Journal of Nursing Regulation 16 (2025) 150–164

Contents lists available at ScienceDirect

Journal of Nursing Regulation

journal homepage: www.journalofnursingregulation.com

Review

Advancing nursing regulation in the digital era: Harnessing AI to bridge workforce gaps and strengthen practice competency and safety

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ARTICLE INFO

Keywords:
Staffing shortages
Artificial intelligence
Regulation
Education
Decision-making
Patient safety

ABSTRACT

Projections point to persistent and potentially worsening nursing workforce shortages in the United States, with the resulting inadequate staffing posing a risk to patient care. Artificial intelligence (AI) offers a disruptive opportunity, not only to relieve staffing pressures but also to fundamentally reshape nursing roles and the healthcare infrastructure. This review aims to advance insight into AI's transformative potential in nursing by examining current and prospective applications of AI across five key domains: workforce planning, education, practice, regulatory frameworks, and the AI-human ecosystem. It highlights key innovations alongside emerging opportunities and risks tied to AI adoption, and it explores ethical concerns, gaps in regulatory guardrails, and implementation challenges that could hinder the responsible and effective integration of AI into nursing practice. Rather than offering definitive answers, the present review aims to encourage ongoing inquiry into the multi-faceted role of AI in nursing, fostering solutions that are not only technologically advanced but also ethically sound and human-centered.

Introduction

The nursing profession is facing increasing healthcare demands fueled by demographic changes, the growing burden of age-related diseases, and recurring global health crises (World Health Organization [WHO], 2020; 2021a; World Health Organization & International Council of Nurses, 2025). The U.S. Bureau of Labor Statistics (2025) projects an average of approximately 194,500 registered nurse (RN) job openings per year from 2023 to 2033, driven primarily by nurse retirements, demographic shifts in the U.S. population, and healthcare expansion. Today, nurses consistently rank as the most trusted profession in Gallup polls (Saad, 2025); nonetheless, they continue to face chronic challenges, including high stress, heavy workloads, and emotional strain -pressures that were brought back into sharp focus during the COVID-19 pandemic (Aiken et al., 2002, 2023; Berlin et al., 2023; Martin, Kaminski-Ozturk, O'Hara, & Smiley, 2023; Paterson et al., 2024; Sinsky, Brown, Stillman, & Linzer, 2021). Similar to the response during the 1918 influenza epidemic, nurses once again rose to meet those challenges (Maughan & Luehr, 2022; Robinson, 1990). However, these conditions are not sustainable, and if left unaddressed, they could chronically undermine the safety of nursing practice and, over time, compromise the stability of healthcare systems (Harrington, 2025; Livanos, 2023; National Council of State Boards of Nursing, 2025a; Smiley et al., 2025; Spetz, 2021).

Plato's oft-cited adage "Necessity is the mother of invention" (Plato, c. 375 BC) was particularly prescient in relation to the COVID-19 pandemic. The integration of digital technologies was accelerated by the pandemic and has been reshaping healthcare delivery, with telehealth experiencing up to a 766 %-3800 % surge in usage in early 2020 compared to pre-pandemic levels (Center for Telehealth and e-Health Law, 2025; Lee et al., 2023). In 2021, 64 % of families surveyed reported using telehealth in the previous 12 months (Adams, 2021). An estimated 43–65% of adults and some hospitals report a preference to continue using telehealth after the pandemic (Adams, 2021; Daly, 2020; Drees, 2020; Robeznieks, 2020). Telehealth is now a common and effective mode of healthcare delivery for providers and patients alike (Center for

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https://doi.org/10.1016/j.jnr.2025.08.015
Received 12 August 2025; Accepted 28 August 2025

Telehealth and e-Health Law, 2025). The rapid shift to virtual care both heightened the need for AI applications (Amjad, Kordel, & Fernandes, 2023; Bhaskar et al., 2020; Center for Telehealth and e-Health Law, 2025) and exposed gaps in nurses' readiness to use AI-enhanced telehealth tools (Choi, Woo, & Ferrell, 2025; Fritz, Wuestney, Dermody, & Cook, 2022; Fritz & Dermody, 2019; Rony, Parvin, & Ferdousi, 2024). AI, which encompasses technologies such as natural language processing (NLP), machine learning, robotics, and predictive and prescriptive analytics, is becoming increasingly integral to healthcare, not just telehealth, by enhancing clinical workflows, monitoring patients, and providing nursing education (Choi et al., 2025; De Micco et al., 2024; Jiang et al., 2017; Pan et al., 2025). AI-powered tools show promise to streamline telehealth (Bates et al., 2021; Choi et al., 2025; De Micco et al., 2024; Yakusheva, Bouvier, & Hagopian, 2025), improving patient outcomes by predicting deterioration risks and optimizing resource allocation, particularly in high-demand settings (Park, Chang, & Kim, 2025). For example, AI tools already facilitate accurate detection of conditions such as glaucoma and chronic wounds, enabling timely interventions by nurses (Bhuiyan, Govindaiah, & Smith, 2021; Ohura et al., 2019). AI sensors with machine learning algorithms can detect pathological changes, recognize human behavior patterns, and assist in decision-making (Fritz & Dermody, 2019; Fritz et al., 2022).

Although these advancements offer opportunities to alleviate workforce pressures, improve access to care, and enhance patient safety, they also introduce complex challenges, raising concerns about ethics and privacy (Glauberman, Ito-Fujita, Katz, & Callahan, 2023; Lee & Yoon, 2021; Watson, Womack, & Papadakos, 2020), algorithmic bias and inequity (Glauberman et al., 2023), as well as anxiety, psychological impacts, and trust barriers (Simsek-Cetinkaya & Cakir, 2023; Zhou et al., 2025). In a controlled comparative test, AI decreased efficiency by producing unreliable or potentially misleading outputs, as demonstrated when developers had to spend additional time correcting AI-generated code (Becker, Rush, Barnes, & Rein, 2025). Regulatory frameworks have struggled to keep pace with the rapid evolution of AI (Livanos, 2025; White & Case, 2025). The principles for ethical AI—autonomy, privacy, transparency, responsibility, safety, and equity—have been outlined in various international and national guidelines (European Commission, 2019; Jobin, Ienca, & Vayena, 2019; Lekadir et al., 2025; NCSBN, 2024a; National Institute of Standards and Technology, 2023; Organisation for Economic and Co-operation Development, 2019; United Nations Educational Scientific and Cultural Organization, 2023; WHO, 2021b), but nursing-specific guidelines remain scarce in the United States. This regulatory gap poses risks to patient safety and professional accountability, necessitating new policies, accreditation standards, and certification programs (Livanos, 2025). The Steering Committee for the National Academy of Medicine released a discussion draft entitled "Artificial Intelligence in Health, Health Care, and Biomedical Science: An AI Code of Conduct Principles and Commitments Discussion Draft" (Adams et al., 2024). In response to the draft, the American Academy of Nursing (AAN, 2024) submitted a letter to the Steering Committee signaling support for the initiative. In the letter, they stated that "to ensure the inclusive adoption of these code principles and commitments the voices of nurses and health care professionals who are experts in AI will be vital in managing the short-term and long-term benefits and risks of AI to the nation's health as legislation, and federal regulations continue to emerge," thus underscoring the need for nursing expertise to be actively engaged in balancing AI's opportunities and risks.

Moreover, like all major technological revolutions, AI embodies both scientific and social dimensions; it serves not only as a powerful engine driving productivity and innovation, but also as a catalyst for social progress, re-prioritizing the needs and aspirations of individuals and communities. Public perception of AI in healthcare remains mixed, requiring proactive engagement to build trust (Ahmed, 2024; Benda et al., 2024; Gehring, Titus, & George, 2025; Rony, Parvin, et al., 2024). This review explores the opportunities and challenges presented by AI, emphasizing its potential to alleviate workforce shortages, boost educational effectiveness, and advance clinical practice. We also discuss the regulatory frameworks essential for the ethical integration of AI into nursing practice and the dynamics of AI-human interactions. This article focuses on a curated selection of core areas representing only the surface of a rapidly expanding field and is not intended to exhaustively cover the full spectrum of AI's transformative potential in nursing.

Methodology

A systematic literature search was conducted using PubMed, Scopus, and CINAHL to identify relevant publications. Search strings included "(artificial intelligence OR machine learning) AND nursing AND (workforce OR education OR regulation)," filtered by peer-reviewed articles and English language. These terms were combined using Boolean operators (e.g., "artificial intelligence AND nursing") to capture a broad range of studies addressing AI applications in nursing practice, education, workforce planning, and regulation (Whittemore & Knafl, 2005). The search was limited to English-language peer-reviewed articles, including original research, reviews, and reports. Additionally, we consulted selected grey literature for its authority and relevance to AI and nursing regulation, though evidence from peer-reviewed journals, authoritative policy reports, and other reputable institutional sources were prioritized. Duplicate articles, non–peer-reviewed sources lacking credibility, and studies unrelated to nursing or AI were excluded.

We categorized the findings into five core AI impact areas: (1) workforce forecasting, (2) education and development of AI-related skills, (3) practical applications in nursing, (4) regulatory challenges, and (5) human factors influencing implementation. Each of these five areas reflect the enduring research focus of the Department of Research at the National Council of State Boards of Nursing (NCSBN; n.d.-b).

Main findings

AI in nursing workforce planning

Traditional workforce projection vs. AI-powered smart forecasting

To make the best investment decisions in the nursing workforce, and to ensure nurses are well-prepared for today's jobs and can upskill for the challenges of tomorrow, reliable and comprehensive labor market information is essential (National Association of State Workforce Agencies, 2023). Current nursing workforce studies rely on periodic surveys (Health Resources and Services Administration; NCSBN, n.d.-c). They provide snapshot headcounts, which are important, but they often fall short in capturing critical information such as specialty shortages, regional disparities, and rapid shifts in demand (Howison et al., 2025). Earlier projections regarding nursing workforce growth and demand (Biviano, Tise, & Dall, 2007) failed to materialize, prompting a critical reassessment of the rigid and often alarmist nature of such forecasts (Buntin, Chen, & Auerbach, 2024). AI-powered smart labor market forecasting leverages big data, NLP, and machine learning to provide real-time, high-resolution analysis (Chen et al., 2025; Griner, Thompson, High, & Buckles, 2020; Howison et al., 2025). For instance, NLP can examine regional job postings to extract critical skill requirements, while machine learning identifies patterns in large datasets to predict workforce demand in real-time (Chen et al., 2025; Howison et al., 2025). This approach, also referred to as "causal forecasting", using AI to integrate econometric models and policy data (Chen et al., 2025), enhances workforce predictions. A comparison of traditional workforce statistical analysis with AI-powered workforce forecasting is summarized in Table 1.

Introduction to AI-powered workforce forecasting

Drawn from published literature (Chen et al., 2025; Howison et al., 2025), Fig. 1 depicts the conceptual framework of an AI-powered nursing labor market forecasting model designed to enhance

evidence-based decision-making. This multi-layered system leverages advanced AI techniques such as NLP and machine learning to process diverse datasets and generate actionable insights. It autonomously integrates multiple data streams, drawing on authoritative sources such as regional and national job postings; the national nursing workforce studies (HRSA, n.d.; NCSBN, n.d.-c); the online query system of Healthcare Cost and Utilization Project (U.S. Department of Health and Human Services [HHS], n.d.-b); the National Sample Survey of Registered Nurses (HRSA, n.d.); enrollment and graduation data from the American Association of Colleges of Nursing and state boards of nursing (NCSBN, n.d.-d); the American Hospital Association annual survey database; Occupational Employment and Wage Statistics (U.S. Bureau of Labor Statistics, n.d.); and other relevant regulatory information from federal and state regulatory bodies (Table 2).

Although AI offers significant potential for advancing labor market forecasting in nursing, its responsible adoption requires scrutiny to identify and address associated challenges and potential pitfalls. First, robust data validation frameworks to ensure representative and unbiased datasets are needed to mitigate data quality risks (Chen et al., 2025; Howison et al., 2025) Second, to address bias and ethical concerns, transparent AI algorithms need be subjected to regular bias audits (Jobin et al., 2019); Third, adequate resources must be allocated to build the infrastructure for AI-powered forecasting systems and to support effective oversight. If implemented effectively, AI models have the potential to accurately forecast future staffing needs, flag emerging skill gaps, and anticipate turnover trends, enabling nursing programs to adapt curricula, expand enrollment in high-demand specialties, and align training with projected workforce realities. By anticipating demand growth in areas such as critical care, telehealth, and community nursing, schools can tailor offerings and students can specialize in roles aligned with future needs (National Academies of Sciences Engineering and Medicine, 2021).

Table 1
Comparison of conventional headcount approach versus AI-powered workforce forecasting in nursing.

Aspect	Conventional headcount methods	AI-based job forecasting
Data source	The NCSBN biennial nursing workforce study (NCSBN, n.d.-c) utilizes data on RNs and licensed practical nurses/licensed vocational nurses from the NCSBN nursys database, along with responses from structured survey questionnaires. The HRSA quadrennial RN workforce study (HRSA, n.d.), is administered either online or via mail. Approximately 1 % of the total RN population was surveyed and completed the most recent HRSA questionnaire.	Licensure-based real-time employer data from NCSBN nursys database, real-time data from regional and national job postings, predicted patient care needs, and labor market trends.
Granularity	Aggregate numbers, limited regional or specialty details. Changes may be diluted owing to the long report timeline, and some regional changes may be missed.	High-resolution with region- and specialty-specific insights. Combined with discipline data to determine the effect of educational and regulatory changes on practice safety.
Timeliness	Lags due to infrequent updates.	Real-time updates for rapid response.
Accuracy	Surveys often suffer from lower return rates and unrepresentative sampling and are prone to errors.	Improved accuracy through complex pattern recognition.
Adaptability	Static and inflexible to rapid changes.	Dynamic and adapts to changing conditions.
Challenges	Inflexibility, urban bias, outdated regulatory frameworks.	Data quality issues, ethical concerns (bias, privacy), algorithm transparency.

Note. AI = artificial intelligence; HRSA = Health Resources and Services Administration; NCSBN = National Council of State Boards of Nursing; RN = registered nurse.

Interstate compacts: a critical backbone for modern nursing regulation

AI-based workforce forecasting may be able to predict nursing demand, but the possibility of easing shortages is critically dependent on the extent to which caregivers can move in a timely manner from areas with surplus to areas in need. Licensure reforms promote workforce flexibility and growth, helping expand or redistribute the nursing workforce. The Nurse Licensure Compact (NLC) increases access to care by allowing an RN or licensed practical nurse/licensed vocational nurse to hold one NLC license and practice across all participating states (Kappel, 2018; NCSBN, 2025). Despite recent progress, interstate mobility in the United States remains significantly limited by legislative barriers, especially for advanced practice registered nurses (APRNs; Edmonson et al., 2024; Livanos, 2020; NCSBN, n.d.-a; Zhong, 2025). Adoption of the APRN Compact would permit APRNs, which include certified nurse practitioners, clinical nurse specialists, certified registered nurse anesthetists, and certified nurse midwives, to provide care across state borders without needing multiple licenses, thereby strengthening the capacity of the healthcare systems to respond to evolving workforce demands (Delgado, 2024; Edmonson et al., 2024; Livanos, 2020; NCSBN, n.d.-a; Zhong, 2025; Zhong et al., 2024).

Besides the NLC, several interstate licensure compacts have been established to facilitate interstate practice for healthcare professionals. These include the Interstate Medical Licensure Compact (Interstate Medical Licensure Compact), the Physical Therapy Licensure Compact (Federation of State Boards of Physical Therapy), the Psychology Interjurisdictional Compact (Psypact Commission, n.d.), the Audiology and Speech-Language Pathology Interstate Compact (ASLP-IC Commission), the Emergency Medical Services Personnel Licensure Interstate Compact (National Registry of Emergency Medical Technicians), the Occupational Therapy Licensure Compact (2025), and the Physician Assistant Licensure Compact (PA Compact). Today, nearly every state has adopted one or more of these interstate healthcare licensure compacts. These compacts represent a critical policy innovation to address regional staffing shortages and historically rooted regulatory barriers that limit healthcare access (Bogulski, Allison, Hayes, & Eswaran, 2025). In public health emergencies, quickly deploying nurses across state lines is life-saving (Adashi, Cohen, & McCormick, 2021; Alexander, 2024; Balboa, 2024; Bogulski et al., 2025; Chaudhry, 2022; Iserson, 2020; Medvec, Titler, & Friese, 2024). AI-powered forecasting can only reach its full potential when nurses are able to move freely to where services are most needed across the country (U.S. Department of Health and Human Services, n.d.-a).

AI in nursing education

Integration of AI into nursing curricula

Recruiting alone won't resolve the workforce crisis (Hatfield, 2024). A joint effort from all stakeholders, including nurses as core partners, is essential to capitalize on the current momentum and harness the vast potential of AI in advancing nursing practice and workforce sustainability. Integrating AI training in nursing education has just begun in the United States (NCSBN, 2024a). AI is classified into three categories: narrow, general, and superintelligent. Currently, only narrow AI, designed for specific tasks, is used in nursing, while general and superintelligent AI remain theoretical and are not yet applicable (Russell & Norvig, 2021). Generative AI focuses on creating content or synthetic data, predictive AI involves forecasting disease risk and outcomes, and prescriptive AI recommends actions for personalized care (Brennan, 2025; Park, Kim, & Go, 2024; Shen, Shen, Liu, & Jin, 2025; Simms, 2025). Technologies used for omics analysis (identifying biomarkers, predicting disease risk, and guiding personalized medicine; Adam et al., 2025; Edvardsson & Heenkenda, 2025; Fischer et al., 2022) and clinical decision-making (generating personalized evidence-based treatment

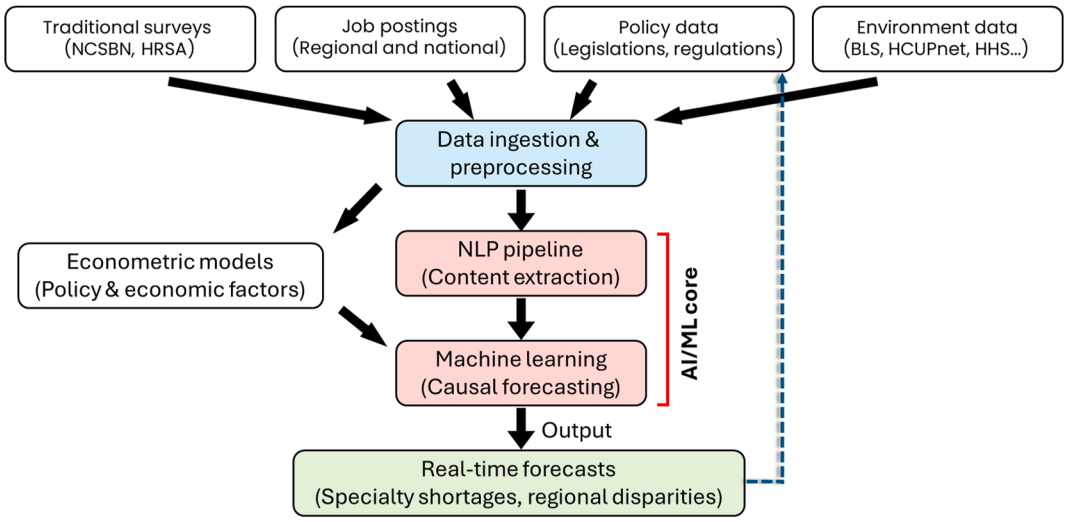

Fig. 1. Schematic of an AI-driven architecture for healthcare market forecasting.
The diagram illustrates three core modules, each marked in a different color: (1) Data ingestion and preprocessing collects and prepares data (see Table 2 for details). (2) NLP powered by Large Language Models analyzes the inputs to support predictive modeling, referencing actual econometric information. (3) Output interpretation presents results through decision-support interfaces for regulatory decisions. Econometric models use historical policy and economic data, along with outcome records, to train ML. AI = artificial intelligence; BLS = Bureau of Labor Statistics; HCUPnet = Healthcare Cost and Utilization Project; HHS = U.S. Department of Health and Human Services; HRSA = Health Resources and Services Administration; ML = machine learning; NCSBN = National Council of State Boards of Nursing; NLP = natural language processing. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

plans and AI-augmented health management; Adam et al., 2025; Edvardsson & Heenkenda, 2025; Fischer et al., 2022; Maleki Varnosfaderani & Forouzanfar, 2024) typically involves predictive or prescriptive AI.

A 2025 survey of more than 300 nursing schools found that only 17 % of nursing programs currently offer coursework in generative AI, and just 5 % teach big data concepts (Wolters Kluwer & National League for Nursing [NLN], 2025). This modest integration likely reflects broader gaps in AI competency across the healthcare workforce. For example, in a study of 50 physicians, only approximately 10 % of physicians report familiarity with LLMs (Powell, 2025). Nevertheless, despite obstacles such as limited funding and insufficient faculty support, a large number of nursing schools are ramping up investment in AI, with 60 % of larger institutions (>150 students) and 46 % of smaller ones (<150 students) planning to integrate generative AI, while 37 % aim to incorporate big data analysis into their curricula by 2029 (Wolters Kluwer, 2025; Wolters Kluwer & NLN, 2025), signaling a decisive shift toward an AI-driven era in nursing education (Fig. 2). To fully and safely harness AI's potential, it is essential to establish uniform curricular standards, expand access to AI-focused educational resources, and build faculty capacity through targeted training and interdisciplinary collaboration (American Nurses Association, 2022; NCSBN, 2024b; National Education Association, 2024; U.S. Department of Education, 2025).

Integrating AI into nursing education serves two primary purposes: first, to enhance instructional effectiveness within the classroom, and second, to equip students with foundational AI knowledge necessary for navigating digital healthcare environments (Alowais et al., 2023; Hwang, Tang, & Tu, 2022; O'Connor & ChatGPT, 2023; Saghiri, Vakhnovetsky, & Nadershahi, 2022). These two aspects require different levels of training for faculty, have different implications for patient safety, raise different levels of concern about AI accuracy, and should be prioritized to different degrees. Applications of AI in enhancing nursing education range from personalized learning, lecture summarization, project outline generation, and visualization of clinical realities through simulation technologies (Agarwal et al., 2025; Padilha, Machado, Ribeiro, Ramos, & Costa, 2019; Shorey et al., 2020; Topaz et al., 2025; Yeung, Ho, Cheung, Tsang, & Chong, 2025). These innovations help improve training efficiency and typically do not raise safety concerns. As AI tools are implemented in the clinical environment, it's vital that nursing students, who will be tasked with using them in their nursing career, are educated about their benefits as well as their shortcomings and are properly trained in a forward-looking way so that they can competently and safely use the tools that exist now and those emerging in the coming years (Rajkomar, Dean, & Kohane, 2019; Taylor, Hudson, Thomson, & Greenlees-Rae, 2021).

Table 3 outlines AI skills related to digital healthcare practice. To responsibly incorporate AI skills into nursing curricula, ethics and safety must be fundamental components (NCSBN, 2020; Spector et al., 2020). Ultimately, despite advances in technology, robust clinical judgment remains indispensable for making sound decisions in clinical practice, rather than depending only on AI recommendations (NCSBN, 2020, 2024a; Spector et al., 2020).

Despite growing interest in AI in education programs, there are barriers hindering its adoption, including insufficient funding, inadequate technology infrastructure, and limited faculty engagement (Wolters Kluwer & NLN, 2025). Additional obstacles include a shortage of qualified educators (Glauberman et al., 2023; Rony, Ahmad, et al., 2025), inflexible academic structures, and the absence of standardized metrics for evaluating the effectiveness of AI-based training tools (Brown et al., 2025; Ramírez-Baraldes et al., 2025). Ample studies have identified funding limitations as a primary barrier to AI adoption (Archibald & Clark, 2023; (Chu et al., 2025); De Gagne, 2023a; (Rony et al., 2025); Rony, Das et al., 2025; Scerri & Morin, 2023). In an era of funding cuts (Lasater et al., 2025), AI adoption in nursing could face significant setbacks, as reduced resources for health services research may limit the development of evidence-based AI applications and exacerbate faculty shortages needed to train nurses in AI competencies. In light of these shifting policy landscapes, securing the future of healthcare will require a special collaborative effort to carry out cost-effective AI pilots, leverage existing datasets for AI-driven analyses, demonstrate AI's value in improving care delivery, and advocate for evidence-based policy changes.

Professional development and AI upskilling

The accelerating pace of AI innovation necessitates a commitment to lifelong learning among nursing professionals (Chang, Wang, Lin, &

Table 2
Summary of nursing workforce data domains and corresponding sources.

Category	Data	Source	Rationale
Workforce supply	Number of employed RNs and LPNs/LVNs by region and specialty, employment trends over time, retirement and attrition rates, RN wage trends by percentile and region, industry distribution across hospitals, long-term care, and ambulatory settings.	BLS, NCSBN, OEWS, NSSRN, HRSA	Identifies current workforce levels, turnover risks, and regional labor market dynamics to predict shortage areas.
Healthcare demand	Hospitalization rates by condition and age group, volumes of emergency department and inpatient visits by location, procedure volumes (e.g., surgery, maternal care, intensive care unit), trends in patient complexity and acuity, regional demand for services across urban and rural areas.	HCUPnet, CMS, AHA annual survey database, regional job postings	Rising demand for complex care drives increased need for skilled nurses.
Population health and service need indicators	Health professional shortage area designations, chronic disease prevalence by region, demographic and aging trends, public health emergencies (e.g., COVID-19), and medicaid/Medicare enrollment data.	HHS, HRSA, NSSRN	Informs AI models on population-driven demand, enabling targeted workforce planning for high-need areas and chronic disease management.
Policy and regulatory environment	Nurse licensure compact participation, scope of practice laws (e.g., NP autonomy, LPN/LVN delegation limits), staffing ratio mandates (e.g., California AB394), education pipeline constraints (e.g., clinical placement caps), and telehealth regulations supporting cross-state practice.	Federal and state agencies, NCSBN	Regulatory frameworks affect workforce mobility, distribution, and scalability.
Education pipeline	Enrollment, graduation, faculty shortages, NCLEX pass rates, trends in advanced practice nursing programs (e.g., DNP, NP tracks)	Federal and state agencies, NCSBN, BONs	Constraints in nursing education limit the supply of new nurses.

Note. AHA = American Hospital Association; AI = artificial intelligence; BLS = Bureau of Labor Statistics; BON = board of nursing; CMS = Centers for Medicare and Medicaid Services; DNP = doctor of nursing practice; HCUPnet = Healthcare Cost and Utilization Project; HHS = U.S. Department of Health and Human Services; LPN/LVN = licensed practical nurse/licensed vocational nurse; NCSBN = National Council of State Boards of Nursing; NP = nurse practitioner; NSSRN = National Sample Survey of Registered Nurses; OEWS = Occupational Employment and Wage Statistics; RN = registered nurse.

Liao, 2025; NCSBN, 2024a; Randhawa & Jackson, 2020; Rony, Parvin, et al., 2024). Continuing education initiatives such as professional development programs, workshops, and seminars are essential for keeping nurses abreast of emerging technologies (AACN, 2024). AI-powered learning platforms can enhance these efforts by delivering personalized updates and insights that support evidence-based practice and foster interdisciplinary collaboration (Mlambo, Silén, & McGrath, 2021; Turco, Sockalingam, & Williams, 2024). Certifications in AI technologies (e.g., AI-RN or smart RN) will not only validate specialized competencies but will also open pathways to career advancement and leadership roles (American Nurses Credentialing Center; Stanford Online, n.d.; The Michener Institute of Education, 2025; University of Illinois Urbana-Champaign). Continuing professional development and relicensure requirements further reinforce ongoing competence.

AI in nursing practice

The surge of AI tools in healthcare practice

AI applications that meet the statutory definition of a medical device, including AI algorithms used in clinical decision support, are regulated under the Federal Food, Drug, and Cosmetic Act (U.S. Food and Drug Administration, 2018). In 2019, the FDA approved 80 AI-enabled medical tools; by 2023, the annual total had risen to 221 (Tjoe & Gomez, 2024). By contrast, the FDA approved 48 new drugs in 2019 and 55 in 2023 (Mullard, 2020; U.S. Food and Drug Administration, 2025), highlighting the rapid acceleration of AI adoption in medical technologies relative to traditional pharmaceuticals.

AI-powered clinical applications

Table 4 outlines key AI applications along with their associated challenges. AI tools can assist in triage and prioritization by assessing the urgency of cases, ensuring that healthcare resources are directed to patients with the greatest need. The integration of AI into clinical judgment and decision-making is poised to transform healthcare by improving diagnostic accuracy, tailoring treatment plans, and enhancing patient outcomes. AI systems can recommend therapies optimized for individual patients, drawing on vast datasets and predictive analytics (Rajkomar et al., 2019). In oncology, for instance, AI models can anticipate a patient's response to immunotherapy based on tumor genomics and historical treatment data, thereby reducing ineffective interventions (Rakaee et al., 2025). As AI technologies continue to evolve to support reliable, predictive, data-driven, and patient-centered care, they will become increasingly indispensable for nursing professionals.

Regulations and policy for AI application in nursing

Regulatory barriers and possible solutions

The rapid advancement of AI has outpaced regulatory frameworks, creating a patchwork of state laws that foster inconsistency and legal uncertainty, particularly in healthcare applications like nursing title protection (Livanos, 2025; Norden, Narang, & Protzmann, 2024). The integration of AI in nursing practice and education faces regulatory barriers, necessitating new policies, accreditation standards, and certification programs to ensure safe and ethical implementation (Livanos, 2025; Yasin, Al-Hamad, Metersky, & Kehyayan, 2025). A cohesive national policy is essential to balance innovation with consumer protection and ensure ethical AI deployment. Table 5 outlines key regulatory barriers and proposed solutions, including new regulatory policies, accreditation, and certification needs. In addition, while interstate licensure compacts have made significant progress in facilitating nurse mobility and cross-state practice, they currently do not specifically address the unique regulatory challenges associated with AI

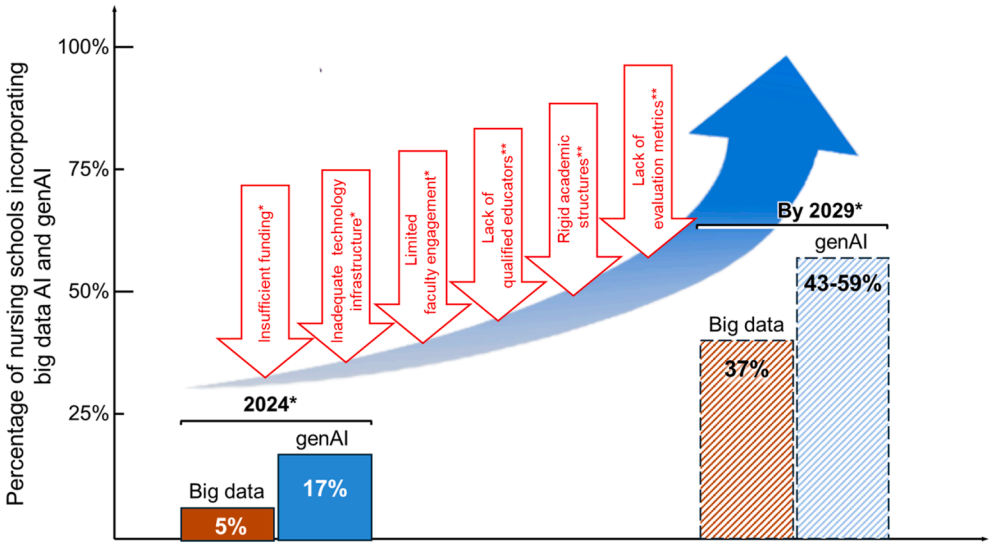

Fig. 2. Projected trend of AI adoption in U.S. nursing schools.
AI = artificial intelligence; genAI = generative AI. *Source: Wolters Kluwer (2025); Wolters Kluwer & National League for Nursing (2025). **Source: De Gagne (2023b); El Arab, Al Moosa, Abuadas, and Somerville (2025); Foronda and Porter (2024); Han, Kang, Gimber, and Lim (2025); Lifshits and Rosenberg (2024); Ma et al. (2025); Ostick, Mariani, and Lovecchio (2025); Shen et al. (2025).

Table 3
Essential AI competencies for healthcare professionals.

AI Skill	Description	Application in Nursing	Educational Approach
Big data analysis (Brennan & Bakken, 2015; Delaney, Pruinelli, Alexander, & Westra, 2016; Kovalainen et al., 2025)	Understanding and interpreting large datasets to identify trends and inform clinical decisions.	Analyzing patient outcomes, staffing needs, and population health trends to optimize care delivery.	Courses on data analytics, statistical methods, and tools like python or R for data processing.
Omics data analysis (Flaherty, Rattan, Melson, & O'Neal, 2025; Tully, Calzone, & Cashion, 2020; Yang et al., 2025)	Analyzing genomic, proteomic, or metabolomic data to support precision medicine.	Personalizing treatment plans based on genetic profiles, e.g., in oncology or chronic diseases.	Training in bioinformatics, genetic data interpretation, and AI-driven omics tools.
Telehealth proficiency (Choi et al., 2025; O'Hara & Reid, 2024; Simbo AI, 2025; Vaismoradi, Rae, Turunen, & Logan, 2024)	Using AI-driven telehealth platforms for remote consultations, monitoring, and patient education.	Conducting virtual patient assessments and managing remote care delivery effectively.	Simulations of telehealth scenarios, training on platforms like zoom or Doxy.me, and AI tool integration.
Machine learning basics (Higgins, Short, Chalup, & Wilson, 2023; Ladios-Martin et al., 2022; Liao, Huang, Ho, & Chu, 2023; Othman, Nashwan, & Abujaber, 2025)	Understanding machine learning concepts to interact with AI tools like predictive models.	Using predictive analytics for patient risk assessment or resource allocation.	Introductory courses on machine learning, focusing on healthcare applications.
NLP (Hossain et al., 2023; Rony, Das et al., 2025)	Leveraging NLP to analyze clinical notes, patient communications, or job postings.	Improving documentation accuracy and extracting insights from unstructured data for better care.	Training in NLP tools and their application in clinical documentation and communication.
Clinical decision support systems (Romero-Brufau et al., 2020)	Using AI systems to provide evidence-based recommendations during patient care.	Enhancing decision-making in complex cases, such as during telehealth or in-person care.	Practical exercises with AI-driven decision support tools and case studies.
Robotics and automation (Rony, Parvin, & Ferdousi, 2024; Stokes & Palmer, 2020; Vasquez et al., 2023; Watson et al., 2020)	Operating and collaborating with robotic systems for tasks like medication delivery.	Assisting with repetitive tasks to focus on patient interaction and improve efficiency.	Hands-on training with healthcare robots and automation systems.
VR/AR (Cieslowski, Craig, Gummadi, & Butler, 2024; Rodríguez-Abad, Martínez-Santos, Fernández-de-la-Iglesia, & Rodríguez-Gonzalez, 2023)	Using VR/AR for immersive training and patient care simulations.	Practicing clinical skills in simulated environments, including telehealth scenarios, to enhance competency.	VR/AR simulation labs and scenario-based training modules.
Predictive analytics (Buchanan et al., 2021; Park et al., 2025; Rony, Das et al., 2025)	Applying AI to predict patient outcomes, readmission risks, or staffing needs.	Enabling proactive interventions and optimizing resource allocation for safer care delivery.	Training in predictive modeling and interpretation of AI-generated risk scores.
Data privacy and ethics (Murdoch, 2021; Rony, Numan, et al., 2024)	Understanding ethical implications and regulations for handling sensitive patient data.	Ensuring compliance with privacy laws and ethical AI use to maintain patient trust and safety.	Courses on healthcare ethics, health insurance portability and accountability Act, general data protection regulation, and AI bias mitigation strategies.

Note. AI = artificial intelligence; NLP = natural language processing; VR/AR = virtual reality/augmented reality.

technologies in clinical care and nursing practice. This omission is particularly notable given the accelerating integration of AI in healthcare delivery, decision support systems, and virtual care environments. The lack of clear regulatory guidance regarding AI use poses potential risks to both nursing professionals and patients (Table 6). Establishing uniform regulatory standards for AI across states would not only strengthen the consistency of care, but also enhance the credibility and accountability of AI-powered tools used in nursing (Madan, 2025; Ratwani & Booker, 2025). Integration of such standards into state and/or federal law would proactively mitigate legal ambiguities, promote safer care environments, and reduce the likelihood of conflicting interpretations of scope and responsibility (Ratwani & Booker, 2025). To effectively close this regulatory gap, it is essential for all stakeholders, including licensing boards, policymakers, healthcare organizations,

Table 4
Applications of AI in nursing practice.

AI Application	Description	Benefits	Challenges
Diagnostic support (Buchanan et al., 2021; Rony, Das et al., 2025)	AI algorithms analyze data from telehealth consultations, such as medical images or vital signs, to assist in diagnosing conditions accurately and quickly.	Improves diagnostic accuracy, reduces errors, and supports nurses in complex cases.	Requires high-quality data and validation to avoid misdiagnosis; ethical concerns around accountability.
Remote monitoring (Choi et al., 2025; Simbo, n.d.)	AI-driven systems continuously monitor patients' health metrics, alerting healthcare providers to potential issues before they become critical.	Enhances patient safety, enables proactive care, and reduces hospital readmissions.	Privacy concerns with continuous data collection; need for reliable technology infrastructure.
Personalized care (Vasquez et al., 2023)	By processing vast amounts of patient data, AI helps create individualized care plans, optimizing treatment efficacy.	Improves patient outcomes, enhances patient satisfaction, and supports tailored interventions.	Data integration challenges; potential for bias in AI-generated care plans.
Triage and prioritization (Park et al., 2025)	AI tools prioritize patient cases based on urgency, ensuring resources are allocated efficiently.	Optimizes resource use, reduces wait times, and improves care delivery in high-demand settings.	Risk of overreliance on AI; need for human oversight to ensure equitable prioritization.
Administrative automation (Lavoie-Gagne et al., 2025; Othman et al., 2025)	AI automates tasks such as documentation, scheduling, and billing, thus reducing administrative burdens.	Frees nurses for direct patient care, increases efficiency, and reduces burnout.	Initial implementation costs; need for training to use AI tools effectively.
Clinical decision support (Abuzaid, Elshami, & Mc Fadden, 2022; De Micco et al., 2024; Hossain et al., 2023)	AI systems provide real-time, evidence-based recommendations to support clinical decision-making.	Enhances decision accuracy, supports less experienced nurses, and improves patient outcomes.	Risk of "black box" algorithms; requires transparency and nurse training for effective use and professional review.
Patient education (Kovalainen et al., 2025)	AI-powered chatbots and virtual assistants provide health information and answer patient queries.	Improves patient engagement, enhances health literacy, and supports self-management.	Ensuring accessibility and cultural sensitivity; addressing patient trust in AI-driven education.
Predictive analytics (Yakusheva et al., 2025)	AI analyzes historical data to predict patient deterioration, readmission risks, and staffing needs.	Enables proactive interventions, optimizes resource allocation, and improves care planning.	Data quality and bias issues; requires robust validation and ethical considerations.

Note. AI = artificial intelligence; NLP = natural language processing; VR/AR = virtual reality/augmented reality.

educators, and technology developers, to recognize the limitations of the current framework and work collaboratively to create and implement forward-looking policies. Addressing these issues early will ensure that

Table 5
Main regulatory gaps and framework recommendations for AI governance in nursing.

Regulatory barrier	Description	Proposed regulatory policies, accreditation & certification	Expected impact
Lack of nursing-specific AI regulations (Livanos, 2025; van der Gaag et al., 2023)	Current regulations are general and do not address nursing-specific AI challenges, risking patient safety and ethical practice.	Develop nursing-specific AI regulations, including guidelines for AI use in clinical decision-making, telehealth, and patient monitoring, aligned with ethical AI principles (e.g., autonomy, privacy, transparency, responsibility, safety, and equity) and incorporate these provisions into the model act/rule revisions.	Enhances patient safety and trust by ensuring AI tools meet nursing-specific standards.
Data privacy and security concerns (Hong, Shin, Kim, & De Gagne, 2025; Rony, Das et al., 2025)	AI systems collect vast patient data, raising risks of breaches and unauthorized access, with insufficient governance policies	Implement robust data encryption, access controls, and compliance with HIPAA and GDPR. Establish national data governance frameworks for AI in healthcare, including regular audits.	Protects patient data, builds trust, and ensures compliance with privacy laws.
Algorithmic bias and equity issues (Seibert et al., 2021)	AI systems may perpetuate biases, leading to unequal treatment outcomes, with no standardized frameworks to address bias in nursing contexts.	Create accreditation standards, regulatory rules, or guidelines for AI tools to ensure bias mitigation, including mandatory testing for fairness and diversity in datasets. Develop certification programs for nurses on bias detection.	Promotes equitable care and reduces disparities in AI-driven nursing practice.
Limited AI literacy in nursing education (Ahmed, 2024)	Nursing curricula lack standardized AI literacy training, hindering educators' and students' ability to use AI tools effectively	Update accreditation standards, regulatory rules or guidelines (e.g., CCNE, ACEN) to include AI literacy, covering big data, omics, telehealth, and ethics. Develop AI-focused CPD certifications for educators and students.	Prepares nurses for AI-driven practice, enhancing competency and readiness.
Unclear liability frameworks (Maliha, Gerke, Cohen, & Parikh, 2021)	Ambiguity in liability for AI-driven errors in nursing practice, especially in telehealth, complicates accountability	Establish clear liability frameworks defining nurse and AI system responsibilities. Update state nursing boards' licensure policies to include AI use accountability.	Clarifies accountability, reducing legal risks and ensuring patient safety.
Inconsistent telehealth regulations	Variations in telehealth regulations	Expand NLC to standardize AI-driven telehealth	Facilitates seamless telehealth delivery

(*continued on next page*)

Table 5 (*continued*)

Regulatory barrier	Description	Proposed regulatory policies, accreditation & certification	Expected impact
(U.S. Rep. Kevin Hern, 2024; Livanos, 2024)	across states (e.g., NLC) create barriers to AI-driven telehealth practice	practice. Develop federal policies for cross-state AI telehealth certification.	and enhances access to care.
Insufficient infrastructure standards (Ahmed, 2024)	Outdated classroom and clinical technology limits AI adoption in education and practice	Mandate accreditation standards for AI-compatible infrastructure (e.g., reliable internet, updated devices). Fund partnerships with tech vendors for resource allocation.	Enables effective AI integration in education and practice settings.
Resistance to AI adoption (Liyanage et al., 2019)	Nurses' reluctance due to fears of job displacement and lack of familiarity with AI technologies	Develop certification programs on AI benefits and ethical use. Promote interdisciplinary collaboration in AI policy development.	Increases nurse acceptance and confidence in using AI, fostering adoption.
Lack of standardized AI tool evaluation (Bates et al., 2021)	Absence of standardized methods to evaluate AI tools' clinical effectiveness in nursing practice	Create accreditation standards for AI tool evaluation, including long-term impact assessments and clinical validation protocols.	Ensures AI tools are safe, effective, and tailored to nursing needs.

Note. ACEN = Accreditation Commission for Education in Nursing; AI = artificial intelligence; CCNE = Commission on Collegiate Nursing Education; CPD = continuing professional development; GDPR = General Data Protection Regulation; HIPAA = Health Insurance Portability and Accountability Act; NLC = Nurse Licensure Compact.

interstate practice remains both innovative and safe in the rapidly evolving landscape of digitally enabled nursing care.

Federal preemption vs. state autonomy

The debate over interstate AI regulation is fundamentally shaped by the ongoing tension between federal preemption and state autonomy. Proponents of federal authority over AI argue that a unified national framework would ease compliance for businesses operating across state lines by eliminating the burden of navigating a patchwork of 50 different state laws (Samp, Tobey, Darling, & Loud, 2025). However, resistance to federal dominance remains strong. In Florida, Governor Ron DeSantis has advocated for state-level AI regulations to protect citizens from potential harms, such as scams and job displacement, emphasizing the need for "guardrails" (Gollon, 2025). In 2025, more than 260 legislators from all 50 states signed a letter opposing a federal moratorium on AI development, emphasizing the importance of preserving state authority in regulating emerging technologies (Fox-Sowell, 2025). Opponents were successful in stripping the moratorium from the One Big Beautiful Bill Act (2025; National Conference of State Legislatures, 2025). The International Association of Privacy Professionals similarly reported growing resistance among state policymakers, citing concerns about maintaining locally relevant and responsive governance (International Association of Privacy Professionals, 2025). Reflecting a broader shift in federal priorities, President Donald Trump signed the Executive Order on Removing Barriers to American Leadership in AI on January 23, 2025, aimed at strengthening U.S. global leadership in AI by removing regulatory constraints perceived as barriers to innovation (The White House, 2025). As federal and state strategies continue to diverge, achieving a balance between state-level flexibility and nationally consistent standards is essential. Such coordination is critical for supporting responsible AI development while protecting the public interest across jurisdictions.

Table 6
Potential threats arising from the lack of regulatory guidance on AI use in nursing.

Category	Concern: Risk	Impact on Nurses	Impact on Patients	Citations
Data privacy	Data breaches, consent issues: AI risks PHI leaks, unclear consent	Liability, compliance issues	Privacy loss, reduced trust	Ahmed, 2024; Holt, 2025; Koumpias, Fleming, & Lin, 2024; Murdoch, 2021; Olawade et al., 2024
Algorithmic bias	Biased outputs, disparities: AI prioritizes groups, worsens inequities	Inequitable care, workload increase	Suboptimal care, disparities	Ahmed, 2024; Holt, 2025; Koumpias et al., 2024; Olawade et al., 2024
Accountability	Unclear liability, opaque decisions: Ambiguity in AI errors, traceability	Lawsuits, legal risks	Delayed justice, trust loss	Ahmed, 2024; De Micco et al., 2024; Holt, 2025; Koumpias et al., 2024; Murdoch, 2021
Patient safety	Unreliable AI, no validation: Inaccurate outputs, untested systems	Error correction, liability	Misdiagnosis, safety risks	Ahmed, 2024; Holt, 2025; Olawade et al., 2024
Ethical issues	Autonomy violations, inequitable access: Consent issues, resource bias	Ethical dilemmas, limited tools	Less autonomy, disparities	Ahmed, 2024; Holt, 2025; Murdoch, 2021
Workflow challenges	Disruptions, training gaps: Unclear AI protocols, no training	Inefficiencies, error risks	Inconsistent care quality	Ahmed, 2024; Koumpias et al., 2024
Cybersecurity	Cyberattacks: AI vulnerable to breaches	Operational, liability issues	Data breaches, care disruptions	Holt (2025)

Note. AI = artificial intelligence; PHI = protected health information.

Human factors influencing AI implementation

Ethical and regulatory considerations

Despite generally positive attitudes toward AI, both nurses and patients express concerns about its integration into nursing care, particularly regarding regulatory oversight, data privacy, and system reliability. Nurses are concerned that current regulatory frameworks may be inadequate to address the ethical and legal complexities introduced by AI technologies (Abuzaid et al., 2022). Patients, meanwhile,

Table 7
Human elements impacting AI integration.

Human element	Description	Role in AI-driven nursing	Challenges and considerations
Ethical considerations (ANA, 2022; Solaiman, 2024; Watson, 2024)	Ensuring AI use aligns with ethical principles like beneficence, non-maleficence, and justice.	Nurses, ethicists, and policymakers collaborate to ensure AI supports patient-centered care and avoids harm.	Risk of AI perpetuating biases (e.g., racial or socioeconomic); need for ethical guidelines specific to nursing.
Privacy protection (Hong et al., 2025; Murdoch, 2021; Price & Cohen, 2019)	Safeguarding patient data collected by AI systems, especially in telehealth and remote monitoring.	Nurses and IT specialists implement robust encryption and comply with HIPAA/GDPR to protect sensitive data.	High risk of data breaches; public mistrust due to lack of transparency in data handling.
Liability (Ciecierski-Holmes, Singh, Axt, Brenner, & Barteit, 2022; Maliha et al., 2021; Price, Gerke, & Cohen, 2024)	Determining accountability for errors caused by AI tools, such as misdiagnoses or incorrect triage.	Nurses and legal experts define clear liability frameworks, ensuring human oversight of AI decisions.	Ambiguity in assigning responsibility (nurse vs. AI system); need for updated legal standards.
Patient interaction (Anker-Hansen & Johansen, 2025; Seibert et al., 2021)	Maintaining compassionate, human-centered care while integrating AI tools such as robots and chatbots.	Nurses, as "telehealth nurses" or "robotic nurses," use AI to enhance, not replace, patient interactions.	Risk of reduced human connection; patients may feel dehumanized by overreliance on technology.
Trust and transparency (Alruwaili et al., 2025; Char, Shah, & Magnus, 2018)	Ensuring patients understand how AI tools function and are used in their care to build trust.	Nurses educate patients on AI's role, whereas developers ensure transparent algorithms and decision-making processes.	"Black box" algorithms reduce trust; need for explainable AI to clarify decisions.
Cultural sensitivity (Jordan, Hauser, Cota, Li, & Wolf, 2023; Quinn et al., 2022)	Ensuring AI tools respect diverse cultural, linguistic, and socioeconomic backgrounds.	Nurses and developers design AI systems with diverse datasets to provide culturally appropriate care.	Risk of cultural insensitivity in AI outputs; need for inclusive design and testing.
Patient autonomy (Esmaeilzadeh, Mirzaei, & Dharanikota, 2021; Guerrero Quiñones, 2024)	Preserving patients' rights to make informed decisions about their care involving AI tools.	Nurses obtain informed consent for AI use and ensure patients can opt out of AI-driven interventions.	Potential for AI to override patient preferences; need for clear consent protocols.
Nurse training and acceptance (Liyanage et al., 2019)	Equipping nurses with skills to use AI effectively and addressing fears of job displacement.	Educators and healthcare institutions provide training on AI tools, emphasizing their role as aids, not replacements.	Resistance due to lack of familiarity or fear of job loss; need for comprehensive training programs.
Interdisciplinary collaboration (Ahmed, 2024; Michalowski, Topaz, & Peltonen, 2025a, 2025b; Zhou, Li, & Li, 2021)	Involving nurses, ethicists, physicians, pharmacists, physical therapists, scientists, engineers, social workers and patients in AI development and implementation.	Multidisciplinary teams ensure AI aligns with clinical needs and ethical standards, enhancing adoption.	Coordination challenges across disciplines; need for structured collaboration frameworks.
Public perception and engagement (Mohamed et al., 2025; Ronquillo et al., 2021)	Addressing public concerns about AI in healthcare to foster acceptance and trust.	Nurses and policymakers engage communities through education campaigns and transparent policy-making.	Mixed public perceptions due to safety and privacy concerns; need for proactive engagement.

Note. AI = artificial intelligence; ANA = American Nurses Association; GDPR = General Data Protection Regulation; HIPAA = Health Insurance Portability and Accountability Act; IT = information technology.

express apprehension over the safety of AI, loss of patient choice, and threats to data security (Benda et al., 2024; Richardson et al., 2021), all of which could undermine trust in AI-mediated care. Ensuring patient data privacy will require robust safeguards, such as advanced encryption and decentralized storage solutions (Esteva et al., 2019). These concerns underscore the urgent need for a unified regulatory framework tailored to AI in nursing practice. Table 7 summarizes frequently discussed human elements impacting AI integration in nursing. By 2030, standardized protocols for AI deployment are expected to emerge, aiming to balance innovation with patient safety (Lekadir et al., 2025; Medicines and Healthcare Products Regulatory Agency, 2024). Engaging nurses' voices and incorporating patients' concerns will be essential for developing ethical, practical, and trustworthy AI systems that genuinely support quality care (Neves, Omori, Petersen, Vered, & Carter, 2024).

AI-human ecosystem

AI can augment nurses' capabilities by supporting decision-making, streamlining workflows, and enabling personalized care (Topaz et al., 2025). AI tools can process complex clinical information rapidly, allowing nurses to focus more on empathetic, patient-centered interactions (Michalowski et al., 2025a, 2025b; Ventura-Silva et al., 2024). Nevertheless, maintaining human oversight is critical to ensure ethical care, prevent overreliance on algorithms, and preserve professional judgment (Lynn, 2019; McKee & Correia, 2025). This ecosystem thrives when AI is used as a partner rather than a substitute, balancing efficiency with compassion and leveraging technological strengths while prioritizing human connection (El Arab et al., 2025; Simms, 2025). AI that can interactively explain its decision-making process helps foster trust. Thus, future systems should provide transparent reasoning by highlighting key data points such as specific laboratory results or imaging findings that support their recommendations (Holzinger, Langs, Denk, Zatloukal, & Müller, 2019).

Overall, nurses are approaching the rise of AI with concerned optimism. While many see AI as a practical tool that could relieve the burden of routine tasks, potentially freeing up nurses to focus on higher-value clinical care (McKinsey & Company, 2024), some express anxiety about job displacement, fearing their training and expertise may be "devalued by machines" (Perrone, 2025; Rony, Parvin, et al., 2024). On the other hand, patients share similar concerns, particularly the fear that healthcare may lose its human touch in favor of robotic efficiency (Mohanasundari et al., 2023; Rony, Das et al., 2025). Nurses and advocacy groups warn that automated care protocols risk undermining vital nurse-to-patient communication, potentially compromising safety and trust (Castillo, 2024; National Nurses United, 2024; Perrone, 2025; Peterson, 2024). However, we argue that AI will not replace human

work. Instead, it will free us to focus more on cognitive depth and interpersonal engagement. The title "RN" will not disappear, but we may increasingly see the emergence of "AI-RNs" or "smart RNs" in the next-generation nursing workforce.

Discussion

Opportunities and challenges

With support from NCSBN funding, a prototype AI tool was introduced at the 2024 NCSBN APRN Roundtable (van der Gaag & Jago, 2024). This tool, using ensemble modeling techniques and tested with data from U.S., U.K., and Australian regulators, will support case managers by linking complaints to regulatory rules and past cases, enhancing efficiency without replacing human judgment (van der Gaag et al., 2023). In addition, the 2023 NCSBN Annual Meeting showcased advancements in remote proctoring for the NCLEX, with AI detecting second-person presence, electronic voices, and shadows, alongside plans for AI-powered item banking to optimize test development (Tillman & Dickison, 2023). While implementation requires thorough scrutiny before advancement, AI's potential is apparent. In workforce planning, AI offers scalable, data-driven solutions that surpass traditional methodologies, particularly in forecasting skill demand (Chen et al., 2025; Howison et al., 2025; Orozco-Castañeda et al., 2024; Varelas et al., 2022). In education, AI enhances training through simulations and adaptive learning, with AI-powered, clinical judgement-centric curricula preparing nurses for the demands of postmodern healthcare delivery. In practice, AI applications such as diagnostic support, remote monitoring, and omics-driven personalized care enhance nursing functions, improving access and efficiency.

As professionals consistently perceived by the public as highly trustworthy (Saad, 2025), nurses play a pivotal role in sustaining patient trust. Human elements, ethical considerations, privacy protection, liability, and patient interaction are critical to ensuring AI complements compassionate care. The integration of AI into nursing raises new ethical, regulatory, and practical considerations (United Nations Educational Scientific and Cultural Organization, 2023). Ethical concerns include the risk of algorithmic bias, which may exacerbate healthcare disparities if AI systems are trained on nondiverse datasets (Badawy, Helal, Hashim, Zinhom, & Shaban, 2025). Privacy issues are paramount as AI tools collect vast amounts of sensitive patient data, necessitating robust safeguards to comply with regulations like the Health Insurance Portability and Accountability Act (1996, pp. 104–191) and the General Data Protection Regulation (Ahmed, 2024; Hong et al., 2025; Rony, Das et al., 2025; Rony, Numan, et al., 2024; Seibert et al., 2021). Liability frameworks remain ambiguous, with uncertainty about accountability for AI-driven errors, such as misdiagnoses in telehealth settings (Geny, Andres, Talha, & Geny, 2024; Livanos, 2024; Maliha et al., 2021; Price et al., 2024). Additionally, the human element of nursing—compassion and patient-centered care—must be preserved, as over-reliance on AI risks dehumanizing interactions (Quinn et al., 2022). Nurses require training to navigate these technologies effectively, yet current educational curricula often lack standardized AI literacy components (Ahmed, 2024). Regulatory barriers, such as the lack of nursing-specific AI guidelines and inconsistent telehealth policies, must be addressed through new regulations, accreditation standards, and certification programs.

Limitations

This review focuses on the practical implications of AI in nursing without drawing sharp distinctions between subtypes such as predictive, prescriptive, generative, or robotic AI. While such distinctions are relevant in technical contexts, in nursing practice, these systems typically appear as integrated tools that assist with decision-making, automation, or communication. This review is organized around five thematic areas in nursing: workforce forecasting, education, practice, regulation, and human experience. It does not cover all aspects of AI's impact on nursing, such as specific clinical specialties or long-term societal implications (Rony, Das et al., 2025), and it is subject to several limitations. First, the systematic literature review relied primarily on PubMed, Scopus, CINAHL, and targeted searches of professional organization websites, which may have excluded relevant studies from other databases and non–English-language sources, potentially limiting the comprehensiveness of the evidence base. Second, the rapid pace of AI development means that some findings may quickly become outdated as new technologies and regulations emerge after July 2025. Third, reliance on both peer-reviewed and grey literature introduces the possibility of publication bias, since studies with negative or inconclusive results are less likely to appear in the literature (Bates et al., 2021). Fourth, although ethical concerns such as algorithmic bias and data privacy are acknowledged, this review does not delve deeply into mitigation strategies due to limited nursing-specific evidence (Rony, Parvin, & Ferdousi, 2024). Finally, the regulatory analysis highlights gaps in AI-specific guidelines but is constrained by the absence of standardized frameworks across states, particularly for telehealth and interstate compacts, which limits generalizability (Livanos, 2024, 2025). These limitations suggest the need for broader, ongoing research to address emerging AI applications and evolving regulatory landscapes in nursing.

Conclusion

As automobiles revolutionized transportation and smartphones redefined communication, AI is set to reshape every profession, including nursing. As Stephen Hawking noted, "every aspect of our lives will be transformed. In short, success in creating AI could be the biggest event in the history of our civilization" (Hern, 2016). What sets AI apart from previous technological advancements is that these systems not only understand and execute human commands, but also generate their own "thoughts," apply autonomous "logic," and draw independent "conclusions" based on what they have "learned" (Coiera, 2020; Eddy, 2025; Edwards, 2023; Fokas, 2023). Recognizing this distinction is crucial for crafting proactive regulations that harness AI's benefits while mitigating its potential risks. When integrated responsibly, AI can support nursing in preserving its core values of compassion, critical thinking, and patient-centered care while enhancing practice through technological innovation (Buchanan et al., 2021; Rony, Parvin, & Ferdousi, 2024).

CRediT authorship contribution statement

Elizabeth H. Zhong: Conceptualization, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Nancy Spector:** Writing – review & editing. **Charlie O'Hara:** Writing – review & editing. **Nicole Livanos:** Writing – review & editing. **Jose Delfin Castillo:** Conceptualization, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare no conflicts of interest.

Human study

No human subjects were involved in this literature review.

Acknowledgement

We sincerely thank Brendan Martin and Jim Cleghorn for their valuable feedback and ongoing support. We also gratefully acknowledge Michaela Reid for her dedicated administrative assistance.

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