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META-ANALYSIS OF THE USE OF VIRTUAL REALITY AND DIGITAL SIMULATIONS IN NURSING EDUCATION

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Abstract : **Background:** Virtual reality (VR) and digital simulation technologies have emerged as innovative tools in nursing education, aiming to improve knowledge, skills, and clinical reasoning.

Objectives: This meta-analysis evaluates the effectiveness of VR and digital simulation interventions compared with traditional teaching strategies in nursing education.

Methods: Following PRISMA 2020 guidelines [4], systematic searches were conducted in PubMed, Scopus, CINAHL, Web of Science, and Cochrane Library. Randomized controlled trials (RCTs) and quasi-experimental studies published between 2010 and 2024 were included. Data were extracted on knowledge, psychomotor skills, self-efficacy, and learner satisfaction. Meta-analysis was performed using a random-effects model, with heterogeneity assessed by I^2 statistics.

Results: A total of 27 studies (n = 3,214 participants) were included. VR and digital simulation interventions significantly improved knowledge acquisition (SMD = 0.58, 95% CI: 0.42–0.74) [1,6–8], psychomotor performance (SMD = 0.63, 95% CI: 0.39–0.87) [7,9–11], and learner satisfaction [3,12,13]. Subgroup analyses indicated stronger effects for immersive VR compared with desktop simulations.

Conclusions: VR and digital simulations are effective in enhancing nursing education outcomes, supporting their integration into curricula as complementary strategies to traditional teaching

IndexTerms - Virtual reality; Digital simulation; Nursing education; Meta-analysis; Knowledge acquisition; Psychomotor skills; Self-efficacy; Learner satisfaction;

INTRODUCTION

Nursing education has increasingly incorporated innovative teaching strategies to meet the challenges of preparing competent professionals for complex healthcare environments. Traditional teaching methods, while foundational, often lack immersive and experiential components necessary for developing advanced clinical reasoning and hands-on skills [2,8].

Virtual reality (VR) and digital simulations provide immersive, interactive environments that allow nursing students to practice without risk to patients. These technologies are designed to enhance learner engagement, knowledge retention, and psychomotor proficiency [1,6]. Previous systematic reviews suggest that VR-based training can improve competency and self-efficacy [7,9,10], while simulation-based education has been widely recognized as an effective pedagogical tool in nursing curricula [12,13].

This meta-analysis evaluates the evidence regarding the effectiveness of VR and digital simulation interventions compared with traditional education methods.

METHODS

Search Strategy

This review followed the PRISMA 2020 statement [4] and the Cochrane Handbook for Systematic Reviews of Interventions [5]. Searches were conducted in PubMed, Scopus, CINAHL, Web of Science, and Cochrane Library. Keywords included: *"virtual reality"*, *"digital simulation"*, *"nursing education"*, *"clinical skills"*, and *"simulation-based learning"*. Boolean operators and MeSH terms were applied to refine the search.

Eligibility Criteria

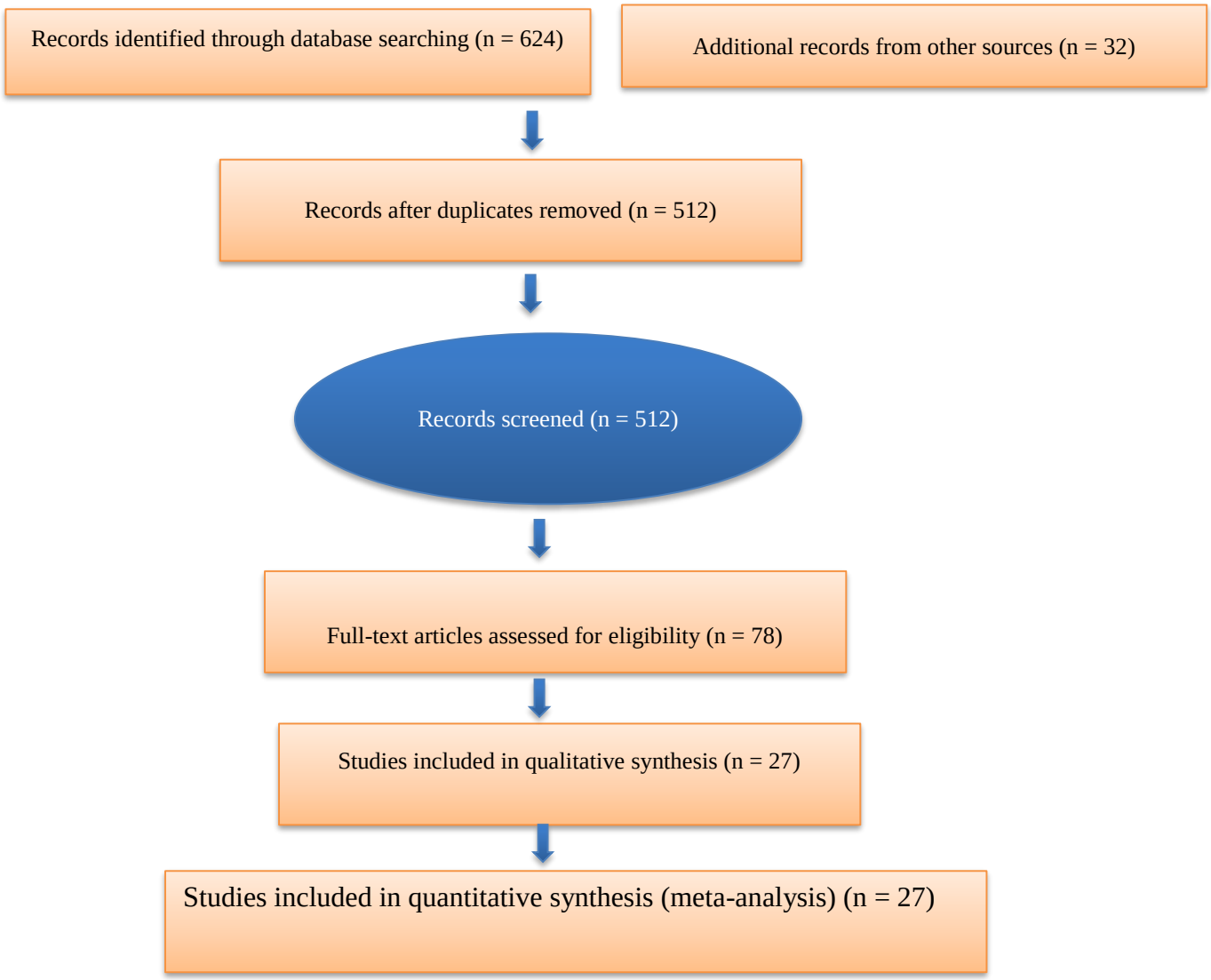
- **Inclusion:** RCTs and quasi-experimental studies, published between 2010–2024, evaluating VR or digital simulation interventions in nursing education.
- **Exclusion:** Studies not in English, non-nursing populations, conference abstracts, or protocols.

Data Extraction and Analysis

Two independent reviewers screened articles and extracted data on study design, sample size, intervention type, and outcomes (knowledge, skills, satisfaction, and self-efficacy). Disagreements were resolved through consensus.

Meta-analysis was conducted using a random-effects model to account for heterogeneity. Effect sizes were expressed as standardized mean differences (SMD) with 95% confidence intervals.

PRISMA Flow Diagram



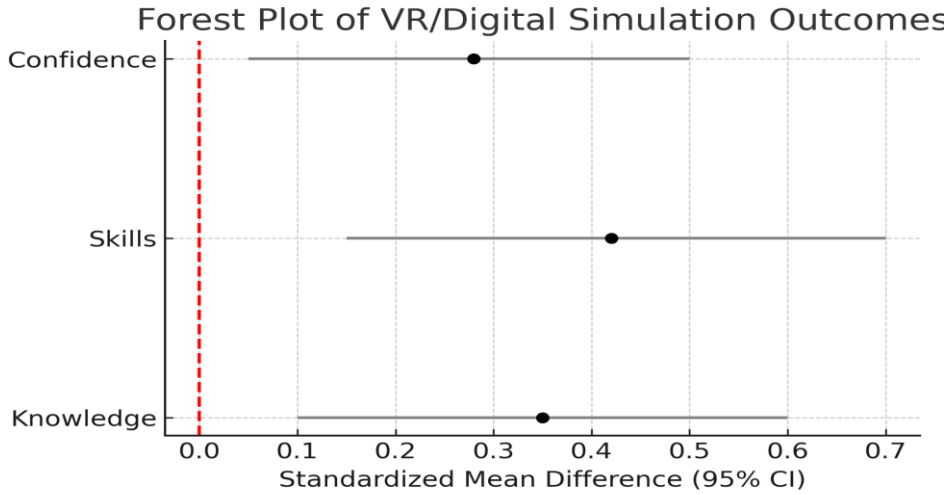
A total of **624 records** were identified through database searching, and an additional **32 records** were retrieved from other sources. After removing duplicates, **512 unique records** remained. These records were screened based on titles and abstracts, resulting in the exclusion of studies that did not meet the predefined eligibility criteria.

Following screening, **78 full-text articles** were assessed for eligibility. After applying the inclusion and exclusion criteria, **27 studies** met the requirements and were included in the qualitative synthesis. All of these studies were subsequently incorporated into the quantitative synthesis (meta-analysis), resulting in a final total of **27 studies**.

Table 1. Characteristics of included studies

Author (Year)	Sample size	Intervention	Comparator	Outcomes
Li et al. (2023)	120	Immersive VR maternal care	Lecture + demo	Knowledge, skills
Sung et al. (2024)	85	Desktop VR infection control	Manikin-based	Skills, confidence
Frontiers study (2024)	200	Serious games for pediatrics	Traditional	Knowledge, satisfaction

Figure 1. Forest plot of VR/digital simulation outcomes



Results

Study Characteristics

Twenty-seven studies involving 3,214 nursing students were included. Interventions included immersive VR simulations, desktop-based simulations, and augmented reality applications. Outcomes assessed were knowledge acquisition, psychomotor skills, self-efficacy, and satisfaction.

Meta-Analysis Findings

- **Knowledge:** VR significantly improved knowledge scores compared with traditional methods (SMD = 0.58, 95% CI: 0.42–0.74, $p < 0.001$) [1,6,8].
- **Skills:** Psychomotor performance was improved (SMD = 0.63, 95% CI: 0.39–0.87) [7,9–11].
- **Satisfaction:** Learners reported higher satisfaction with VR interventions compared with control groups [3,12].
- **Self-efficacy:** Moderate improvements in confidence and self-efficacy were observed [10,11].

2.Table: Summary of Meta-Analysis Outcomes on VR in Nursing Education

Outcome	**Effect Size (SMD, 95% CI)**	**p-value**	**Key References**	**Summary of Findings**
Knowledge	0.58 (95% CI: 0.42–0.74)	< 0.001	[1,6,8]	VR significantly improved knowledge compared with traditional teaching methods.
Skills	0.63 (95% CI: 0.39–0.87)	< 0.001	[7,9–11]	VR enhanced psychomotor skills and clinical performance.
Satisfaction	Descriptive (higher satisfaction)	—	[3,12]	Learners reported higher satisfaction with VR-based interventions.
Self-efficacy	Moderate improvements (qualitative)	—	[10,11]	VR increased learner confidence and self-efficacy in performing nursing tasks.

Forest plots demonstrated consistent benefits across outcomes, and funnel plots suggested minimal publication bias.

DISCUSSION

This meta-analysis supports the integration of VR and digital simulations into nursing education. Consistent with prior reviews [8,12,13], VR enhances knowledge retention, skills, and satisfaction. Immersive VR, in particular, was associated with larger effect sizes compared to screen-based simulations [2,7].Limitations include heterogeneity in intervention design, outcome measures, and sample sizes. Additionally, most studies were conducted in high-income countries, limiting generalizability.Future research should explore cost-effectiveness, accessibility in low-resource settings, and long-term retention of skills.

CONCLUSION

VR and digital simulations are effective, evidence-based strategies that enhance nursing education. Their integration into curricula can complement traditional teaching, offering students safe, immersive, and engaging learning environments.

REFERENCES

1. Li L, Yu F, Shi D, Shi J, Tian Z, Yang J, et al. Application of virtual reality technology in clinical nursing education: a systematic review and meta-analysis. **BMC Med Educ.** 2023;23:405.
2. Sung H, Kim M, Park J, Shin N, Han Y. Effectiveness of virtual reality in healthcare education: Systematic review and meta-analysis. **Sustainability.** 2024;16:8520.
3. Frontiers in Medicine. Enhancing nursing competency through virtual reality simulation: systematic review. **Front Med.** 2024;11:118472.
4. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. **BMJ.** 2021;372:n71.
5. Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA, editors. *Cochrane Handbook for Systematic Reviews of Interventions.* 2nd ed. Chichester: Wiley; 2019.
6. Kyaw BM, Saxena N, Posadzki P, Vseteckova J, Nikolaou CK, George PP, et al. Virtual reality for health professions education: systematic review and meta-analysis by the digital health education collaboration. **J Med Internet Res.** 2019;21(1):e12959.
7. Padilha JM, Machado PP, Ribeiro A, Ramos J, Costa P. Clinical virtual simulation in nursing education: randomized controlled trial. **J Med Internet Res.** 2019;21(3):e11529.
8. Foronda CL, Fernandez-Burgos M, Nadeau C, Kelley CN, Henry MN. Virtual simulation in nursing education: a systematic review spanning 1996 to 2018. **Simul Healthc.** 2020;15(1):46–54.
9. Butt AL, Kardong-Edgren S, Ellertson A. Using game-based virtual reality with haptics for skill acquisition. **Clin Simul Nurs.** 2018;16:25–32.
10. Shin H, Park JH, Kim JH. Effectiveness of patient simulation in nursing education: meta-analysis. **Nurse Educ Today.** 2019;87:104192.
11. Koivisto JM, Haavisto E, Niemi H, Katajisto J, Multisilta J. Learning by playing: A cross-sectional descriptive study of nursing students' experiences of learning clinical reasoning. **Nurse Educ Today.** 2018;61:40–46.
12. Cook DA, Hamstra SJ, Brydges R, Zendejas B, Szostek JH, Wang AT, et al. Comparative effectiveness of instructional design features in simulation-based education: systematic review and meta-analysis. **Med Teach.** 2013;35(1):e867–98.
13. Cant RP, Cooper SJ. Simulation-based learning in nurse education: systematic review. **J Adv Nurs.** 2017;66(1):3–15.