822

Contents lists available at ScienceDirect

Nurse Education Today

journal homepage: www.elsevier.com/locate/nedt

Review

# Patterns, advances, and gaps in using ChatGPT and similar technologies in nursing education: A PAGER scoping review

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## ARTICLE INFO

*Keywords:*
ChatGPT
Nursing education
Generative AI
Artificial Intelligence
PAGER framework
Scoping review
Educational technology

## ABSTRACT

*Background and aim:* Generative AI (GenAI) can transform nursing education and modernise content delivery. However, the rapid integration of these tools has raised concerns about academic integrity and teaching quality. Previous reviews have either looked broadly at artificial intelligence or focused narrowly on single tools like ChatGPT. This scoping review uses a structured framework to identify patterns, advances, gaps, evidence, and recommendations for implementing GenAI in nursing education.

*Methods:* This scoping review followed the JBI methodology and PRISMA-ScR guidelines. We searched PubMed, CINAHL, SCOPUS, ERIC, and grey literature (October to November 2024). Data synthesis utilised the PAGER framework as a mapping tool to organise and describe patterns, advances, gaps, evidence for practice, and recommendations.

*Results:* Analysis of 107 studies revealed GenAI implementation across four key domains: assessment and evaluation, clinical simulation, educational content development, and faculty/student support. Three distinct implementation patterns emerged: restrictive, integrative, and hybrid approaches, with hybrid models demonstrating superior adoption outcomes. Technical advances showed significant improvement from GPT-3.5 (75.3 % accuracy) to GPT-4 (88.67 % accuracy) in NCLEX-style assessments, with enhanced capabilities in multilingual assessment, clinical scenario generation, and adaptive content creation. Major gaps included limited methodological rigour (29.0 % of empirical studies), inconsistent quality control, verification challenges, equity concerns, and inadequate faculty training. Geographic distribution showed North American (42.1 %) and Asian (29.9 %) dominance, with ChatGPT representing 83.2 % of tool implementations. Key recommendations include developing institutional policies, establishing quality verification protocols, enhancing faculty training programs, and addressing digital equity concerns to optimise GenAI integration in nursing education.

*Conclusions:* GenAI has transformative potential in nursing education. To realise its full potential and ensure responsible use, research should focus on developing standardised governance frameworks, empirically validating outcomes, developing faculty in AI literacy, and improving technical infrastructure for low-income contexts. Such efforts should involve international collaboration, highlighting the importance of the audience's role in the global healthcare community.

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https://doi.org/10.1016/j.nedt.2025.106822
Received 12 January 2025; Received in revised form 15 June 2025; Accepted 1 July 2025
Available online 5 July 2025

## 1. Introduction

Healthcare education is undergoing rapid transformation through Artificial Intelligence (AI) (Alowais et al., 2023; Wang and Li, 2024). Within this broader field, Generative Artificial Intelligence (GenAI) emerges as a specialised branch capable of creating new content in text, image, and simulation formats (Chiarello et al., 2024; Zubiaga, 2024). Large language models (LLMs) represent a key subset of GenAI, using vast datasets to generate human-like text responses (Law, 2024). Throughout this review, we use GenAI as an umbrella term encompassing these related technologies transforming nursing education (Yun et al., 2024).

In nursing education, GenAI is being used to simulate clinical scenarios, support academic writing, and deliver tailored feedback (Lifshits and Rosenberg, 2024). These applications suggest new ways to engage students and extend teaching resources. At the same time, concerns have been raised about misinformation ('hallucination'), embedded bias, and the risk of weakening core nursing values such as empathy and ethical reasoning (Laizure, 2024; Shiferaw et al., 2024). As use increases, the literature has expanded through editorials, exploratory studies, and pilot implementations. However, a coherent synthesis of this emerging evidence is lacking. This gap raises important questions: How are nursing programs currently implementing GenAI? What evidence supports these approaches? What implementation patterns show promise? This scoping review addresses these questions by systematically mapping the evidence landscape using a structured framework.

## 2. Background and rationale

A few reviews have begun to examine GenAI in nursing education, but most lack structured analytical frameworks for systematically mapping evidence into actionable insights. Abujaber et al. (2023) used SWOT analysis to identify strengths and threats associated with ChatGPT without mapping implementation patterns across educational contexts. Gunawan et al. (2024) employed text network analysis to identify thematic clusters without tracking evidence progression. Hobensack et al. (2024) focused on bibliometric trends rather than synthesising implementation strategies. Without frameworks to organise findings into patterns, advances, gaps, evidence, and recommendations, the evidence remains fragmented and challenging to translate into practical guidance.

Despite their distinct educational implications, many scoping reviews do not differentiate GenAI from broader AI technologies. Unlike traditional AI applications for clinical decision support (Khosravi et al., 2024), GenAI tools generate original content in real time, enabling adaptive simulations, dialogue-based learning, and automated feedback (Chen et al., 2024). These capabilities raise unique pedagogical and ethical considerations for nursing education. However, reviews like Montejo et al. (2024) and El Arab et al. (2025) discuss AI broadly without focusing on GenAI's interactive, generative functions, overlooking implementation questions specific to nursing education.

Most evaluations focus on earlier versions like ChatGPT-3.5 (Kleib et al., 2024), despite newer models showing marked improvements. Wu et al. (2024) report that GPT-4 outperformed GPT-3.5 by over 13 percentage points in nursing assessment tasks, a differential with practical implications for formative assessment and personalised learning. Existing reviews, thus, may not provide timely guidance for educators adapting newer, more capable GenAI tools.

Despite comprehensive search strategies, reviews have reported low study yields; Kleib et al. (2024) identified only 17 studies across eight databases, while Yalcinkaya and Yucel (2024) included just 15 articles. This reflects the field's recency and the dissemination of innovations through commentaries or practice reflections, which are not consistently indexed in academic databases. Early reviews appropriately relied on opinion pieces and grey literature to document initial responses to GenAI (Hobensack et al., 2024). As the field matures, systematically mapping emerging empirical work becomes increasingly important.

Existing reviews have highlighted methodological heterogeneity (El Arab et al., 2025), lack of evaluation standards (Gerdes et al., 2024), and limited real-world implementation evidence (Montejo et al., 2024). Ethical concerns are commonly raised, but few reviews propose risk management strategies (Liu et al., 2023). This scoping review addresses these limitations by applying the PAGER framework (Bradbury-Jones et al., 2022) to organise findings across five domains: Patterns of implementation, Advances in capabilities, Gaps in knowledge, Evidence from practice, and Recommendations for development. This structured approach enables educators to assess GenAI's current state and future direction in nursing education, supporting evidence-based decisions about its responsible integration.

## 3. Aim and review questions

This scoping review examines how GenAI tools such as ChatGPT are implemented in nursing education. It seeks to identify common implementation patterns, document technological advances, highlight gaps in current evidence, summarise practice-based findings, and propose recommendations for responsible integration. The review applies the PAGER framework to structure the synthesis across five domains: Patterns, Advances, Gaps, Evidence, and Recommendations. To guide the review, the following questions were developed:

1. What patterns emerge in how GenAI are discussed, studied and applied in nursing education?
2. What advances have been made in GenAI technology and its applications in nursing education?
3. What gaps exist in current knowledge and practice regarding GenAI use and integration?
4. What types of evidence exist regarding the use and outcomes of GenAI in nursing education?
5. What recommendations can be made to integrate GenAI in nursing education successfully?

## 4. Methodology

### 4.1. Design

We followed the JBI methodology for scoping reviews (Peters et al., 2020) to map and synthesise evidence on GenAI in nursing education. A protocol was registered in the Open Science Framework (OSF) registry (doi:10.17605/OSF.IO/PNUE8). The methodological change to the protocol involved the inclusion of the PAGER framework as a structured mapping tool to organise and describe the available evidence in this emerging field. This framework was specifically selected to provide systematic, actionable insights and identify knowledge gaps in GenAI's complex and rapidly evolving landscape (Bradbury-Jones et al., 2022). The complete review process and findings are reported following the PRISMA Extension for Scoping Reviews (PRISMA-ScR) reporting guidelines (Tricco et al., 2018) (Supplementary material 1).

### 4.2. Eligibility criteria and study types

This scoping review followed the JBI PCC (Population, Concept, Context) framework to guide inclusion and exclusion criteria. We included studies of all types, such as research articles and opinion pieces, that examined the use or discussion of GenAI tools (**Concept**), including ChatGPT, Claude, and Perplexity, in nursing education settings (**Context**). Eligible studies involved nursing students, faculty, or researchers (**Population**). We included only English-language publications published between November 2022 and November 2024. Studies focusing on general AI, non-GenAI chatbots, or clinical practice outside educational settings were excluded.

### 4.3. Search strategy and information sources

From October 2024 to November 2024, we searched PubMed, CINAHL, SCOPUS, ERIC, and grey literature (Google Scholar). Initial searches in PubMed informed the development of a comprehensive search strategy adapted for each database (Appendix 1). Reference lists of included studies were hand-searched for additional relevant articles.

### 4.4. Screening

Citations were imported into Covidence® software for duplicate removal and systematic screening. Six reviewers (EE, DC, EK, AJF, MD, KS) independently assessed titles and abstracts against inclusion criteria. This multi-reviewer approach was implemented to manage the substantial volume of citations while enhancing the identification of relevant studies through diverse expertise. Full-text articles were then evaluated by the same reviewers, with two senior reviewers (SB, SG) resolving disagreements through discussion and consensus. Regular calibration meetings ensured consistent application of inclusion criteria across all reviewers. The selection process followed PRISMA-ScR guidelines and is documented in the accompanying flow diagram (Tricco et al., 2018).

### 4.5. Data extraction

Data extraction was conducted using Covidence systematic review software, which enabled blinded screening and automated conflict resolution. Six reviewers (EE, DC, EK, AJF, MD, KS) independently extracted data using a custom form structured around the review questions and PAGER framework elements, covering bibliometric data, methodology, findings, challenges, recommendations, and PAGER components. The form was piloted with 10 random papers and refined to include theoretical frameworks, expanded outcomes, and supporting quotes. Regular calibration meetings ensured consistency, with disagreements resolved through consensus using Covidence's conflict resolution feature. Data quality was verified through random spot-checking of 20 % of the extracted data.

### 4.6. Quality appraisal

Given the heterogeneous nature of the included articles and per scoping review guidelines (Peters et al., 2020), a quality appraisal was not conducted.

### 4.7. Data analysis

Data analysis followed the PAGER framework (Bradbury-Jones et al., 2022), employing systematic synthesis. Data were organised in standardised templates and cross-checked for accuracy. The iterative analysis identified *Patterns* in themes, *Advances* in knowledge, *Gaps* in current understanding, *Evidence* for practice, and *Recommendations*. Team meetings and analytical memos documented decision-making processes, while cross-validation between reviewers ensured interpretative rigour. The synthesis underwent multiple refinements to maintain methodological transparency, including: (1) development of preliminary thematic matrices followed by team consolidation of overlapping concepts; (2) standardisation of coding frameworks across all PAGER elements; (3) systematic verification of synthesised findings against source data; and (4) documentation of analytical decision points where interpretations diverged, with final categorisation determined through consensus.

### 4.8. Data presentation

Results are presented in multiple formats: a PRISMA flow diagram detailing the selection of studies, comprehensive tables illustrating study characteristics, and systematic synthesis using the PAGER framework. The PAGER framework structures the findings through thematic matrices mapping Patterns and Advances across six key domains with supporting evidence and quotes, structured tables presenting Gaps across five categories with representative quotes and study identifiers, Evidence for practice organised by six key areas with supporting study data, and detailed tables linking Recommendations to specific themes and evidence. The synthesis includes an integrated summary table aligning findings across PAGER elements, with all components supported by direct quotes and study identifiers to ensure analytical rigour and transparency.

## 5. Findings

### 5.1. Selection of studies

The review identified 4787 references through database and grey literature searching. After removing 2289 duplicates, the remaining 2498 records were screened by title and abstract. Of these, 2262 records were excluded as they did not meet the inclusion criteria. A total of 235 full-text articles were retrieved and assessed for eligibility. A further 128 studies were excluded for not focusing on nursing education ($n = 50$), being studies involving non-nursing professionals ($n = 21$), unclear descriptions of GenAI's role ($n = 20$), and lack of relevance to GenAI ($n = 17$). Other reasons for exclusion included publication in non-English languages ($n = 11$), reviews or commentaries lacking primary findings ($n = 7$), and the unavailability of full text (n = 2). One hundred and seven (107) studies met the eligibility criteria (Fig. 1).

### 5.2. Characteristics of included studies

Table 1 summarises the characteristics of the included studies. Sixty-two (62, 57.9 %) studies were published in 2024, while 45 (42.1 %) were published in 2023. Most publications were commentaries, editorials, or opinion pieces (39, 36.4 %), followed by original research and educational innovation studies (34, 31.8 %). Other publication types included letters to the editor and correspondence (18, 16.8 %), reviews, and special articles (16, 15.0 %). Geographically, most publications originated from North America (45, 42.1 %), followed by Asia (32, 29.9 %), Europe (11, 10.3 %), and Oceania (4, 3.7 %). Only one study (0.9 %) came from Africa, while 14 (13.1 %) were international collaborations. Regarding GenAI tools implemented, ChatGPT dominated (89, 83.2 %), with varying version specifications (GPT-3.5: 31, GPT-4: 17, unspecified: 41), while other tools were minimally represented (DALL-E: 6, Bard/Gemini: 4, Claude: 3). The focus areas of the publications included educational applications (82, 76.6 %), implementation strategies (48, 44.9 %), ethical considerations (45, 42.1 %), assessment methods (38, 35.5 %), technical aspects (32, 29.9 %), and policy or guidelines (25, 23.4 %). Methodologically, the studies were predominantly theoretical or conceptual (42, 39.3 %), with practice-based (34, 31.7 %) and empirical studies (31, 29.0 %) also well-represented. (Supplementary material 2: Detailed characteristics of included studies).

### 5.3. Patterns in GenAI use in nursing education and research

Our analysis identified six interrelated patterns in GenAI use in nursing education (see Table 2 and Supplementary Table S3.1). Assessment and evaluation emerged as the primary pattern, with faculty using GenAI to generate NCLEX-style questions and provide automated student feedback (Li et al., 2024; Stamm, 2024; Teubner et al., 2023). Despite varying accuracy rates across versions (Hsu, 2023), these tools demonstrated value in creating diverse assessment formats across multiple studies (Cox et al., 2023; Huang and Tan, 2023; Kaneda et al., 2023; Parker et al., 2023; Seney et al., 2023a; Su et al., 2024a; Vaughn et al., 2024; Krueger et al., 2024; Li et al., 2024; Taira et al., 2023)

Simulation development constituted another significant pattern, particularly in mental health and paediatric scenario creation. Building

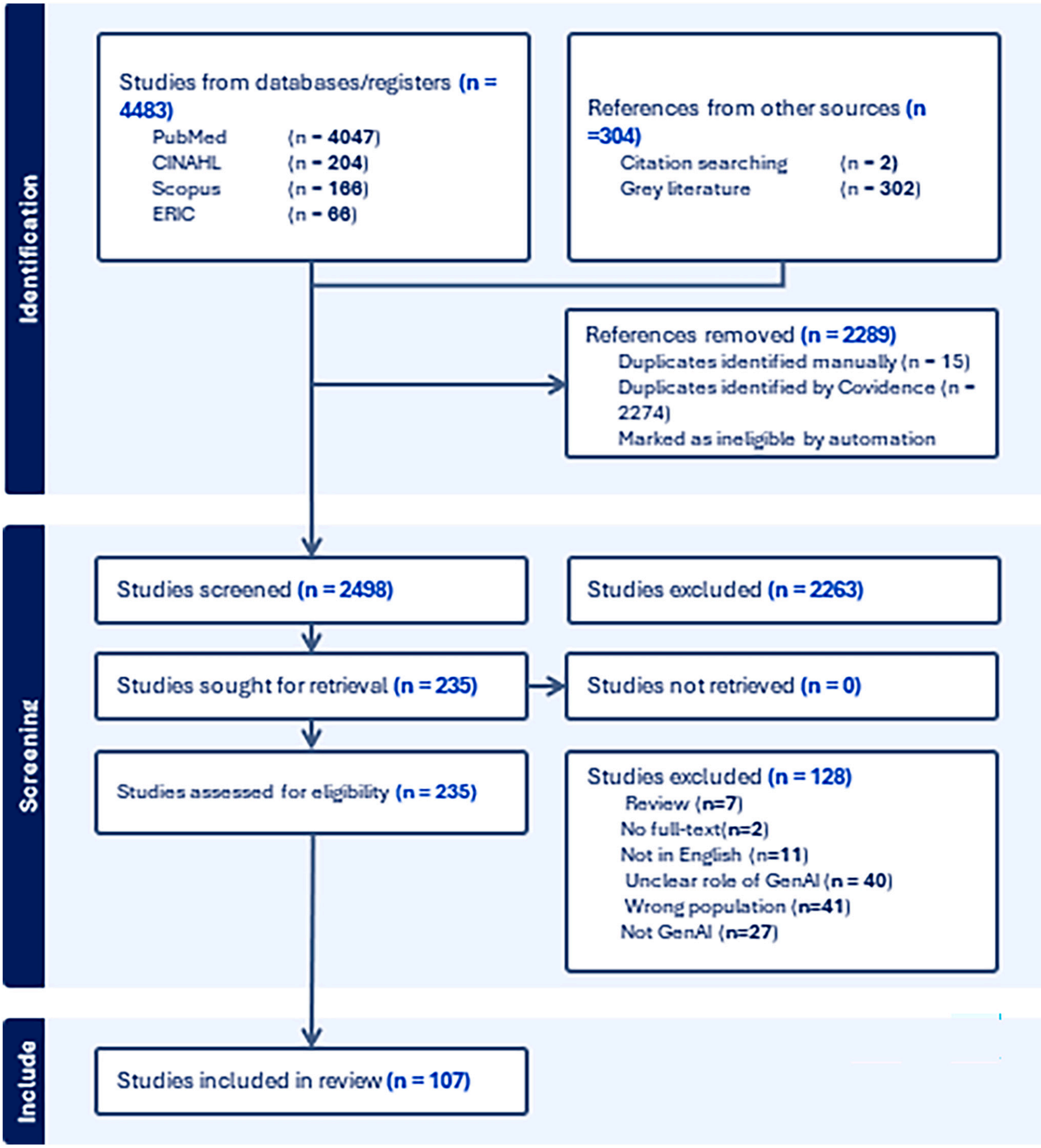


**Fig. 1.** PRISMA flow diagram of study selection process (Tricco et al., 2018).

on basic scenarios, integration with text-to-speech technologies enhanced simulation authenticity (Reed and Dodson, 2024), thereby improving communication practice opportunities in several contexts (Benfatah et al., 2024; Jung, 2023; Sharma and Sharma, 2023; Sharpnack, 2024). Complementing these applications, educational content creation through teaching materials and case studies formed another prominent pattern (Bumbach, 2024; Irwin et al., 2023; O'Connor, 2023a; Maykut et al., 2024; O'Connor et al., 2024), where faculty combined visual tools with GenAI-generated content to produce comprehensive clinical narratives and course materials (Bumbach, 2024; Harrison, 2024; Thakur et al., 2023; Musallam et al., 2024a,b; Quattrini et al., 2024; Draganic, 2023; Elting and Desio, 2024; Foronda and Porter, 2024; Krueger et al., 2024; Musallam et al., 2024a,b; O'Connor, 2023b; Quattrini et al., 2024; Reed and Dodson, 2024; Simms, 2024a,b; Stamm, 2024).

Notable differences emerged in usage patterns between faculty and students. While faculty focused on content preparation, assessment development, and quality control (Bumbach, 2024; Cox et al., 2023; Irwin et al., 2023; Liu et al., 2023; Thakur et al., 2023), with an emphasis on content oversight (Sessions and Ness, 2024), students utilised GenAI primarily for exam preparation and self-directed learning (Kowitlawakul et al., 2024; Liu et al., 2023; Elting and Desio, 2024;

**Table 1**
Characteristics of included studies ($N = 107$).

| Characteristics | n | % |
|---|---|---|
| Publication year | | |
| 2023 | 45 | 42.1 |
| 2024 | 62 | 57.9 |
| Publication type | | |
| Commentaries, editorials, and opinion pieces | 39 | 36.4 |
| Original research and educational innovation studies | 34 | 31.8 |
| Letters to the editor and correspondence | 18 | 16.8 |
| Reviews and special articles | 16 | 15.0 |
| Geographical distribution | | |
| North America (US and Canada) | 45 | 42.1 |
| Asia (East, Southeast, South, West) | 32 | 29.9 |
| Europe | 11 | 10.3 |
| Oceania | 4 | 3.7 |
| African | 1 | 0.9 |
| International collaborations | 14 | 13.1 |
| Focus areas[a] | | |
| Educational applications | 82 | 76.6 |
| Implementation strategies | 48 | 44.9 |
| Ethical considerations | 45 | 42.1 |
| Assessment methods | 38 | 35.5 |
| Technical aspects | 32 | 29.9 |
| Policy/guidelines | 25 | 23.4 |
| Methodological approach | | |
| Theoretical/conceptual | 42 | 39.3 |
| Practice-based | 34 | 31.7 |
| Empirical studies | 31 | 29.0 |
| GenAI tools mentioned/implemented | | |
| ChatGPT (all versions) | 89 | 83.2 |
| -ChatGPT (version not specified) | 41 | 38.3 |
| -ChatGPT - 3.5 | 32 | 29.0 |
| -ChatGPT - 4 | 17 | 15.9 |
| DALL-E | 6 | 5.6 |
| Google Bard/Gemini | 4 | 3.7 |
| Claude by Anthropic | 3 | 2.8 |
| Other GenAI tools | 5 | 4.7 |
| No specific tool mentioned | 18 | 16.8 |

[a] Note: Studies may address multiple focus areas; hence, percentages exceed 100 %.

Simms, 2024b), leveraging cognitive scaffolding for complex tasks (Turchioe et al., 2024).

Beyond these user-specific patterns, the review identified three distinct implementation approaches: 1) restrictive, 2) integrative, and 3) hybrid. Restrictive approaches limit GenAI use, particularly in assessments, emphasising verification requirements and traditional skill development (Alkhaqani, 2023b; Choi et al., 2023). Integrative implementations actively incorporate GenAI as a learning tool with structured guidelines for practical use and critical evaluation (Archibald and Clark, 2023; Baker Stein and Jones-Schenk, 2024). Hybrid approaches enable GenAI in specific learning activities while restricting it in others, employing verification protocols and clear boundaries for appropriate use (Miao and Ahn, 2023; Riley, 2024; Kleebayoon and Wiwanitkit, 2023; Lim, 2023; Nashwan and AbuJaber, 2023; Teixeira da Silva and Tsigaris, 2024).

### *5.4. Advances in GenAI applications in nursing education*

The review identified advances in GenAI's technical capabilities and educational applications (Table 2 and Supplementary Table S3.2). Newer GenAI versions demonstrated improved accuracy rates across multiple studies (Hallas, 2023; Huang, 2023; Hyewon et al., 2024; Kaneda et al., 2023; Kelly, 2023; Liu et al., 2023; Metersky et al., 2024; Ni et al., 2024; Su et al., 2024b). Most notably, GPT-4 achieved an 88.67 % accuracy rate in NCLEX-style questions, compared to GPT-3.5's 75.3 %, with Wu et al. (2024, p. 4) confirming that "ChatGPT 4.0 had an accuracy rate of 88.67% when answering NCLEX-RN MCQs." Beyond accuracy improvements, studies also reported enhanced multilingual capabilities and integration with speech technologies (Taira et al., 2023; Ye, 2024).

The review further identified improvement in educational content development, from basic text generation to more sophisticated applications. Shu-Ling (2024, p. 1) described this evolution as creating content that "provides students with a more effective and interactive learning experience." Building on this trend, several studies documented improved scenario-generation capabilities and depth of educational materials (Bumbach, 2024; Irwin et al., 2023; Liu et al., 2023; O'Connor et al., 2023). Similarly, assessment tools progressed from simple questions to context-specific evaluation instruments with enhanced feedback mechanisms and explanation quality (Sun, 2024), ultimately enabling more varied and practical assessment formats (Cox et al., 2023; Huang, 2023; Kaneda et al., 2023).

Student and faculty support systems demonstrated notable evolution, with distinct but parallel advances in both areas. For students, studies documented improved personalisation and self-directed learning capabilities, where GenAI functions as cognitive scaffolding that helps "students advance towards the performance of complex tasks" (Turchioe et al., 2024, p. 4; Huang, 2023; Kowitlawakul et al., 2024; Liu et al., 2023). Complementing these student-focused advances, research also described faculty support tools evolving into teaching assistance systems with advanced feedback generation (Alqahtani et al., 2023), though with the important caveat that "faculty must carefully evaluate and revise the ChatGPT 3.5 output before student use" (Sessions and Ness, 2024, p. 1; Bumbach, 2024; Cox et al., 2023; Irwin et al., 2023).

### *5.5. Gaps in GenAI applications in nursing education and research*

The review identified significant methodological, conceptual, and practical gaps (Table 2 and Supplementary Table S3.3). Studies reporting GenAI heavily relied on non-empirical sources with limited long-term investigations. Primary studies featured small sample sizes and lacked standardised evaluation methods (Berşe et al., 2023; Hsu and Chen, 2024; Parker et al., 2023; Rusandi et al., 2023). The key conceptual gap was insufficient integration with established pedagogical frameworks and unclear definitions of GenAI roles in education (Castonguay et al., 2023; Shepherd and Griesheimer, 2024; Sun, 2024; Teixeira da Silva, 2023; Topaz et al., 2024).

Implementation barriers included privacy concerns and academic dishonesty risks (Sun, 2023), with students potentially using GenAI to complete assignments rather than develop original work (Thakur et al., 2023). Limited hands-on evaluation methods and overreliance risks further challenge effective implementation (Abujaber et al., 2023; Alkhaqani, 2023b; Srinivasan et al., 2024; Vitorino and Júnior, 2023). Equity gaps emerged through digital access disparities and language barriers, with a concerning concentration of studies in high-income settings creating knowledge deficits in low-resource contexts (Jung, 2023; Alkhaqani, 2023a; Reed, 2023; Summers et al., 2024; Vitorino and Júnior, 2023).

Technical challenges included inconsistent accuracy and training data biases, with GenAI models processing information in ways difficult to interpret (Wu et al., 2024, p. 3). Integration difficulties and system compatibility issues added complexity to implementation (Shay, 2023; Tran et al., 2024). Quality assurance gaps included a lack of verification standards and risks of generating inaccurate content, requiring stringent controls and validation protocols (Shay, 2023; Summers et al., 2024; Thakur et al., 2023; Vitorino and Júnior, 2023).

### *5.6. Evidence for practice in GenAI applications in nursing education*

Evidence supporting GenAI's practical application in nursing education is summarised in Table 2 and Supplementary Table S3.4. Assessment and evaluation tools demonstrate effectiveness in generating standardised testing materials, with GPT-4 achieving an 88.67 % accuracy rate in NCLEX-style questions. Wu et al. (2024) documented that GPT-4 consistently produces high-quality, context-specific questions

**Table 2**
Comprehensive PAGER framework analysis of GenAI in nursing education.

| Domain | Patterns | Advances | Gaps | Evidence | Recommendations |
|---|---|---|---|---|---|
| Assessment & evaluation | • Regular use for NCLEX-style questions<br>• Consistent application in formative assessments<br>• Recurring use for providing automated feedback<br>• Variable accuracy rates (75–89 %) | • Improved accuracy rates (GPT-4: 88.67 % vs GPT-3.5: 75.3 %)<br>• Enhanced feedback mechanisms<br>• Context-specific question generation<br>• Development of varied assessment formats | • Limited validation studies<br>• Inconsistent quality control<br>• Potential assessment bias<br>• Standardisation challenges<br>• Verification difficulties | • GPT-4 achieves 88.67 % accuracy in NCLEX questions<br>• Multilingual assessment capabilities documented<br>• Enhanced explanation quality for all answer options<br>• Efficient generation of standardised testing materials | • Develop verification standards<br>• Integrate with existing assessment systems<br>• Implement quality control measures<br>• Regular benchmark testing<br>• Faculty oversight of generated questions |
| Clinical simulation | • Systematic use in creating patient scenarios<br>• Regular application in mental health simulations<br>• Consistent integration with communication practice<br>• Combining with text-to-speech technologies | • Enhanced simulation realism<br>• Integration with text-to-speech technologies<br>• Improved scenario-generation capabilities<br>• Better personalisation for specific clinical contexts | • Limited real-world validation<br>• Technical integration challenges<br>• Authenticity limitations<br>• Limited performance in complex scenarios<br>• Equity and access concerns | • Integration with TTS/STT enhances realism<br>• Specialised effectiveness in mental health/ paediatric scenarios<br>• Improved communication training opportunities<br>• Enhanced authenticity in patient interactions | • Combine with traditional simulation approaches<br>• Validate clinical reasoning outcomes<br>• Enhance technology integration<br>• Address equity and accessibility<br>• Develop specialty-specific applications |
| Educational content | • Regular use for developing teaching materials<br>• Consistent pattern of case study generation<br>• Integration with visual learning tools<br>• Curriculum support material development | • Development of adaptive learning materials<br>• Streamlined content creation<br>• Enhanced visual integration<br>• Improved scenario generation depth | • Quality verification challenges<br>• Overreliance concerns<br>• Limited theoretical frameworks<br>• Content diversity limitations<br>• Academic integrity issues | • Streamlined teaching material creation<br>• Visual enhancement through DALL-E integration<br>• Reduced faculty workload<br>• Production of comprehensive clinical narratives<br>• Adaptive resource development | • Establish content quality verification protocols<br>• Develop best practice guidelines<br>• Balance traditional and AI-generated content<br>• Enhance faculty skills in prompt engineering<br>• Implement oversight mechanisms |
| Implementation approaches | • Three distinct models: restrictive, integrative, and hybrid<br>• Consistent development of policy frameworks<br>• Regular focus on ethical guidelines<br>• Verification requirements<br>• Varied institutional responses | • Evolution from ad-hoc to structured approaches<br>• Development of comprehensive policies<br>• Integration of ethical guidelines<br>• Enhanced verification methods<br>• Better alignment with educational objectives | • Unclear implementation standards<br>• Privacy and security concerns are limited<br>• Equity considerations Inconsistent policy development, Variable faculty acceptance | • Structured ethical guidelines improve outcomes<br>• Hybrid models show the best adoption<br>• Transparent documentation requirements enhance integrity<br>• Integration with existing curricula shows sustainability<br>• Faculty training improves implementation | • Develop institutional policies<br>• Focus on ethical integration<br>• Create structured implementation frameworks<br>• Address digital equity concerns<br>• Establish clear verification protocols |
| Faculty & student use | • Faculty: content preparation, assessment, feedback<br>• Students: exam preparation, self-directed learning<br>• Pattern of cognitive scaffolding support<br>• Faculty emphasis on quality oversight | • Advanced personalisation capabilities<br>• Better integration with learning systems<br>• Improved feedback generation<br>• Enhanced content creation efficiency | • Digital access disparities<br>• Academic integrity risks<br>• Pedagogical framework gaps<br>• Overreliance concerns<br>• Faculty training limitations | • Enhanced content creation efficiency<br>• Cognitive scaffolding benefits learning<br>• Faculty oversight improves content quality<br>• Personalised learning supports diverse needs | • Develop faculty training initiatives<br>• Address digital equity concerns<br>• Establish academic integrity frameworks<br>• Create student guidance on effective use<br>• Balance innovation with traditional methods |

Abbreviations: TTS, Text-to-Speech; STT, Speech-to-Text.

and comprehensive explanations for all answer options. Moreover, studies highlighted GPT-4's multilingual capabilities and advanced feedback mechanisms that address diverse learning needs (Cox et al., 2023; Huang, 2023; Kaneda et al., 2023; Parker et al., 2023).

GenAI demonstrates improved training quality in clinical simulation through advanced integration of text-to-speech and speech-to-text technologies. Such integration enhances simulation realism by creating more authentic patient interactions and enabling personalised educational opportunities (Reed and Dodson, 2024; Bumbach et al., 2024; Reed et al., 2023). These benefits are particularly evident in mental health and paediatric scenarios, where communication skills are paramount (Cox et al., 2023; Jung, 2023; Sharma and Sharma, 2023; Sharpnack, 2024). Building on these simulation advances, educational content development helps reduce faculty workload while maintaining quality. The combination of visual tools like DALL-E with ChatGPT enhances content delivery, with Reid (2024) confirming ChatGPT's capacity to produce detailed clinical scenarios, while additional studies substantiate GenAI's role in creating adaptive learning resources (Bumbach, 2024; Huh, 2023; Liu et al., 2023; O'Connor et al., 2023).

For faculty, GenAI streamlines content creation and feedback processes, though Riley (2024) emphasised that instructor review of ChatGPT content remains essential before distribution to students. Complementing faculty applications, student evidence supports cognitive scaffolding effectiveness and personalised learning support (Bumbach, 2024; Cox et al., 2023; Huang, 2023; Irwin et al., 2023; Kowitlawakul et al., 2024; Liu et al., 2023). Beyond educational settings, clinical applications demonstrate GenAI's capacity to bridge theory-practice gaps (Alkhaqani, 2023c), with documented ability to produce clinically relevant material and develop task-specific reasoning skills (Metersky et al., 2024), while maintaining necessary oversight for complex scenarios (Hallas, 2023; Kaneda et al., 2023; Luo et al., 2023; Ni et al., 2024).

### 5.7. Recommendations for GenAI implementation in nursing education

Several recommendations emerge from the included studies (Table 2 and Supplementary Table S3.5). Short-term training initiatives should focus on developing AI literacy and digital proficiency among faculty and students, incorporating prompt engineering as an essential curriculum component (O'Connor et al., 2024). Building on this foundation, authors emphasise the need for content that develops critical thinking abilities alongside the establishment of ethical guidelines to ensure responsible AI use (Alkhaqani, 2023b; Archibald and Clark, 2023; Athilingam and He, 2024). Moving from training to curriculum design, studies recommend systematically integrating AI into nursing education while preserving traditional teaching methods, noting that such integration can strengthen student writing skills (Parker et al., 2023) while maintaining balance between innovation and established pedagogical practices through ethics and data literacy integration (Alkhaqani, 2023a; Allen and Woodnutt, 2023; Castonguay et al., 2023; De Gagne et al., 2024).

Technical recommendations focus on improving GenAI's accuracy and reducing bias by refining models to reflect nursing standards and classification systems better (Gosak et al., 2024; Ye, 2024). Complementing these technical considerations, studies emphasise developing advanced features while ensuring seamless integration with existing educational systems (Benfatah et al., 2024; Gosak et al., 2024; Hsu and Chen, 2024; Jung, 2023). Beyond technical aspects, institutional recommendations include developing policies and inclusive tools to ensure equity, access, and support for diverse user needs (Abujaber et al., 2023), thereby reducing language barriers and improving geographic access to resources (Abujaber et al., 2023; Fontenot, 2023; Hsu, 2023; Huh, 2023).

Policy recommendations highlight the importance of establishing clear standards for AI implementation through comprehensive guideline development with regular updates. This includes developing ethical protocols for AI implementation in qualitative and mixed-methods research (Lyon, 2023) that address academic integrity and ensure transparent GenAI use (Abdulai and Hung, 2023; Abujaber et al., 2023; Alkhaqani, 2023a,b). Finally, research recommendations emphasise the need for longitudinal and outcome evaluation studies to determine the enduring effects of GenAI integration (Benfatah et al., 2024; Chang et al., 2024; Cox et al., 2023; De Gagne et al., 2024), particularly focusing on how GenAI influences students' development of ethical reasoning (De Gagne et al., 2024).

## 6. Discussion

This scoping review employed a PAGER framework to examine patterns, advances, gaps, evidence, and recommendations for GenAI in nursing education across 107 publications. Our analysis revealed systematic patterns across five domains, with assessment generation, clinical simulation and educational content development showing consistent adoption. Implementation approaches ranged from restrictive to integrative models, with faculty maintaining oversight while students utilised GenAI for self-directed learning. Technical advances were substantial, with newer GenAI versions demonstrating improved performance and applications evolving from basic content generation to adaptive learning materials with enhanced simulation realism. Despite these advances, significant gaps persist in methodological rigour, conceptual frameworks, equity considerations, and quality assurance. While educational applications dominated our findings, practical implementation strategies, assessment methods, and technical integration remain underexplored. Evidence demonstrates GenAI's practical utility in assessment generation, clinical training enhancement, and faculty workload reduction while maintaining educational quality. Our recommendations emphasise faculty development, balanced curriculum integration, technical improvements, comprehensive policy frameworks, and longitudinal research examining long-term impacts.

The geographical and thematic landscape of GenAI publications in nursing education reveals important patterns that demand attention. While North America (42.1 %) and Asia (29.9 %) dominate the discourse, Africa's minimal contribution (0.9 %) and limited European engagement (10.3 %) signal knowledge generation disparities that could perpetuate global inequities in technology adoption (Hoagland and Kipping, 2024). Similarly, the overwhelming predominance of ChatGPT (83.2 % of studies) with minimal exploration of alternatives like DALL-E suggests a narrow technological focus that may limit understanding of how different GenAI architectures could uniquely support nursing education. The observed geographical imbalance and limited international collaborations (13.1 %) may suggest emerging GenAI implementation discussions that reflect well-resourced nursing education contexts. Also, the finding of the field's strong focus on educational applications (76.6 %) demonstrates recognition of GenAI's pedagogical potential. The relatively lower emphasis on assessment methods (35.5 %), technical aspects (29.9 %), and policy guidelines (23.4 %) contrasts with the prominent ethical considerations (42.1 %). This disparity may indicate a misalignment between aspirational goals and operational readiness. The pattern aligns with the observed early technology adoption challenges in nursing education during the peak of the COVID-19 pandemic (Amankwaa et al., 2022). A balanced research agenda that bridges theoretical enthusiasm with robust implementation frameworks is needed.

The observed patterns of GenAI use for assessment, clinical simulation, and content creation reveal opportunities and gaps. While faculty demonstrate creative applications, the predominant reliance on conceptual papers and anecdotal evidence raises fundamental questions about implementation efficacy (Alam and Mohanty, 2023; Asad et al., 2021). Also, the evidence of restrictive, integrative, and hybrid implementation models (Gerdes et al., 2024) represents a significant theoretical advancement that requires careful consideration. Each model presents distinct trade-offs between innovation and control. It is important to interrogate their contextual appropriateness and scalability across different educational settings. For example, the restrictive model that emphasises controlled implementation may protect academic integrity. However, it may limit transformative learning opportunities. Conversely, the integrative approach's embrace of GenAI tools risks reproducing educational inequities without proper safeguards.

We found significant advancements in GenAI capabilities, with technical progress observed in assessment applications (GPT-4 improved accuracy [88.7 %] in generating NCLEX-style questions). The finding represents a substantial improvement over GPT -3.5 (75.3 %) in computational precision (Lucas et al., 2024). This advancement aligns with broader patterns in healthcare education, as demonstrated by Jin et al. (2024) meta-analysis that revealed GPT-4's significantly higher accuracy (64.4–100 %) compared to GPT-3.5 (36–77 %) across health professional licensing examinations. The observed advancements extend our understanding of GenAI capabilities beyond simple automation. GenAI offers sophisticated applications that can be used in clinical simulation and adaptive learning environments. This promises to enhance accessibility and personalised learning (Furey et al., 2024).

However, as noted in previous studies (Wu et al., 2024; Zhou et al., 2024), the promising technological improvements require careful consideration, given the observed variations in performance across different healthcare education contexts (Jin et al., 2024). The variation in performance may indicate potential barriers to equitable adoption in favour of high-income, English-speaking regions (Shorey et al., 2024). Additionally, this variation suggests the need for discipline-specific validation approaches (Martzoukou et al., 2024). Studies reporting technical issues, training data biases, and AI system opacity (Hobensack et al., 2024) underscore the need for empirical validation to support evidence-based implementation.

Our review further showed significant advances in GenAI's capacity to create adaptive learning materials and realistic simulations. The finding aligns with broader trends in medical education, where AI has supported personalised learning and context-specific training (Lucas et al., 2024). While technologically sophisticated, the observed innovations require careful alignment with established pedagogical frameworks to ensure meaningful learning outcomes (Shorey et al., 2024). The findings suggest a need for structured implementation frameworks that address challenges in data privacy, academic integrity, and assessment validity (Stahl and Eke, 2024). These advances demand robust pedagogical oversight and systematic evaluation to ensure that technological capabilities genuinely enhance educational quality rather than merely automating existing practices.

## 7. Recommendations

This review identified important gaps and opportunities in support of GenAI implementation to advance nursing education. The findings indicate the necessity of establishing a comprehensive system that balances innovation with academic integrity in nursing assessment and clinical training. These frameworks should establish clear data privacy and security standards guidelines and ensure compliance with educational regulations (Foronda and Porter, 2024). To address identified disparities, incentive structures should promote equitable access to GenAI technologies across diverse settings, with particular attention to underserved populations and low-resource settings. Targeted strategies are needed for bridging digital divides and maximising global applicability.

Longitudinal studies are needed to evaluate the impact of GenAI use on student outcomes and ethical decision-making. Comparative effectiveness research between AI-enhanced and conventional teaching methods should be given priority. There should be efforts to ensure that findings are generalisable and practical across diverse educational environments. Research should focus on how GenAI influence clinical reasoning, professional judgment, and academic integrity over time. Critical examination is required to ensure GenAI alignment with pedagogical frameworks, particularly investigating impacts on critical thinking and reflective learning. Additionally, research must examine the integration of AI into didactic education and its effect on teaching quality.

Implementation should follow evidence-based approaches in assessment generation and clinical simulation development, aligning with established pedagogical frameworks to enhance rather than replace effective teaching practices. Systematic documentation and evaluation of implementation experiences will contribute to developing best practices. Developing technical and ethical competencies is crucial, especially for upholding academic integrity and ensuring equitable student access. Cross-institutional collaboration should be encouraged to share implementation strategies and lessons learned.

## 8. Limitations

Our review has several limitations. First, the prevalence of non-empirical publications in our included studies reflects the emerging nature of GenAI in nursing education. While understandable given the technology's recency, this limits the availability of evidence-based practices and frameworks for implementation. Our reliance on tool-specific terms (e.g., "ChatGPT") in our search strategy may have excluded certain GenAI studies due to the evolving terminology. However, we mitigated this by including broader conceptual terms (e.g., "Artificial Intelligence"). The absence of standardised "generative AI" MeSH terms during our search period further constrained comprehensiveness. Future reviews should incorporate emerging controlled vocabulary (e.g., 2025 MeSH updates). Our decision to exclude non-English publications may have overlooked valuable perspectives from regions leading in educational technology innovation.

## 9. Conclusion

Our review demonstrates GenAI's transformative potential in nursing education. It has shown promise in improving assessment accuracy, clinical simulation sophistication, and adaptive learning capabilities. However, geographical disparities in research contributions and predominantly theoretical evidence base present critical challenges. The limited focus on practical implementation frameworks, assessment methods, and policy guidelines signals a pressing need for evidence-based integration strategies. There is a need for coordinated response through multi-institutional research networks, comprehensive faculty development programs, and robust governance frameworks aligned with professional nursing standards. Research efforts must focus on developing validated instruments for measuring AI-enhanced learning outcomes, establishing longitudinal studies examining pedagogical effectiveness, and fostering international collaboration to ensure equitable adoption.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.nedt.2025.106822.

## CRediT authorship contribution statement

**Isaac Amankwaa:** Writing – original draft, Formal analysis, Data curation, Conceptualization. **Emmanuel Ekpor:** Writing – review & editing, Methodology, Formal analysis, Data curation. **Daniel Cudjoe:** Writing – review & editing, Formal analysis. **Emmanuel Kobiah:** Writing – review & editing, Formal analysis. **Abdul-Karim Jebuni Fuseini:** Writing – review & editing, Formal analysis. **Maximous Diebieri:** Writing – review & editing, Formal analysis, Data curation. **Sebastian Gyamfi:** Writing – review & editing, Supervision. **Sharon Brownie:** Writing – review & editing, Supervision.

## Funding

This research received no specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Appendix 1. Search strategy

| Database | Search terms | Results |
|---|---|---|
| PubMed | ("ChatGPT" OR "Artificial Intelligence" OR "AI" OR "Language Model" OR "Chatbot" OR "Chat Generative Pre-trained Transformer") AND ("Nursing" OR "Nursing Education" OR "Nurse" OR "Nursing Practice" OR "Nursing Research" OR "Patient Care" OR "Nursing Profession") AND ("Impact" OR "Effect" OR "Role" OR "Contribution" OR "Evaluation" OR "Performance" OR "Trustworthiness" OR "Value" OR "Risk" OR "Potential" OR "Integration") | 4047 |
| CINAHL | MH "ChatGPT" OR MH "Artificial Intelligence" OR "AI" OR "Language Model" OR "Chatbot" OR "Chat Generative Pre-trained Transformer" AND MH "Nursing" OR MH "Nursing Education" OR "Nursing Practice" OR "Nursing Research" OR "Patient Care" OR "Nursing Profession" AND "Impact" OR "Effect" OR "Role" OR "Contribution" OR "Evaluation" OR "Performance" OR "Trustworthiness" OR "Value" OR "Risk" OR "Potential" OR "Integration" | 204 |
| Scopus | TITLE-ABS-KEY ("ChatGPT" OR "Artificial Intelligence" OR "AI" OR "Language Model" OR "Chatbot" OR "Chat Generative Pre-trained Transformer") AND TITLE-ABS-KEY ("Nursing" OR "Nursing Education" OR "Nurse" OR "Nursing Practice" OR "Nursing Research" OR "Patient Care" OR "Nursing Profession") AND TITLE-ABS-KEY ("Impact" OR "Effect" OR "Role" OR "Contribution" OR "Evaluation" OR "Performance" OR "Trustworthiness" OR "Value" OR "Risk" OR "Potential" OR "Integration") | 166 |
| ERIC | "ChatGPT" OR "Generative Pre-trained Transformer" OR "Chat Generative Pre-trained Transformer" OR "OpenAI" AND "Nursing" OR "Nurse Education" OR "Nursing Practice" OR "Nursing Research" AND "Artificial Intelligence" OR "AI" OR "Language Model" OR "Chatbot" AND "Patient Care" OR "Clinical Judgment" OR "Clinical Practice" OR "Nursing Ethics" OR "Nurse-Patient Relationship" AND "Healthcare Technology" OR "Digital Health" OR "AI Integration" OR "Healthcare Informatics" | 66 |
| Google Scholar | "ChatGPT" OR "Artificial Intelligence" OR "AI" OR "Language Model" OR "Chatbot" OR "Chat Generative Pre-trained Transformer" AND "Nursing" OR "Nursing Education" OR "Nurse" OR "Nursing Practice" OR "Nursing Research" AND "Impact" OR "Effect" OR "Role" OR "Contribution" OR "Evaluation" OR "Performance" OR "Trustworthiness" OR "Value" OR "Risk" OR "Potential" OR "Integration" | 302 |

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