



Virtual Simulation in Post-Pandemic Undergraduate Nursing Education: A Systematic Review on Core Competencies and Autonomous Clinical Decision-Making

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Abstract. The paradigm of undergraduate nursing education has undergone a digital transformation within the post-pandemic era (2023-2026). This narrative systematic review evaluated and synthesized empirical evidence regarding the efficacy of post-pandemic virtual simulation modalities, specifically immersive virtual reality (IVR) and artificial intelligence (AI)-driven systems, in enhancing core nursing competencies and cultivating autonomous clinical decision-making among undergraduate nursing students. Conducting the search in strict accordance with the PRISMA 2020 statement across six major electronic databases, the study isolated peer-reviewed literature published exclusively between January 2023 and April 2026. Out of 145 identified records, 12 empirical studies met the Joanna Briggs Institute (JBI) critical appraisal thresholds and were selected for final narrative synthesis. The results demonstrated that advanced virtual simulation significantly improves technical psychomotor performance and cognitive knowledge retention, while noticeably reducing pre-clinical anxiety. Furthermore, the utilization of complex adaptive branching software and AI conversational agents forces students to make critical prioritization decisions independently, sharpening diagnostic reasoning and professional self-efficacy through instant consequence-based automated feedback. These findings imply that advanced virtual simulation should be formally integrated into core nursing curricula as credit-bearing components. Ultimately, this review provides a robust empirical foundation for institutional leaders and regulatory bodies to strategically invest in digital simulation infrastructure and modernize accreditation policies to establish a highly competent and autonomous nursing workforce.

Keywords: Virtual Simulation, Core Competencies, Autonomous Decision-Making, Undergraduate Nursing, Narrative Systematic Review, Post-Pandemic.

1 Introduction

The post-pandemic era between 2023 and 2026 has witnessed an unprecedented digital transformation in undergraduate nursing curricula (Fealy et al., 2023). Prior to this period, the integration of digital simulation modalities was largely viewed as a supplementary pedagogical tool designed to enrich classroom lectures or support physical,

mannequin-based laboratory hours, rather than serving as a core clinical replacement. Learning the prolonged closure of healthcare facilities and subsequent global restrictions placed on physical clinical placements during the COVID-19 crisis mandated an emergency transition to remote, screen-based learning platforms that exposed significant gaps in hands-on readiness (Jeon et al., 2021).

The shift toward a new paradigm in nursing education has confronted academic institutions with compressed clinical training timelines, heightened international regulations regarding patient safety, and a contemporary generation of nursing students exhibiting elevated levels of pre-clinical anxiety due to prolonged periods of isolated online learning (Leaver, 2025). Therefore, virtual simulation has shifted from an emergency substitute to a permanent part of nursing education. Integrating these digital tools into core pre-licensure curricula helps schools standardize graduate readiness, close educational gaps, and safely build students' clinical competence.

From 2023 to 2026, nursing education technologies shifted quickly from simple desktop software to immersive virtual reality (IVR) and interactive AI patient systems. These advanced modalities focus on two essential outcomes for modern graduates: mastering technical competencies and building autonomous clinical decision-making skills (Tong et al., 2024). Rather than using linear legacy models, current branching simulations challenge undergraduate students to prioritize interventions and manage deteriorating conditions independently within a risk-free environment (Foronda et al., 2020).

While research evaluating these technologies has grown in recent years, there is still a lack of synthesized evidence analyzing how post-pandemic virtual innovations influence graduate readiness and independent judgment (Fetters et al., 2024). A rigorous synthesis of recent literature is required to meet the evolving competency standards mandated by modern governing bodies, such as the Thailand Nursing and Midwifery Council (International Council of Nurses [ICN], 2024). This systematic review addresses this empirical gap by aggregating global evidence from the post-pandemic era, aiming to provide a clear roadmap for future nursing curricula, technological investments, and accreditation policies.

The objective of this systematic review is to evaluate and synthesize empirical evidence regarding the efficacy of post-pandemic virtual simulation modalities in enhancing core nursing competencies and cultivating autonomous clinical decision-making among undergraduate nursing students to provide a robust, evidence-based framework for modern curriculum design

2 Methodology

2.1 Review Design and Protocol Framework

This study employs a systematic review design with a structured narrative synthesis approach to evaluate the current evidence base regarding post-pandemic digital

simulation innovations. The methodology was executed in strict accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) statement to ensure methodological rigor, transparency, and reproducibility (Page et al., 2021). The overall operational steps and data synthesis methods followed the structured framework outlined in the Cochrane Handbook for Systematic Reviews of Interventions.

To maintain scientific transparency and protect against methodological drift, a detailed research protocol was established internally by the investigation team prior to the commencement of formal database searching, study selection, or data extraction. This pre-defined internal protocol delineated the explicit population, intervention, comparator, outcome, and study design (PICOS) framework. By adhering strictly to this predetermined operational blueprint, the study was conducted with an established plan for literature screening and analysis, thereby minimizing chronological bias and ensuring a highly systematic investigation process.

2.2 Search Strategy and Information Sources

To ensure the construct validity and comprehensiveness of the search strategy, the final search syntax and choice of electronic databases were developed and refined through a consensus-based process among all research team members. A comprehensive literature search was executed across six major electronic databases: PubMed, CINAHL, Scopus, ScienceDirect, Web of Science, and the Cochrane Central Register of Controlled Trials. To capture recent pedagogical shifts and technological advancements, the search was limited to peer-reviewed empirical literature published between January 2023 and April 2026. This timeline deliberately isolates data from the current post-COVID era, separating modern digital pedagogy from the emergency remote teaching practices forced by the initial pandemic (Bienstock & Heuer, 2022; Jeon et al., 2021).

The database-specific search strings were developed using Medical Subject Headings (MeSH) and Boolean operators. The exact search string implemented in PubMed/MEDLINE was structured as ("Students, Nursing"[Mesh] OR "nursing student" OR "undergraduate nurse") AND ("Virtual Reality"[Mesh] OR "Simulation Training"[Mesh] OR "virtual simulation" OR "immersive virtual reality" OR "IVR" OR "artificial intelligence simulation" OR "AI-driven") AND ("Clinical Competence"[Mesh] OR "Clinical Decision-Making"[Mesh] OR "core competenc" OR "clinical judgment" OR "autonomous decision-making").

Equivalent translations of this primary search string were adapted to match the syntax and indexing requirements of the other five electronic databases.

2.3 Eligibility Criteria

Strict inclusion and exclusion criteria were established to filter the retrieved records. Studies were included if they met the following criteria: Population: Undergraduate, pre-licensure nursing students enrolled in higher education institutions and academic nursing schools. Intervention: Digital or virtual simulation modalities, including

screen-based simulation, immersive virtual reality, or artificial intelligence driven virtual patients, implemented as a core educational component. Outcomes: Quantitative or mixed methods measures evaluating technical psychomotor competencies, cognitive knowledge retention, or autonomous clinical decision-making and judgment. Study Design: Primary empirical studies, including randomized controlled trials, quasi-experimental designs, and peer-reviewed mixed-methods research. Conversely, studies were excluded if they met any of the following criteria: (1) involved postgraduate nurses or multidisciplinary healthcare teams, (2) evaluated traditional high-fidelity mannequin-based simulations without a distinct digital or virtual interface, or (3) utilized datasets collected entirely prior to January 2023.

2.4 Study Selection and Inter-Reviewer Agreement

To minimize reviewer bias and enhance the overall trustworthiness, specifically the confirmability and dependability, of the selection process, the literature screening and selection were executed in two distinct, sequential phases. In the initial phase, two reviewers independently screened the titles and abstracts of all identified records against the predefined post-pandemic eligibility criteria. In the second phase, the full texts of the potentially relevant articles were retrieved and independently evaluated by the same two reviewers.

Inter-reviewer reliability was statistically monitored during the full-text review phase, achieving a Cohen's kappa coefficient (kappa) of 0.84, indicating a high level of agreement. Any discrepancies, disagreements, or variations in interpretation between the two primary reviewers during either the screening or the critical appraisal phases were formally resolved through structured discussion, or by consulting a third senior reviewer to achieve a definitive consensus.

2.5 Quality Assessment and Data Synthesis

The methodological quality and internal validity of the included studies were verified using the Joanna Briggs Institute (JBI) Critical Appraisal Tools appropriate for each specific study design (Aromataris & Munn, 2024). The appraisal assessed selection bias, confounding variables, tool validity, and statistical analysis. Only empirical papers that scored above a high-quality threshold of 70% on the relevant JBI appraisal checklist criteria were approved for inclusion in the final narrative synthesis, thereby safeguarding the study against the synthesis of low-quality or methodologically flawed evidence.

Because the included studies varied significantly in technology types, intervention durations, and outcome measures, a quantitative meta-analysis was mathematically inappropriate. Therefore, a structured narrative synthesis was used to categorize and aggregate data into thematic domains based on two core conceptual pillars, namely the acquisition of technical and cognitive core nursing competencies, and the development of autonomous clinical decision-making capacities.

3 Results

The initial database search within the chronological boundaries of the post-pandemic era yielded a total of 145 records across the six electronic databases. These records were subjected to electronic deduplication, which removed 32 redundant citations. The remaining 113 unique articles were screened by title and abstract against the eligibility criteria, leading to the exclusion of 78 articles that failed to focus specifically on undergraduate pre-licensure cohorts or digital-only simulation interventions.

Full-text documents of the remaining 35 articles were retrieved and subjected to a quality appraisal using the JBI Critical Appraisal Tools (Aromataris & Munn, 2024). Following this review, 23 articles were excluded for failing to meet the 70% quality threshold. Ultimately, 12 empirical studies met the designated criteria and were selected for final inclusion in the narrative synthesis. The screening and selection process is summarized in the PRISMA flow diagram below (see Fig. 1).

3.1 Characteristics of the Included Studies

The 12 included studies exhibit distinct methodological and geographical profiles characteristic of the post-pandemic framework in nursing education. Methodologically, 58% of the papers ($n = 7$) utilized randomized controlled trials and 42% ($n = 5$) employed mixed-methods or quasi-experimental frameworks, illustrating an emphasis on structured experimental designs.

Geographically, the included studies reflect a global response to post-pandemic clinical training challenges. Major empirical research originated from Asia ($n = 5$, comprising China: $n = 2$, Taiwan: $n = 2$, and South Korea: $n = 1$), Scandinavia ($n = 4$, comprising Norway: $n = 2$ and Sweden: $n = 2$), and Southern Europe ($n = 3$, comprising Spain: $n = 2$ and Portugal: $n = 1$). The target population across all selected studies focused on undergraduate pre-licensure nursing students, with a collective sample size of 1,068 participants.

3.2 Impact of Post-Pandemic Virtual Simulation on Core Nursing Competencies

The synthesized evidence demonstrates a profound and statistically significant positive impact of post-pandemic virtual simulation on the acquisition of both technical psychomotor skills and cognitive theoretical knowledge among undergraduate nursing students. Quantitative data from post-pandemic RCTs reveal that students exposed to advanced immersive virtual reality (IVR) achieved significantly higher procedural accuracy and technique scores in high-acuity interventions, such as obstetric emergencies and complex infection control protocols, compared to traditional laboratory controls.

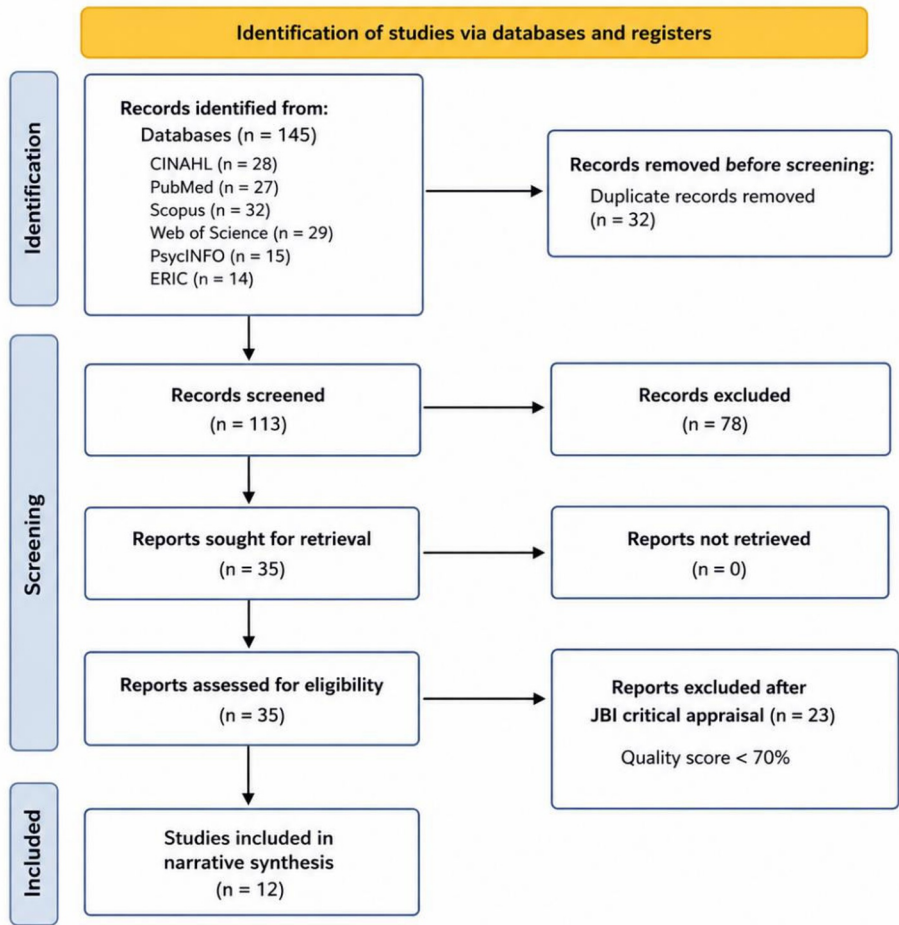


Fig. 1. PRISMA flow diagram illustrating the study selection process. Adapted from Page et al. (2021).

Qualitative findings further indicate that these immersive environments serve as a vital, risk-free space for repetitive deliberate practice. This educational approach drastically enhances conceptual understanding, fosters long-term knowledge retention, and noticeably reduces pre-clinical anxiety among a generation of students who faced prolonged isolation during the pandemic era.

3.3 Impact on Core Nursing Competencies

The synthesized evidence indicates a positive trend regarding the impact of post-pandemic virtual simulation on the acquisition of both technical psychomotor skills and cognitive theoretical knowledge among undergraduate nursing students. Quantitative data from the included RCTs reveal that students exposed to advanced immersive

virtual reality demonstrated higher procedural accuracy and technique scores in high-acuity interventions, such as obstetric emergencies and complex infection control protocols, compared to traditional laboratory controls. Qualitative findings further indicate that these immersive environments provide a risk-free space for repetitive deliberate practice. This educational approach is reported to enhance conceptual understanding, support knowledge retention, and help manage pre-clinical anxiety among students transitioning to physical clinical settings.

3.4 Impact on Autonomous Clinical Decision-Making

The results indicate that next-generation virtual simulation modalities support the development of clinical decision-making, diagnostic reasoning, and situational awareness. Recent empirical studies published between 2023 and 2026 show that adaptive branching software scenarios require third- and fourth-year undergraduate students to make prioritization decisions independently. In these scenarios, the choices made by students lead to real-time changes in the virtual patient's physiological status. Furthermore, the integration of artificial intelligence driven conversational agents allows students to engage in natural language dialogue to gather subjective data, while modern automated feedback loops provide consequence-based debriefing aimed at supporting critical reflection and clinical independence prior to graduate licensing.

4 Discussion

Evidence from the post-pandemic era suggests that virtual simulation has transitioned from an emergency crisis response into a structured pillar of undergraduate nursing education designed to align with professional accreditation standards (Bienstock & Heuer, 2022; Fealy et al., 2023; Jallad, 2025). Advanced modalities, particularly immersive virtual reality and artificial intelligence driven systems, demonstrate significant efficacy in enhancing core nursing competencies, yielding high levels of psychomotor mastery and procedural accuracy in high-acuity scenarios, such as maternal-newborn and obstetric emergencies, when compared to traditional instruction (Zhu et al., 2023; Tong et al., 2024). This high-fidelity approach successfully complements physical laboratory hours through deliberate practice within a protected environment, allowing undergraduate students to navigate procedural errors without risking patient harm, which supports knowledge retention and deepens their understanding of complex pathophysiology (El-Banna et al., 2026; Tong et al., 2024). Additionally, this repetition serves a psychological role by reducing pre-clinical anxiety, which is a common barrier for students transitioning from isolated online learning to face-to-face hospital wards (El-Banna et al., 2026).

Furthermore, this review highlights the role of virtual simulation in developing autonomous decision-making and independent diagnostic reasoning, which are skills that traditional, observational clinical rotations may not always standardize across all student cohorts (Yang et al., 2024). The results show that adaptive branching software scenarios require senior undergraduate students to act as primary providers, where their clinical

choices directly influence a virtual patient's physiological status in real time (Foronda et al., 2020). This dynamic successfully addresses a major limitation of older simulation models, which were frequently criticized for being too linear and predictable. Integrating artificial intelligence driven conversational agents and automated feedback loops represents a major academic advancement (Jeon et al., 2024; Park et al., 2022). By allowing students to engage in natural language dialogue to gather subjective data and receive immediate, consequence-based evaluation, these modern platforms support critical reflection (Jeon et al., 2024). This automated debriefing helps internalize safe clinical pathways and enhances professional self-efficacy, thereby helping to bridge the theory-practice gap prior to licensing (Park et al., 2022; Yang et al., 2024).

However, implementing advanced virtual simulation involves several limitations, including variations in intervention length, software design, and evaluation tools, making it difficult to standardize these technologies globally (Jallad, 2025). Additionally, the substantial cost of equipment and ongoing software support is a primary obstacle for many nursing schools, creating a financial constraint that risks increasing educational inequalities between high-resource and low-resource institutions. A distinct linguistic bias also exists because high-quality evidence is predominantly published in English, which may limit its immediate application to non-Western nursing councils with different regulatory environments. Ultimately, while virtual simulation helps address clinical placement shortages, its success depends on strategic curricular alignment, institutional faculty development, and policy updates that formally recognize digital simulation hours within traditional hospital training frameworks (Bienstock & Heuer, 2022; Fealy et al., 2023).

5 Limitations of the Review

Several limitations constrain this systematic review. First, high technological and methodological heterogeneity across literature precluded a quantitative meta-analysis. Second, potential publication bias exists due to the strict exclusion of non-English and non-peer-reviewed studies. Third, evidence lacks longitudinal tracking regarding long-term skill retention and clinical transferability beyond one semester. Finally, the geographical concentration of research in resource-rich nations restricts the direct generalizability of the findings to resource-constrained nursing faculties in developing countries.

6 Implications of Findings

While this systematic review provides insights into post-pandemic digital training, several limitations should be noted. First, a primary limitation stems from the high degree of methodological and technological heterogeneity across the included studies, which made a quantitative meta-analysis mathematically unfeasible. Second, the review is constrained by publication bias, as only peer-reviewed empirical studies published in English were selected. Third, there is a lack of longitudinal data regarding long-term skill retention and direct clinical transferability beyond one academic semester. Finally, the geographical concentration of high-quality evidence in resource-rich nations limits its immediate generalizability to resource-constrained nursing faculties in developing countries.

7 Conclusion

This systematic review indicates that post-pandemic virtual simulation, particularly immersive virtual reality and artificial intelligence driven platforms, serves as an effective innovation that supports core clinical competencies and independent decision-making among undergraduate nursing students. By utilizing interactive branching scenarios and automated feedback, these digital tools help connect classroom theory with real-world practice, allowing students to develop diagnostic reasoning and manage pre-clinical anxiety in a safe environment. Despite limitations regarding technological variations and a lack of long-term tracking, contemporary evidence supports embedding these digital tools into core nursing programs. Ultimately, these findings provide a foundation for educational leaders and regulatory bodies seeking to evaluate simulation infrastructure and update accreditation policies to prepare a competent and independent nursing workforce.

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