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(IJMOE)**www.gaexcellence.com/ijmoe**GLOBAL RESEARCH TRENDS IN ARTIFICIAL
INTELLIGENCE IN NURSING EDUCATION**

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Abstract:

Artificial intelligence (AI) has rapidly developed into a disruptive and highly influential force across the domains of healthcare and education, with an expanding role in nursing education where it is increasingly applied to strengthen teaching practices, learning processes, and clinical decision-making competencies. Despite increasing interest, the global research landscape concerning AI in nursing education remains disjointed, with limited consolidation of publication trends, thematic developments, and collaborative patterns. This investigation seeks to deliver an extensive bibliometric examination of global scholarly output on artificial intelligence within nursing education. A systematic retrieval of literature was carried out using the Scopus database, applying an advanced search framework anchored on three principal keywords: “artificial intelligence,” “nursing education,” and “student.” In total, 523 pertinent publications were retrieved and subsequently

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subjected to analysis. Bibliometric methodologies, comprising Scopus Analyzer, OpenRefine, and VOSviewer, were utilized to facilitate data refinement, descriptive statistical evaluation, and visualization of relational networks. The results demonstrate a marked escalation in publication activity, especially following 2020, with peak contributions observed in 2025 at 38 percent and in 2026 at 29%, signaling a swift and substantial surge in academic engagement within the field. Keyword co-occurrence mapping identifies central conceptual clusters, including artificial intelligence, nursing education, and nursing students, alongside progressively emerging areas such as generative artificial intelligence, ChatGPT, simulation-driven learning environments, and ethical considerations surrounding AI deployment. At the national level, the United States exhibits the highest levels of research productivity, citation impact, and international research collaboration, with notable contributions also originating from Australia, the United Kingdom, and developing research centers across Asia and the Middle East. The most frequently cited studies are largely recent publications, underscoring the continuously evolving and fast-paced nature of this research domain. In summary, artificial intelligence within nursing education has evolved into a rapidly expanding and inherently interdisciplinary area of scholarship, propelled by technological innovation and the escalating need for digital competency in contemporary healthcare education systems. This study offers meaningful insights for researchers, educators, and policymakers in shaping future investigative pathways and implementation strategies.

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Keywords:

Artificial Intelligence, Nursing Education, Students



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Introduction

Artificial intelligence (AI) is transforming nursing education by redefining the methods through which knowledge is imparted, altering the practice of clinical skills development, as well as professional roles for a digital healthcare system. Across recent reviews and empirical studies, AI is framed both as a powerful catalyst for more personalized, competency-based learning and as a source of ethical, pedagogical, and infrastructural challenges that demand thoughtful curriculum reform (R. El Arab et al., 2024; R. A. El Arab et al., 2025; Buchanan et al., 2021a; Chan et al., 2025; Jiatian et al., 2025; Lifshits & Rosenberg, 2024; Montejo et al., 2024; Simms, 2024). This introduction and literature review situate AI within contemporary nursing education, outlining major applications, benefits, risks, and gaps to justify deeper scholarly inquiry.

Early work mapped how AI healthcare technologies, including predictive analytics, virtual avatars, smart home systems, as well as robotic applications, were anticipated to shape nursing education across both academic and clinical contexts, emphasizing an urgent need for curricular reform and new pedagogies that incorporate AI while sustaining person-centered, compassionate care (Simms, 2024). Subsequent systematic and scoping reviews confirm that AI is now embedded across multiple educational functions: simulation, tutoring, predictive analytics, debriefing, performance assessment, and content generation (Chan et al., 2025; Lifshits & Rosenberg, 2024)

AI-driven simulations and virtual environments expose students to realistic clinical scenarios, supporting case-management performance, standardization of experiences, and richer engagement, albeit sometimes with increased cognitive load, anxiety, and stress (R. A. El Arab et al., 2025; Jiatian et al., 2025; Shen et al., 2025). Large language models, chatbots, as well as generative AI tools like ChatGPT are used to create virtual patient cases, provide on-demand explanations, assist with assignments, and support prompt-based care planning, enabling more personalized and self-directed learning while raising concerns about academic integrity and overreliance (R. El Arab et al., 2024; Buchanan et al., 2021a; Chan et al., 2025; Hwang et al., 2022; Jiatian et al., 2025). Bibliometric and topic-modeling analyses indicate that research has concentrated on usability, simulation education, exam and assignment support, and patient education, with relatively less focus on systematic appraisal of strengths, weaknesses, and threats (Bozkurt et al., 2025; Seo & Kim, 2024).

Evidence from mixed-methods and systematic reviews suggests that AI can improve nursing students' learning attitudes, psychological outcomes, knowledge acquisition, clinical decision-making, and comprehensive competencies (Jallad et al., 2024; Jiatian et al., 2025; Ramírez-Baraldes et al., 2025; Simms, 2024). AI-supported interventions foster engagement, self-efficacy, and confidence, and may help learners manage the complexities of contemporary healthcare (R. A. El Arab et al., 2025; Jallad et al., 2024; Ramírez-Baraldes et al., 2025). Machine-learning models have been utilized to forecast academic performance and graduation outcomes, enabling early identification of students needing support, while adaptive platforms and intelligent agents profile learner needs and tailor content (Bozkurt et al., 2025; Hwang et al., 2022; Simms, 2024). At the same time, nursing students and educators report technical issues, language barriers, limited realism, and inconsistent precision in AI-generated outputs, which can undermine trust and require strong critical-evaluation skills (Lifshits & Rosenberg, 2024; Ramírez-Baraldes et al., 2025; Rony et al., 2025; Shen et al., 2025). Empirical work on generative AI shows that thoughtful prompt engineering can enhance the relevance and clarity of AI-generated care plans and free cognitive resources for higher-order reasoning, yet students remain aware of partial or incomplete outputs, constrained capacity for emotional comprehension, and concerns surrounding data privacy. As a result, they generally position AI as an adjunct tool rather than a substitute for human-centred competencies (R. El Arab et al., 2024; R. A. El Arab et al., 2025; Rony et al., 2025). These findings underline the dual imperative to cultivate AI literacy in understanding underlying technologies, interrogating bias, and appraising evidence, while safeguarding empathy, communication, and ethical judgment (Buchanan et al., 2021a; Chan et al., 2025; Montejo et al., 2024; Sathiya, 2025).

A consistent theme across umbrella, integrative, and scoping reviews is that nursing curricula have not kept pace with AI's rapid expansion in healthcare and education. Reviews highlight a shortage of detailed models for integrating AI into formal programs, limited longitudinal

evaluations, uneven study populations, and weak or non-standardized outcome measures (R. El Arab et al., 2024; Buchanan et al., 2021a; Jallad et al., 2024; Lifshits & Rosenberg, 2024; Montejo et al., 2024; Simms, 2024). Nurse educators often lack training, institutional support, and infrastructure to implement AI-enhanced teaching, especially in low-resource settings, where technological and funding constraints, connectivity, and hardware limitations compound ethical and pedagogical concerns (Buchanan et al., 2021a; Montejo et al., 2024; Sathiya, 2025; Shen et al., 2025; Wei et al., 2025). Faculty readiness and AI literacy are repeatedly identified as prerequisites for responsible integration, leading to calls for multimodal educational strategies combining didactic content on AI concepts and ethics with experiential learning through simulation, clinical practicum, and co-designed AI tools (R. El Arab et al., 2024; Buchanan et al., 2021a; Cucci et al., 2025; Montejo et al., 2024; Ramírez-Baraldes et al., 2025; Shen et al., 2025; Simms, 2024). Frameworks such as the Nursing AI Integration Roadmap emphasize transformational education, ethical governance, participatory design, and economic evaluation as interlocking dimensions for sustainable implementation (R. A. El Arab et al., 2025; Buchanan et al., 2021a). At a systems level, students' actual use of AI tools ranging from mobile applications and virtual reality to ChatGPT and PowerPoint AI appears widespread, suggesting that curricula must move from prohibition or ad-hoc usage toward structured guidance, assessment, and support (R. El Arab et al., 2024; Sathiya, 2025; Seo & Kim, 2024).

Ethical and social implications permeate the literature, with recurring issues emerging regarding security, data privacy, transparency, algorithmic bias, accountability, as well as equitable access (R. El Arab et al., 2024; R. A. El Arab et al., 2025; Buchanan et al., 2021a; Chan et al., 2025; Cucci et al., 2025; Montejo et al., 2024; Rony et al., 2025). AI's potential to dehumanize care or erode critical thinking is contrasted with opportunities to offload routine tasks, reduce burnout, and enhance time for direct patient interaction when implemented within robust ethical frameworks that preserve the human-centered essence of nursing (R. A. El Arab et al., 2025; Buchanan et al., 2021a; H.-S. Wu, 2024). Reviews and conceptual papers argue that AI literacy must explicitly incorporate the capacity to critically evaluate AI-produced outputs, recognize inherent constraints and systematic biases, and preserve academic integrity standards, especially amid the rise of generative AI technologies and automated grading (R. El Arab et al., 2024; Chan et al., 2025; Cucci et al., 2025; Hwang et al., 2022; Jiatian et al., 2025; Montejo et al., 2024; Seo & Kim, 2024). Research gaps include the scarcity of AI tools tailored specifically for nursing practice, insufficient longitudinal evidence concerning extended educational outcomes as well as patient impacts, underexplored threats and weaknesses relative to opportunities, and the exclusion of grey literature, which may skew the evidence base toward optimistic findings (R. A. El Arab et al., 2025; Bozkurt et al., 2025; Buchanan et al., 2021b; Seo & Kim, 2024; Simms, 2024; H.-S. Wu, 2024). In conclusion, the existing scholarship portrays AI as a powerful but still developing influence within nursing education: it offers substantial promise for personalized, interactive, and competency-based learning, but its benefits are contingent on deliberate curriculum redesign, faculty development, rigorous evaluation, and comprehensive ethical governance. A sustained research agenda is needed to move beyond descriptive enthusiasm toward empirically grounded models that integrate AI within nursing in a way that remains consistent with the profession's foundational principles of compassion, equity, and safe, person-centered care (R. A. El Arab et al., 2025; Buchanan et al., 2021a; Cucci et al., 2025; Doston et al., 2025; Jallad et al., 2024; Jiatian et al., 2025; Lifshits & Rosenberg, 2024; Montejo et al., 2024; Ramírez-Baraldes et al., 2025; Simms, 2024; H.-S. Wu, 2024).

Research Question

1. How has the volume of scholarly publications on artificial intelligence in nursing education changed over time from 1985 to 2026?
2. Which publications demonstrate the strongest influence in artificial intelligence in nursing education based on citation impact?
3. What are the dominant and emerging research themes in artificial intelligence in nursing education based on keyword co-occurrence analysis?
4. What are the patterns of international research collaboration in artificial intelligence in nursing education, as revealed through country-level co-authorship networks?

Methodology

Bibliometric analysis is defined as the structured process of identifying, organizing, and quantitatively assessing bibliographic information obtained from academic literature (Alves et al., 2021; Assyakur & Rosa, 2022; Verbeek et al., 2002). In addition to standard descriptive indicators such as publication outlets, chronological patterns, and prominent authorship contributions (Y. C. J. Wu & Wu, 2017), bibliometric methodologies have progressively expanded to include more sophisticated analytical procedures, notably co-citation mapping and network-based analyses, which are employed to reveal the underlying intellectual architecture of a specific field of study.

A stringent bibliometric review necessitates an iterative, methodologically sound procedure encompassing precise keyword formulation, comprehensive database retrieval, and in-depth analytical assessment. Such a systematic approach facilitates the construction of a reliable and comprehensive evidence base, thereby enhancing the validity and reproducibility of findings (Fahimnia et al., 2015).

In this investigation, priority was given to publications of substantial scholarly impact to ensure the incorporation of seminal works that make meaningful contributions to the theoretical and conceptual advancement of the discipline. To preserve precision and uniformity in the dataset, Elsevier's Scopus database was selected as the principal source for data retrieval (Al-Khoury et al., 2022; di Stefano et al., 2010; Khiste & Paithankar, 2017). The scope of inclusion was confined strictly to peer-reviewed journal articles in order to maintain academic rigor, whereas non-peer-reviewed materials such as books and lecture notes were intentionally omitted (Gu et al., 2019). Leveraging the broad and multidisciplinary reach of Scopus, relevant publications from 1985 through May 2026 were collected and subjected to analysis.

Data Search Strategy

The bibliometric data collection for research on AI within nursing education was gathered through an advanced search strategy within the Scopus database to ensure comprehensive coverage and high relevance of retrieved publications. As presented in Table 1, the search string was carefully constructed to encompass artificial intelligence-related terminology, including "AI," "artificial intelligence," "deep learning," "machine learning," as well as "neural network" with key nursing-related terms, including "nursing education," "nursing practice," and "nursing profession," alongside educational dimensions such as "teaching," "learning," and "curriculum," with a specific focus on student-related contexts. This structured

query ensured that the retrieved publications explicitly addressed the intersection between artificial intelligence applications and educational methodologies within the field of nursing.

To enhance disciplinary specificity, the search was restricted to the nursing subject area (NURS) within Scopus. Furthermore, only publications written in English were selected to ensure uniformity in interpretation and analytical consistency. The study’s temporal boundaries were restricted to works published from 2006 through December 2025, encompassing the initial emergence, accelerated advancement, and expanding incorporation of artificial intelligence technologies within nursing education. A comprehensive outline of the inclusion and exclusion criteria employed throughout the screening procedure is presented in Table 2.

After the application of all predetermined criteria, 523 publications were ultimately retained for final analysis. This dataset reflects a growing body of scholarly work and sustained research interest in the incorporation of AI in nursing education across the last twenty years. The volume and diversity of publications indicate that AI has gradually evolved from an emerging technological concept to an integral component of educational innovation in nursing.

The resulting dataset demonstrates a multidisciplinary convergence, encompassing technological advancements in artificial intelligence alongside pedagogical and professional developments in nursing education. This comprehensive corpus provides a robust foundation for subsequent bibliometric analysis, allowing for a structured assessment of publication trajectories, key contributors and scholarly outlets, collaborative relationship networks, as well as the progression of thematic developments across research in this field.

Table 1: The Search String

Scopus	TITLE-ABS-KEY ((“artificial intelligence” OR AI OR “machine learning” OR “deep learning” OR “neural network”) AND (nursing OR “nursing education” OR “nurse training” OR “nursing practice” OR “nursing profession”) AND (education OR “educational methods” OR “teaching” OR “learning” OR “curriculum”) AND (student)) AND (LIMIT-TO (SUBJAREA , “NURS”)) AND (LIMIT-TO (LANGUAGE , “English”))
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Table 2: The Selection Criterion is Searching

Criterion	Inclusion	Exclusion
Language	English	Non-English
Subject	Nursing	Others
Timeline		<2006

Data Analysis

This is a broadly utilized and user-focused instrument for bibliometric analysis, created by Nees Jan van Eck and Ludo Waltman at Leiden University (van Eck & Waltman, 2010, 2017). The software is purpose-built to enable both visualization and quantitative evaluation of scientific literature, offering sophisticated capabilities for building network representations, grouping interconnected entities through clustering, and producing density-based visual mappings. Its analytical versatility allows for the investigation of various bibliometric linkages,

such as co-authorship networks, co-citation structures, and keyword co-occurrence patterns, thus facilitating a thorough representation of the intellectual architecture within a given research domain.

A significant advantage of VOSviewer is its ability to convert intricate bibliometric datasets into clear, accessible, and easily interpretable visual formats. The software is particularly effective in network-based analyses, allowing for the identification of thematic clusters, emerging research trends, and patterns of scholarly collaboration. Its interactive interface enhances usability for both novice and experienced researchers, while continuous software development ensures adaptability to evolving analytical needs and large-scale datasets. Furthermore, its ability to calculate bibliometric metrics, tailor visualization outputs, and assimilate data from multiple heterogeneous sources reinforces its robustness as a methodological tool in bibliometric research.

In the present study, bibliographic data comprising article title, publication year, author names, citation counts, source journals, as well as keywords were retrieved in PlainText format from the Scopus database, spanning the timeframe from 2004 through December 2024. The subsequent analytical procedures were carried out using VOSviewer version 1.6.20, wherein mapping and clustering techniques were implemented to construct and interpret bibliometric networks. Unlike traditional approaches such as Multidimensional Scaling (MDS), VOSviewer adopts the Visualization of Similarities (VOS) mapping framework, which arranges elements within a reduced-dimensional space so that the spatial separation between any pair of items corresponds to the magnitude of their relational similarity (van Eck & Waltman, 2010). While this approach is theoretically comparable to MDS (Appio et al., 2014), the VOS methodology diverges in its computational foundation through the use of normalization strategies specifically designed for co-occurrence datasets, with particular emphasis on the association strength metric (AS_{ij}) (Van Eck & Waltman, 2007);

$$AS_{ij} = \frac{C_{ij}}{W_i W_j}$$

The association strength (AS_{ij}) is defined as the proportion between the empirically observed frequency of co-occurrence between elements i and j and the expected frequency of their co-occurrence under the assumption that both items occur independently of one another (Van Eck & Waltman, 2007).

Result and Discussion

There are 4 research questions being discussed in this section.

RQ1: How Has the Volume of Scholarly Publications on Artificial Intelligence in Nursing Education Changed Over Time From 1985 To 2026?

The longitudinal distribution of scholarly output on AI within nursing education between 1985 and 2026 demonstrates a distinct evolution from a nascent research area to a rapidly expanding field, as mentioned in Figure 1 and Table 3. Between 1985 and approximately 2010, scholarly output remained extremely limited, with only sporadic publications (typically one to three per year), reflecting the early developmental stage of both artificial intelligence technologies and

their application in nursing education. During this period, technological constraints, limited digital integration in healthcare education, and low awareness of AI's pedagogical potential contributed to minimal research activity. A gradual increase can be observed from 2011 to 2019. However, the growth remained modest, indicating a transitional phase in which digital learning tools and simulation-based education began gaining acceptance, while AI had not yet become a central focus within nursing curricula or research priorities.

A substantial and accelerated increase in publication output is evident from 2020 onwards, with a sharp surge between 2023 and 2026, where publications increased dramatically from 23 (4%) in 2023 to 198 (38%) in 2025 and remained high at 152 (29%) in 2026. This surge in exponential growth can be linked to a set of intersecting drivers. To begin with, swift progress in artificial intelligence, especially within deep learning, machine learning, as well as intelligent simulation, has significantly expanded its applicability in education and clinical training. Second, the COVID-19 pandemic served as a pivotal catalyst, accelerating the rapid uptake of digital and AI-supported learning environments, thereby stimulating research and innovation in this domain. Third, increasing global emphasis on digital health competencies and workforce preparedness has positioned AI as a central element in contemporary nursing education. The prevalence of recent publications (2024–2026, accounting for nearly 80% of total output) indicates that this field is currently in a high-growth phase, suggesting strong future research potential and continued interdisciplinary integration between nursing, education, and technological sciences.

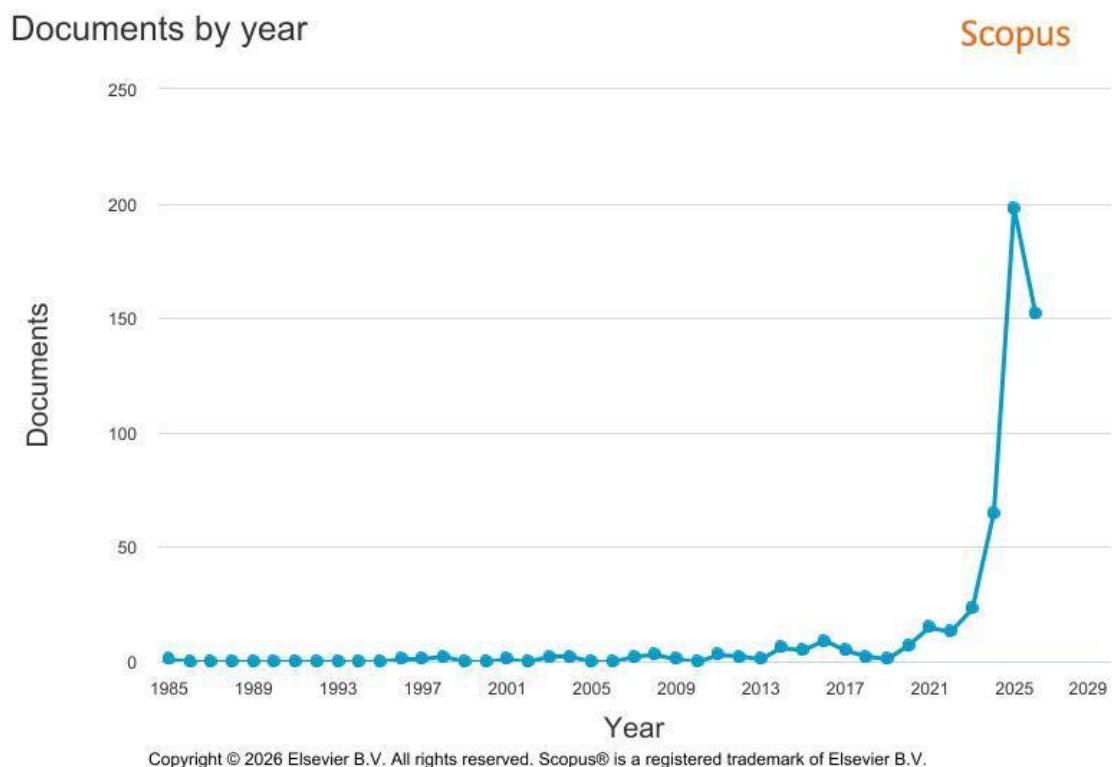


Figure 1: Trend Of Research in Artificial Intelligence in Nursing Education Over Time From 1985 To 2026

Table 3: Annual Distribution of Publications in Artificial Intelligence in Nursing Education (1985–2026)

Year	No of Publication	Percentage
2026	152	29%
2025	198	38%
2024	65	12%
2023	23	4%
2022	13	2%
2021	15	3%
2020	7	1%
2019	1	0%
2018	2	0%
2017	5	1%
2016	9	2%
2015	5	1%
2014	6	1%
2013	1	0%
2012	2	0%
2011	3	1%
2009	1	0%
2008	3	1%
2007	2	0%
2004	2	0%
2003	2	0%
2001	1	0%
1998	2	0%
1997	1	0%
1996	1	0%
1985	1	0%

RQ2: Which Publications Demonstrate the Strongest Influence in Artificial Intelligence in Nursing Education Based on Citation Impact?

The most frequently cited ten articles within the field of artificial intelligence in nursing education demonstrate a pronounced clustering of impactful scholarly work in recent years. The leading publication, authored by Buchanan C. et al. (2021), which has accumulated 223 citations, underscores the central importance of scoping review methodologies in framing and advancing scholarly discussions on the role and implications of AI in nursing education. Similarly, high citation counts for recent articles such as Sun G.H. and Hoelscher S.H. (2023) on ChatGPT (211 citations) and Kwak et al. (2022) (197 citations) indicate rapid scholarly engagement with emerging AI technologies and their implications for education and practice. Notably, although most highly cited works are recent, older studies such as Clifton and Mann (2011) remain highly cited (183 citations), suggesting that foundational research on digital learning platforms (e.g., YouTube) continues to influence current AI-related educational innovations. This pattern demonstrates that citation impact is driven not only by recency but also by the enduring relevance of earlier technological integration in nursing education.

Furthermore, the dominance of journals like JMIR Nursing Nurse as well as Education Today in Table 4 underscores their central role as key dissemination platforms for high-impact research in this field. A significant proportion of the top-cited publications concentrates on developing areas, including AI ethics, virtual reality simulation, chatbot integration, and students' acceptance of AI technologies, reflecting a shift from traditional teaching methods toward technologically enhanced and student-centered learning environments. The elevated citation figures attributed to studies released between 2020 and 2023 can be reasonably explained by the rapid expansion and normalization of digital and AI-driven tools during and after the COVID-19 pandemic, which intensified global research interest. Additionally, the presence of studies examining behavioral intention, self-efficacy, and attitudes toward AI suggests that the field is not only technologically driven but also grounded in educational and psychological theories. Overall, the citation landscape presented in Table 4 indicates a rapidly evolving and interdisciplinary research domain, where recent innovations, combined with foundational digital learning studies, collectively shape the trajectory of AI in nursing education.

Table 4: The Top 10 Most Cited Authors in Artificial Intelligence in Nursing Education Demonstrate a Strong Concentration of Influential Publications in Recent Years.

No	Authors	Title	Year	Source title	Cited by
1	Buchanan et al. (2021a)	Predicted Influences of Artificial Intelligence on Nursing Education: Scoping Review	2021	JMIR Nursing	223
2	Sun & Hoelscher (2023)	The ChatGPT Storm and What Faculty Can Do	2023	Nurse Educator	211
3	Kwak, Ahn, et al. (2022)	Influence of AI ethics awareness, attitude, anxiety, and self-efficacy on nursing students' behavioral intentions	2022	BMC Nursing	197
4	Clifton & Mann (2011)	Can YouTube enhance student nurse learning?	2011	Nurse Education Today	183
5	Liaw et al. (2023)	Artificial intelligence in virtual reality simulation for interprofessional communication training: Mixed method study	2023	Nurse Education Today	179
6	Tam et al. (2023)	Nursing education in the age of artificial intelligence-powered Chatbots (AI-Chatbots): Are we ready yet?	2023	Nurse Education Today	161
7	Castonguay et al. (2023)	Revolutionizing nursing education through AI integration: A reflection on the disruptive impact of ChatGPT	2023	Nurse Education Today	140
8	Shorey et al. (2020)	Communication skills training using virtual reality: A descriptive qualitative study	2020	Nurse Education Today	122
9	Labrague et al. (2023)	Student nurses' attitudes, perceived utilization, and intention to adopt artificial intelligence (AI) technology in nursing practice: A cross-sectional study	2023	Nurse Education in Practice	122
10	Kwak, Seo, et al. (2022)	Nursing students' intent to use AI-based healthcare technology: Path analysis using the unified theory of acceptance and use of technology	2022	Nurse Education Today	104

RQ3: What Are the Dominant and Emerging Research Themes in Artificial Intelligence in Nursing Education Based on Keyword Co-Occurrence Analysis?

Figure 2 presents the keyword co-occurrence network, exposing a strongly centralized and thematically organized research domain surrounding artificial intelligence within nursing education. The most prominent nodes, artificial intelligence (259 occurrences; 695 link strength), nursing education (188; 503), and nursing students (118; 286) form the core of the network, indicating that the field is primarily anchored around the integration of AI technologies within educational contexts targeting student populations. The strong link strengths among these keywords suggest frequent co-occurrence, reflecting a well-established conceptual alignment between AI applications and nursing pedagogy. Additionally, the presence of emerging technological terms such as ChatGPT (47; 152), generative artificial intelligence (31; 96), machine learning, and large language models reflects a contemporary transition toward sophisticated AI-based systems. This trend can be explained by the swift progression of generative AI technologies alongside their increasing adoption in education, particularly for enhancing teaching, learning, and assessment processes.

Furthermore, Figure 2 highlights several interconnected thematic clusters that extend beyond technological applications to include educational outcomes and professional competencies. Keywords such as clinical reasoning, clinical judgment, critical thinking, and clinical competence suggest a strong emphasis on the role of AI in improving higher-order cognitive skills essential for nursing practice. Simultaneously, the co-occurrence of terms like attitude, self-efficacy, anxiety, and ethics reflects growing scholarly attention to the psychological, behavioral, and ethical implications of AI integration. The inclusion of pedagogical approaches such as simulation, virtual reality, simulation-based learning, and competency-based education further indicates that immersive and technology-enhanced learning environments are central to current research trends. This multidimensional network structure demonstrates that the field is evolving from a purely technology-driven focus toward a more holistic and interdisciplinary approach, integrating technical innovation with educational theory, learner outcomes, and professional development.

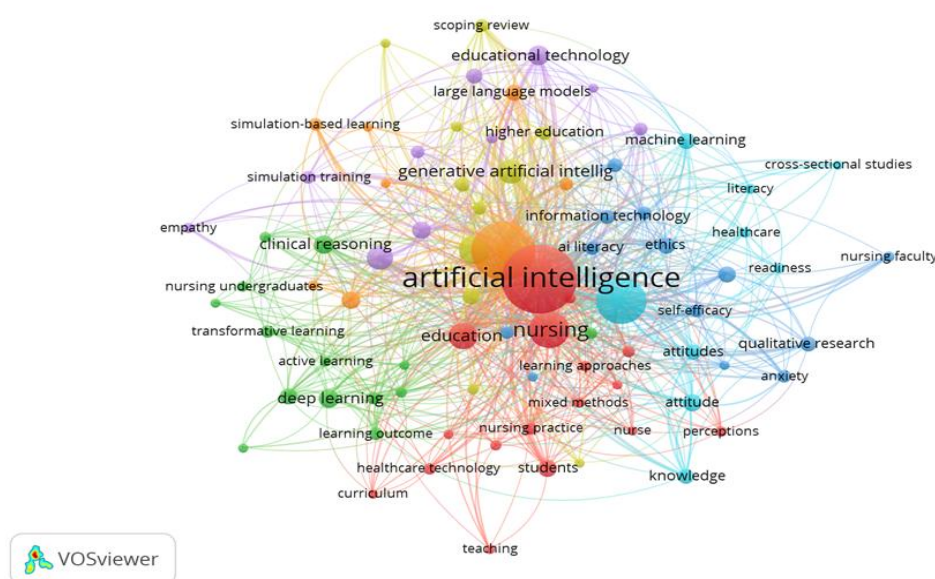


Figure 2: Network Visualization Map of Keywords' Co-Occurrence

RQ4: What Are the Patterns of International Research Collaboration in Artificial Intelligence in Nursing Education, As Revealed Through Country-Level Co-Authorship Networks?

Figure 3 illustrates the country-level co-authorship network, highlighting significant disparities in research productivity, citation impact, and international collaboration within the domain of AI applied to nursing education. The United States stands out as the leading contributor, recording the greatest volume of publications (170), citation count (2053), and overall link strength (47), indicating both strong research output and extensive international collaboration. This leadership position can be attributed to advanced technological infrastructure, substantial research funding, and the early integration of artificial intelligence into healthcare and educational systems. Similarly, nations like Australia, the United Kingdom, as well as Singapore register high citation counts relative to their publication volume, suggesting the production of high-impact research. In contrast, Turkey and China exhibit relatively high publication outputs but comparatively lower citation counts, which may reflect differences in research visibility, journal indexing, or international dissemination.

Furthermore, Figure 3 reveals the growing contribution of emerging and developing countries, particularly in the Middle East and Asia. Notably, Egypt and Saudi Arabia show exceptionally high total link strength (both 40), indicating strong collaborative networks despite moderate publication output. This indicates that these nations are actively participating in cross-border research partnerships, which enhances knowledge exchange and research visibility. In addition, countries like the United Arab Emirates as well as Jordan also demonstrate notable collaboration strength, reinforcing the importance of regional and global partnerships in advancing this field. Conversely, some countries (e.g., Israel, South Africa, and Iran) show low or zero link strength despite having publications, indicating limited international collaboration. Overall, the network structure in Figure 3 reflects an increasingly globalized research landscape, where collaboration rather than sheer publication volume alone functions as a decisive driver in determining research influence and in propelling innovation within artificial intelligence applications in nursing education.

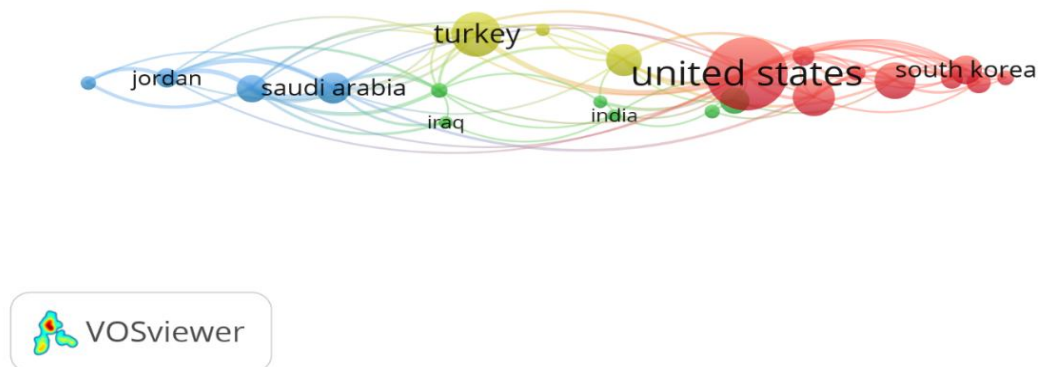


Figure 3: Country-Level Co-Authorship Networks

Conclusion

This study set out to investigate worldwide research trajectories concerning artificial intelligence within nursing education by employing a comprehensive bibliometric methodology. It concentrated on influential studies, publication growth, thematic development, as well as international collaboration patterns. The analysis addressed key questions related to how research output has evolved over time, which publications have the greatest scholarly impact, what themes dominate and emerge in the field, and how countries collaborate in advancing this area. Collectively, the results offer a consolidated perspective on the organization, intellectual structure, and developmental progression of research in artificial intelligence within nursing education.

The results indicate a clear transition from limited and sporadic publications in earlier decades to a rapid and sustained increase in research output after 2020. Highly cited publications are largely recent, reflecting the fast-paced development of artificial intelligence technologies and their growing relevance in education. Thematic analysis reveals that the field is centered on nursing education, artificial intelligence, and nursing students, whereas newer areas, including generative artificial intelligence, simulation-based learning, and ethical considerations, are gaining increasing attention. Collaboration analysis shows that research activity is led by developed countries, particularly the United States, while emerging regions demonstrate strong collaborative networks, indicating a more globalized research landscape.

This study advances the field by delivering a systematically organized, evidence-grounded synthesis of research development, highlighting key areas of growth and identifying important knowledge domains. The outcomes yield valuable perspectives for researchers, educators, as well as policymakers in understanding current directions and aligning future research priorities. In practice, the results emphasize the necessity of embedding AI into nursing education curricula, strengthening digital competencies, as well as addressing ethical and pedagogical challenges associated with technology adoption.

However, several limitations should be recognized. The review was confined to one database and restricted to publications written in English, which may have resulted in the omission of pertinent studies indexed elsewhere or reported in other languages. Moreover, bibliometric techniques primarily emphasize numerical and structural patterns, which means they may not adequately reflect the nuanced depth, contextual richness, or methodological quality of individual works. Subsequent investigations could benefit from drawing on a broader range of databases, integrating qualitative methodologies, and employing longitudinal designs to achieve a more holistic perspective. In sum, this work underscores the increasing prominence of artificial intelligence within nursing education and illustrates the usefulness of bibliometric analysis in charting research trajectories and informing the direction of future scholarly inquiry in this domain.

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