Review

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Immersive simulation in nursing and midwifery education: a systematic review

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Purpose: Immersive simulation is an innovative training approach in health education that enhances student learning. This study examined its impact on engagement, motivation, and academic performance in nursing and midwifery students.
Methods: A comprehensive systematic search was meticulously conducted in 4 reputable databases—Scopus, PubMed, Web of Science, and Science Direct—following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. The research protocol was pre-registered in the PROSPERO registry, ensuring transparency and rigor. The quality of the included studies was assessed using the Medical Education Research Study Quality Instrument.
Results: Out of 90 identified studies, 11 were included in the present review, involving 1,090 participants. Four out of 5 studies observed high post-test engagement scores in the intervention groups. Additionally, 5 out of 6 studies that evaluated motivation found higher post-test motivational scores in the intervention groups than in control groups using traditional approaches. Furthermore, among the 8 out of 11 studies that evaluated academic performance during immersive simulation training, 5 reported significant differences ($P<0.001$) in favor of the students in the intervention groups.
Conclusion: Immersive simulation, as demonstrated by this study, has a significant potential to enhance student engagement, motivation, and academic performance, surpassing traditional teaching methods. This potential underscores the urgent need for future research in various contexts to better integrate this innovative educational approach into nursing and midwifery education curricula, inspiring hope for improved teaching methods.

Keywords: Computer simulation; Educational measurement; Nursing student; Virtual reality; Morocco

Immersive simulation in nursing and midwifery education: **a systematic review**

Subject

Impact of immersive simulation on engagement, motivation, and academic performance of nursing and midwifery students

Method
A. Database search
B. Screening
C. Eligibility criteria
D. Data extraction

Study characteristics
6 Countries
Study types:
8 Quasi-experimental
2 Crosse sectional
1 Mixed design
1,090 Nursing students
Included studies published 2019-2024

Result
Immersive simulation approach
Make students engaged
Increase motivation
Good academic performance
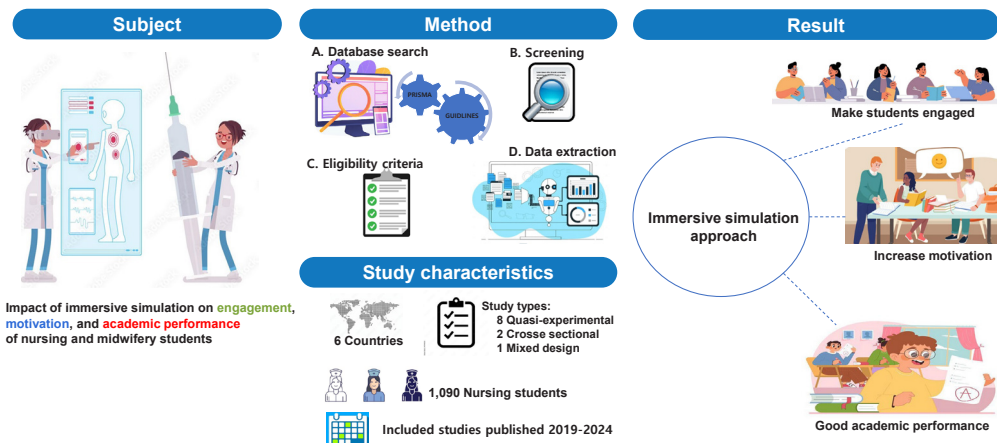
Introduction

Background

Health sciences training is constantly evolving to improve the quality-of-care services by adapting the skills and knowledge of professionals to advances in the field [1]. Traditional education in the health sector encounters numerous challenges. Shortened hospital stays, the specialization of care, patient safety, and a shortage of clinical trainers all contribute to significant limitations in opportunities for conventional training of health professionals, especially in nursing education [2].

Therefore, clinical simulation represents an innovative alternative [3]. It offers diverse educational opportunities to facilitate the learning of complex skills [4]. Furthermore, it enables an in-depth exploration of concepts and their interrelationships, thereby enhancing problem-solving and decision-making [5]. The increasing integration of this approach aims to strengthen student skills [6]. However, this development presents significant challenges related to quality and costs [7,8].

Immersive simulation is an educational method using advanced technologies such as virtual, augmented, and mixed reality to create realistic synthetic environments. It allows participants to immerse themselves and interact with simulated scenarios, promoting learning and skill acquisition in a safe and controlled setting [9]. It enables the creation of highly realistic teaching-learning environments, depicting real-world scenarios while ensuring student safety and mitigating actual risks [10]. Simultaneously, it fosters student engagement, promotes constructive learning, and provides authentic learning experiences [11]. Furthermore, it boosts information retention and the application of knowledge after virtual reality exercises [12]. Students are immersed in interactive experiences, recreating realistic clinical scenarios and significantly enhancing practical training while upholding patient integrity and comfort [13].

However, the effectiveness of immersive simulation has yet to be proven in other contexts. The study conducted by Sarvan and Efe [14] demonstrated that, compared to traditional teaching methods, immersive simulation training based on virtual reality did not result in differences in knowledge, satisfaction, and self-confidence in nursing students. Similarly, Jensen and Konradsen [15] revealed no significant benefits attributed to immersive simulation. Moreover, this approach has counterproductive effects due to the prevalence of cybersickness and associated technological issues or because the immersive experience diverts learners' attention from the main learning objective [16]. Likewise, a meta-analysis found that virtual reality is only as practical as conventional methods for developing nursing skills [17].

These variations in effectiveness highlight the necessity of assessing the impact of immersive simulation on students' learning experiences prior to incorporating this method into educational systems.

Objectives

This review aimed to assess existing research evidence to identify the impact of immersive simulations on nursing and midwifery learning. Specifically, it sought to answer the following research question: How do immersive simulations impact nursing and midwifery students' engagement, motivation, and academic performance?

Methods

Ethics statement

This study did not involve materials of human origin; therefore, neither ethical committee approval nor informed consent was required.

Study design

We described this systematic review according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [18]. Furthermore, we pre-registered the present research protocol in the International Prospective Register of Systematic Reviews (PROSPERO: [CRD42024499405], https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=499405).

Eligibility criteria

The inclusion and exclusion criteria were defined using the PICOS (population, intervention, comparison, outcome, and study design) framework (Table 1).

Information sources

We searched 4 databases: Scopus, PubMed, Web of Science, and Science Direct. Only studies published in English or French from 2019 to February 2024 were reviewed. The last access to the databases was on February 25, 2024.

Search strategy

Two researchers (L.B. and G.C.), worked together to identify the terms, key words, and combinations for inclusion in each database. Examples are provided in Table 2.

Selection and data collection process

Two authors (L.B. and A.N.) worked independently based on

Table 1. Criteria for eligibility

Variable	Description of criteria
Population	Nursing and midwifery students, regardless of their level of study
Intervention	Research that explores immersive simulation or immersive virtual reality.
Comparison	Studies with or without comparison groups employing traditional methods or non-immersive simulations.
Outcome	Studies focusing on nursing and/or midwifery students' engagement, motivation, and academic performance, as these students' experiences and outcomes were at the heart of our research.
Study design	Included studies: randomized controlled trials, case-control studies, cross-sectional studies, or mixed studies. Excluded: qualitative studies, letters to the editor, editorials, conference abstracts, book chapters, and reviews.

Table 2. Search strategies for each database

Database	Terms with a publication date limit February 25, 2024	Combination
Web of Science	#1 ((((((TS = ("immersive simulation")]] OR TS = ("virtual simulation technology")]] OR TS = ("virtual reality")] OR TS = ("Immersive technology-based")] OR TS = ("immersive learning ")] OR TS = ("immersive education technologies ") #2 (TS = ("midwifery education")) OR TS = ("Nursing education") #3 ((TS = ("Engagement")) OR TS = ("Motivation")) OR TS = ("academic performance")	#4: #1 AND #2 AND #3
PubMed	#1 ((((("Immersive simulation"[Title/Abstract]) OR ("virtual simulation technology"[Title/Abstract])) OR ("virtual reality"[Title/Abstract])) OR ("Immersive technology-based"[Title/Abstract])) OR ("immersive learning"[Title/Abstract])) OR ("immersive education technologies"[Title/Abstract]) #2("Nursing education"[Title/Abstract]) OR ("midwifery education"[Title/Abstract]) #3(("academic performance"[Title/Abstract]) OR ("Motivation"[Title/Abstract])) OR ("Engagement"[Title/Abstract])	#4: #1 AND #2 AND #3
Scopus	(TITLE-ABS («Immersive simulation" OR "virtual simulation technology" OR "virtual reality" OR "Immersive technology-based" OR "immersive learning" OR "immersive education technologies»)) AND (TITLE-ABS («Nursing education" OR "midwifery education»)) AND (TITLE-ABS («academic performance" OR "Motivation" OR "Engagement»))	–

the inclusion and exclusion criteria. Titles, abstracts, full texts of articles, and keywords were all examined. Duplicate removal was performed electronically using EndNote X9 (Clarivate). Subsequently, the selection and screening were carried out using Rayyan QCRI (Rayyan Systems Inc.) [19]. Potentially eligible articles were downloaded for a comprehensive analysis. Any disagreements between the 2 authors regarding the selection of studies were resolved by a third researcher (G.C.).

Data items

The following data were extracted from the included studies: general information, including the first author, year of publication, country, and study design, which provide crucial context for the data presented; and specific information, such as sample size, nature of the intervention, educational content, and frequency and duration of the intervention. The specific information was deemed key to understanding each study's findings. The inferential data, which included information on student motivation, engagement, and academic performance expressed in terms of average or median scores or percentages, revealed the impact of the in-

terventions. The measurement instruments used were also considered.

Study risk of bias assessment

Two authors (L.B. and G.C.) independently assessed the risk of bias in the included studies using the Medical Education Research Study Quality Instrument (MERSQI). This instrument consists of 10 items distributed across 6 domains: study design, sampling, types of data, validity of the assessment instrument, data analysis, and outcomes. The total score can range from 5 to 18. Agreement between the results of the 2 reviewers was analyzed using the kappa statistic (κ).

Effect measures

Data were extracted in accordance with the study reports and under the conditions required for each test (analysis of variance [ANOVA], multivariate ANOVA, Student t-test, and correlation coefficient) to facilitate comparisons and identify associations.

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Synthesis methods

Two authors (L.B. and A.N.) conducted data extraction and classification. Each study was reviewed twice to facilitate more precise variable classification. In instances of uncertainty about an instrument or variable, researchers with relevant expertise (G.C. and M.R.) were consulted. The extracted data were analyzed through a narrative synthesis. This process was conducted in 3 phases: the development of a theoretical framework, the execution of a preliminary synthesis, and the exploration of relationships within the data. The theoretical framework, based on the research question, aimed to evaluate the impact of immersive simulation on students' engagement, motivation, and academic performance. The preliminary synthesis involved extracting key findings from each included study, with data systematically organized in a tabular format. Descriptions and contextualization of these findings were provided in the "Results of syntheses" section. The exploration of relationships aimed to identify significant differences between the results of the 2 groups in each study.

Reporting bias assessment

To minimize reporting bias, 2 authors (A.N. and L.B.) investigated the publication processes and conditions of each journal where the included studies were published. Study results were compared with published protocols and registrations to check for selective outcome reporting.

Certainty assessment

Note done.

Results

Study selection

The search strategy identified 90 articles, 42 of which were duplicates. Of the 48 studies for which the titles and abstracts were assessed, 35 were excluded. The remaining 13 studies were selected for further analysis. Finally, 11 studies were included in this review [20-30]. The selection process for the studies included in this review is represented in Fig. 1 using a PRISMA diagram.

Study characteristics

Eleven studies were included in this review. All were conducted in high-income countries: Canada (n = 2) [27,29], Taiwan (n = 2)
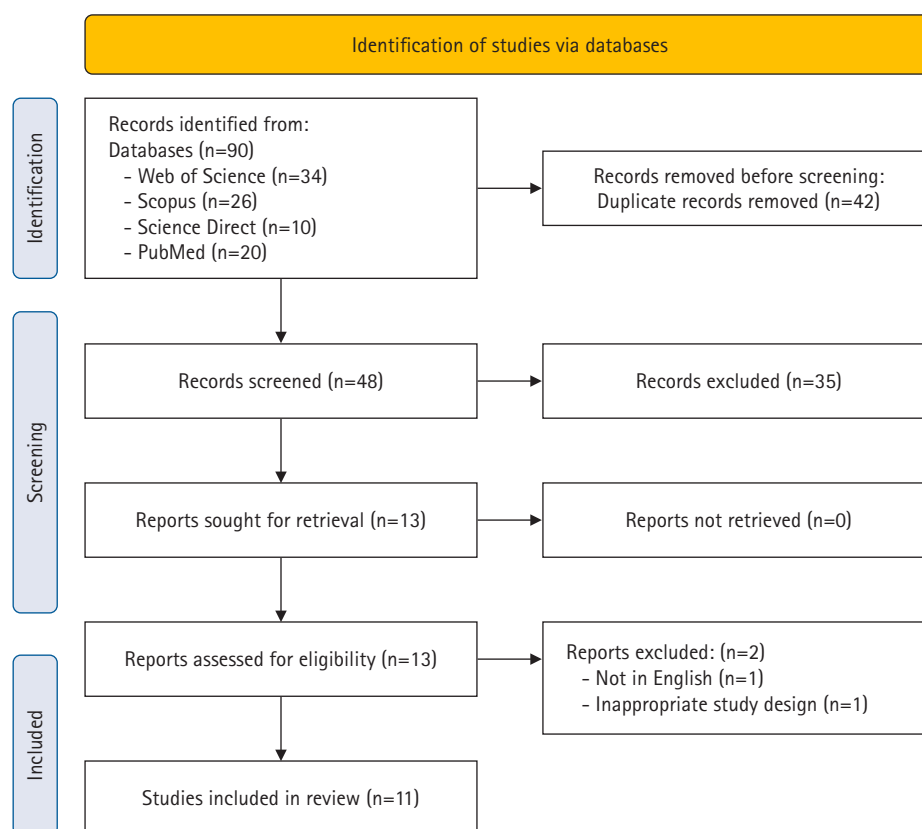
Fig. 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart of the selected studies.

Table 3. Summary of studies included in the review

Author (year) (country)	Study design	Participants/ sample size	Intervention Experimental/ sample	Control/sample	Frequency/ duration	Course content	Study outcomes	Outcomes in accordance with review objectives Outcomes (measurement)	Key findings
Chang et al. [20] (2019) (Taiwan)	QE design; 2 groups; pre-test and post-test	Nursing students/64	SVVR/32	Video/32	Weekly/16 weeks (3 hours 3 sessions)	Childbirth education training	Learning achievement; motivation; critical thinking; learning attitude; learning satisfaction	Learning achievement (3 open-ended questions and 20 multiple-choice items constructed by the authors; Cronbach's $\alpha=0.70$) Motivation (6 items: 3 items for intrinsic and 3 for extrinsic motivation; 5-point Likert scale; Cronbach's $\alpha>0.79$)	Significant effects of the SVVR approach on the learning achievement of students (mean=81.12, SD=0.41) compared to the conventional approach (mean=79.94, SD=0.74); (F=20.30, P<0.001). The 2 groups significantly differed in learning motivation (F=8.37, P<0.05). A stronger correlation was observed between the SVVR approach and nursing students' motivation (intrinsic: $\eta2=0.061$, extrinsic: $\eta2=0.371$).
Chang et al. [21] (2023) (Taiwan)	Mixed method; 1 group; pre- and post-test	Nursing students/128	Intravenous injection virtual VR/128	NA	ND/2.5 hours (10 min per session)	Intravenous injection	Learning motivation; VR acceptance; knowledge.	Learning motivation (14 items; instrument developed by the authors; 5-point Likert scale; Cronbach's $\alpha=0.93$) Knowledge (one open-ended question with the skill-checking list for intravenous injections)	High motivation (score=4.69, SD=0.39; out of 5 points) among VR students. No statistically significant differences existed in the mean learning motivation for VR education across student characteristics. Significant improvement in knowledge scores from the pre-test (mean=3.08, SD=1.29) to the post-test (mean=4.96, SD=2.01) (P<0.001).
Dang et al. [22] (2021) (USA)	QE design; 4 groups; pre- and post-test	Nursing students/160	Immersive telepresence/51	3 groups (roles): AP/29, BO/20, AVO/60	Once/15 min	Medical-surgical course interventions for deep vein thrombosis	Knowledge; engagement; spatial presence; ecological validity/naturalness and negative effects; system usability	Knowledge (20 items; developed and adapted from NCLEX-RN test; 1 point/question, scores from 0 to 20) Engagement (44 items; independent television company sense of presence inventory; 5-point Likert scale; Cronbach's $\alpha=0.962$)	There were no significant differences in knowledge post-test scores among the different roles (AP, AVO, BO, ITO) (F[3, 153]=1.645, P=0.18). Engagement varied significantly, with small effect sizes, among learners in different roles (F [3, 154]=5.297, P=0.002) Engagement in immersive telepresence had significantly higher mean scores than AVO learners (P=0.001).
Hardie et al. [23] (2020) (Ireland)	Crosse sectional design	Nursing students/42 Midwifery students/52	IVR/94	NA	Once/ND	Storytelling 9 months of a baby's life inside the mother's womb	Attitudes; educational practices	Motivation (adapted from [31]; 5-point Likert scale and open-ended responses; Cronbach's $\alpha=0.95$) Engagement (a guide to practitioner research in education outlined by Menter et al. [32])	High levels of motivation toward the IVR storytelling experience mean score of 4.40 (SD=0.63). IVR experience effectively engaged students' imaginations (average score=4.40, SD=0.63).
Lee et al. [24] (2020) (Korea)	QE design; 2 groups; pre- and post-test	Nursing students/120	VR simulation/60	2D video clips/60	Weekly/2-week (1.5 hr/wk)	Mental-health nursing education	Knowledge acquisition; problem-solving; learning satisfaction	Knowledge acquisition (18 multiple choice questions)	No significant difference between the 2 groups regarding knowledge acquisition (t=-1.69, P=0.096)

(Continued on next page)

Table 3. Continued

Author (year) (country)	Study design	Participants/ sample size	Intervention Experimental/ sample	Control/sample	Frequency/ duration	Course content	Study outcomes	Outcomes (measurement)	Key findings
Jung and Park [25] (2022) (Korea)	QE design; 2 groups; pre- and post-test	Nursing students/60	VR/30	Traditional method (handouts)/30	Once/30 min	Chemoport insertion surgery	Motivation; knowledge; learning attitude; satisfaction	Motivation (34 items; modified Instructional Materials Motivation Scale; 5-point Likert scale; Cronbach's α=0.67) Knowledge (10-item questionnaire developed by the authors. Cronbach's α=0.73.)	There was no significant difference in scores for motivation between the 2 groups (t=1.59, P=0.118). There were significant differences between the 2 groups in the subdomains of attention (t=2.51, P=0.016) and relevance (t=2.10, P=0.040). Significant difference in the score for knowledge between the 2 groups (t=4.01, P=0.001).
Lee and Son [26] (2023) (Korea)	QE design; 2 groups; pretest-post-test	Nursing students/76	VR simulation/38	Conventional education/38	ND/20 min	Neurological examination	Transfer motivation; performance; academic self-efficacy.	Transfer motivation (10 items; developed and adapted by Park and Kweon [33]; 7-point Likert scale; Cronbach's α=0.90) Performance (20 items; neurological assessment developed by Newbase Co. Ltd.)	No significant difference in transfer motivation between the 2 groups (t=-1.76, P=0.082). The experimental group had higher neurologic examination performance than the control group (t=-11.62, P<0.001).
Lavoie et al. [27] (2024) (Canada)	QE design; 2 groups; pre- and post-test	Nursing students/179	VR simulation/63	Hybrid simulations (actor and manikin)/116	Once/90 min	Assessment of a 6-month-old child	Engagement; learning satisfaction; learning confidence; mental effort; cognitive load; clinical reasoning	Engagement (12-item User Engagement Scale–Short Scale; items are rated from 0 to 10; Cronbach's α for subscales ranged from 0.86 and 0.93)	Significant difference; the hybrid group showed a higher engagement level than the VR group (t=0.05, P<0.01).
Ma et al. [28] (2023) (USA)	QE design; 2 groups; pre- and post-test	Nursing students/22	VR/11	Video/11	Once/25 min	Safety awareness; regular checking; psychological communication.	Motivation; knowledge gains; simulation sickness; system usability; presence	Motivation (11 questions; Motivated Strategies for Learning Questionnaire) Knowledge gains (based on the contents covered in the VR module and recorded video to collect measurements through pre- and post-test scores)	Equal motivation levels were observed among participants through both the VR approach and video education (t=0.79, P=0.3). The VR and traditional video approaches improved students' knowledge (VR group: pretest mean=3.53, post-test mean=4.64, P<0.05; traditional video group: pretest mean=3.36, post-test mean=5.09, P<0.05).
Thompson et al. [29] (2020) (Canada)	Cross-sectional design	Nursing students/46	VR (low immersive)/46	NA	Weekly/1 hr/wk	Anatomy, physiology, and health assessment	Engagement	Engagement (18 items; modified version of a perceived engagement questionnaire; 5-point Likert scale; Cronbach's α=0.88)	Significantly higher engagement levels in VR, with 91% indicating a preference for VR over traditional methods.
Dubovi [30] (2022) (Israel)	QE design; 2 groups; pre- and post-test	Nursing students/141	VR/72	Vicarious approach/69	ND/85 min	Clinical pharmacology course	Knowledge gains, engagement, sense of presence	Knowledge gains (13 multiple-choice questions with 2 sub-scales; Cronbach's α=0.61 and 0.59); Engagement (adapted Medical Emotions Scale; 5-point Likert scale; Cronbach's α=0.88 for negative emotions, Cronbach's α=0.91 for positive emotions)	No significant differences in the learning knowledge gains between the 2 groups (paired t=-1.62, P=0.11). Higher level of positive emotions in the VR group than in the vicarious condition (t=4.17, P<0.001). No significant differences were found between the 2 conditions (direct condition [VR] versus vicarious condition) in the students' total negative emotions (t=-0.44, P=0.660).

QE, quasi-experimental; SVVR, spherical video-VR; VR, virtual reality; SD, standard deviation; AP, active participant; BO, bedside observer; AVO, audio-visual observer; IVR, immersive virtual reality; NA, not applicable; ND, not detected; 2D, 2-dimensional.

[20,21], the United States (n = 2) [22,28], Ireland (n = 1) [23], Israel (n = 1) [30], and South Korea (n = 3) [24-26] (Table 3) [31-33]. The total number of participants was 1,090 students. Of these, 52 (4.77%) were midwifery students and 1,038 (95.23%) were enrolled in nursing programs. The sample sizes ranged from 22 students [28] to 179 students [27]. Of the 11 included studies, 8 adopted a quasi-experimental design, 2 were cross-sectional studies [23,29], and one adopted a mixed-method design [21]. Most of the included research was monocentric (n = 10) [20-23,25-30], and only one study was multicentric [24]. The studies were published between 2019 and February 2024, with a significant concentration of 54.54% of the publications between 2022 and 2023. Approximately 73% (8 out of 11) of the studies employed virtual reality applications, incorporating computer-generated scenario-based virtual simulations. However, 3 studies adopted different approaches by utilizing 360-degree videos that were recorded and projected in real-time for 2 studies [23,24] and in a delayed format for another study [20]. Regarding the equipment used, 91% (10 out of 11) of the studies adopted fully immersive virtual reality, including head-mounted displays. In contrast, only one study opted for a low-immersive virtual reality device running on a computer [30]. Student engagement was examined in 5 studies [22,23,27,29,30] and motivation in 6 studies [20,21,23, 25,26,28], while academic performance was evaluated in 8 studies conducted among nursing and midwifery students [20-22,24-26,28,30].

Risk of bias in studies

Eleven studies were included in this review [20-30]. As stated in Table 3, 10 [20-23,25-30] were monocentric, while one study [24] was conducted at 2 institutions. Eight studies [20,22,24-28,30] were quasi-experimental, utilizing a 2-group pre-test and post-test design. The average MERSQI score was 11.86 ± 1.63, with a median score of 12.50 (interquartile range, 11.50–13). The MERSQI scores across the studies ranged from 8/18 to 13.50/18. The kappa statistic for inter-rater agreement was κ = 0.79, indicating a high level of agreement among raters [34] and demonstrating the reliability of this review. The results are presented in Table 4.

Results of syntheses

Student engagement

Five of the 11 included studies examined student engagement. Of these, 4 demonstrated an increase in the learning engagement of nursing and midwifery students using an immersive simulation compared to the vicarious approach and technological approach-

Table 4. Evaluation of the quality of the included studies

Study	Sampling			Validity of the evaluation instrument			Data analysis			Outcome					Total score
	Study design	Institution studied	Response rate score	Type of data	Internal structure	Content	Relationships to other variables	Appropriateness of analysis	Sophistication of analysis	Satisfaction, attitudes, perceptions	Knowledge, skills	Behaviors	Patient/ health care outcome		
Chang et al. [20]	2	0.5	1.5	1	1	1	1	1	2	1	1.5	0	0		13.5
Chang et al. [21]	1.5	0.5	1.5	1	1	1	0	1	2	1	1.5	0	0		12
Dang et al. [22]	1.5	0.5	1.5	1	1	1	1	1	2	1	0	0	0		11.5
Hardie et al.[23]	1	0.5	1	1	1	1	0	1	1	1	1.5	0	0		10
Lee et al. [24]	2	1	1.5	1	1	1	0	1	2	1	1.5	0	0		13
Jung and Park [25]	2	0.5	1.5	1	1	1	0	1	2	1	1.5	0	0		12.5
Lee and Son [26]	2	0.5	1.5	1	1	1	0	1	2	1	1.5	0	0		12.5
Lavoie et al. [27]	2	0.5	1.5	1	1	1	0	1	2	1	1.5	0	0		12.5
Ma et al. [28]	2	0.5	1.5	1	1	0	0	1	2	1	1.5	0	0		11.50
Thompson et al. [29]	1	0.5	0.5	1	1	1	0	1	1	1	0	0	0		8
Dubovi [30]	2	0.5	1.5	1	1	1	1	1	2	1	1.5	0	0		13.5

es such as video-based learning [22,23,29,30], while one study indicated that hybrid simulations (actor and manikin) led to better learning engagement than virtual simulation [27]. A study conducted by Dang et al. [22] in 2021 reported a statistically significant difference (P = 0.001) in engagement among learners in various roles. Specifically, learners in immersive telepresence roles exhibited significantly higher average engagement scores than those in audio-visual observer roles. Although statistically significant, these differences had a negligible effect size, suggesting their theoretical impact may be limited. Furthermore, 2 cross-sectional studies have reported that the immersive virtual reality experience was more engaging than traditional methods. One study found that a staggering 91% of participants preferred immersive virtual reality over traditional approaches [29], indicating a strong preference for immersive simulation. In another study conducted by Hardie et al. [23], involving 42 nursing and 52 midwifery students, high levels of motivation toward the immersive virtual reality storytelling experience were noted, with a mean score of 4.40 (standard deviation [SD] = 0.63). Moreover, a study conducted by Dubovi [30] with a sample of 141 nursing students revealed no significant difference in terms of negative emotions (e.g., anxiety, frustration, and fear) between the 2 groups (t = -0.44, P = 0.660) [30]. However, a significant difference was observed in positive emotions (e.g., pleasure, pride, happiness, and curiosity), with higher levels in the virtual reality group than in the vicarious approach group (t = 4.17, P < 0.001). Additionally, positive emotions were positively correlated with learning gains exclusively in the immersive virtual reality condition. However, a study conducted by Lavoie et al. [27] reported that students reported significantly higher levels of learning engagement in the hybrid simulation (combining actor and mannequin) with a mean score of 5.5 (SD = 1.2) than in the virtual simulation group, which had a mean score of 5.1 (SD = 1.4). This indicates a small but statistically significant difference (t = 0.05, P < 0.01) in engagement scores between the control group and the immersive simulation group [27].

Student motivation

Of the 11 studies included, 6 focused on student motivation [20,21,23,25,26,28]. Among these, 3 studies revealed a significant boost in student motivation within the experimental group using virtual simulation methods compared to conventional methods involving video technology and clinical simulation [20,21,23]. A study by Chang et al. [20] was particularly insightful, showing a significant difference (F = 20.30, P < 0.001) in student motivation in the virtual reality group. Both intrinsic and extrinsic motivation levels were found to be statistically significant (intrinsic: F = 3.95,

P < 0.05; extrinsic: F = 36.04, P < 0.01) in the immersive simulation group compared to the control group. This strong correlation between the virtual reality approach and students' intrinsic (η^2 = 0.061) and extrinsic (η^2 = 0.371) motivation points toward a substantial impact of this approach on their motivation levels. A study by Chang et al. [21] among 128 nursing students further reinforced this, reporting a high mean motivation of 4.69 (SD = 0.39) out of 5 during virtual reality learning. This high level of motivation is a promising sign of the potential of virtual reality in education. However, no statistically significant differences were found in learning motivation for virtual reality teaching according to student characteristics, including gender and experience of different games [21]. Likewise, Hardie et al. [23] reported that the 52 midwives and 42 nurses participating in the study expressed high levels of motivation toward the virtual reality interactive storytelling experience, achieving an overall mean score of 4.40 (SD = 0.63). However, Jung and Park [25] found no statistically significant difference (t = 1.59, P = 0.118) in the total motivation scores between the groups using virtual methods and those using traditional methods (handouts). Nevertheless, significant differences were observed between the 2 groups in the subdomains of motivation, particularly concerning attention (t = 2.51, P = 0.016) and relevance (t = 2.10, P = 0.040). The authors reported improved motivation scores in the virtual reality group [25]. However, 2 studies found no significant difference in motivation between participants in the experimental and control groups. Lee and Son [26] reported no significant difference in transfer motivation between the 2 groups (t = -1.76, P = 0.082). Similarly, Ma et al. [28] reported in 2023 that the level of motivation among students was equivalent in both the virtual reality approach and the video-based approach (t = 0.79, P = 0.3).

Academic performance

The concept of academic performance is interpreted differently in the literature; hence, a broad interpretation has been adopted in this review. This concept includes learning achievement [20], knowledge [21,22,25], knowledge acquisition [24], performance [26], and knowledge gain [28,30]. Among the included studies, 8 assessed the impact of the immersive simulation approach on students' academic performance [20-22,24-26,28,30]. The learning content varied greatly in terms of context and environment. In the cognitive context, 5 studies investigated the improvement of basic skills necessary for managing pregnant women [20] and patients with schizophrenia [24], assessing patient consciousness [26], safety awareness, regular monitoring [28], and drug administration [30]. Four other studies examined the impact of immersive simulation on students' performance across various procedural

skill domains, including intravenous insertion [21], medical-surgical interventions [22], regular checking communication [28], and Chemoport insertion surgery [25]. Four studies demonstrated a positive impact on students' knowledge gains and skills compared to conventional approaches. A study conducted by Chang et al. [20] among 64 nursing students showed that immersive virtual reality had significantly better effects (F = 20.30, P < 0.001) on student learning achievements than a video-based learning approach. In addition, this investigation demonstrated a stronger correlation with nursing students' learning outcomes (η^2 = 0.253). Moreover, a study carried out by Chang et al. [21] involving a sample of 128 nursing students revealed a significant improvement (P < 0.001) in knowledge scores from pre-test (mean = 3.08, SD = 1.29) to post-test (mean = 4.96, SD = 2.01). Two investigations conducted by Jung and Park [25] and Lee and Son [26] demonstrated a significant difference (P < 0.001) in knowledge scores between the control group and the virtual reality group, in favor of the latter. However, the results of 3 studies indicate no statistically significant difference (P > 0.05) in the improvement of participants' knowledge and performance between the group with the traditional methods (including clinical simulation, video-based learning, and vicarious approaches) and the group with the virtual reality method [22,24,30]. Nonetheless, these studies demonstrated improvements in knowledge acquisition within each group (control and experimental) based on post-test scores compared to pre-test scores. A fourth study conducted by Ma et al. [28] in 2023 reported that the virtual reality approach was at least equivalent to the video-based educational approach in terms of knowledge gains (virtual reality group: pre-test mean 3.53, post-test mean 4.64; P < 0.05; video group: pre-test mean 3.36, post-test mean 5.09; P < 0.05).

Reporting biases

All included studies were published in peer-reviewed journals. However, it was not possible to determine whether all the results were included in the published reports.

Discussion

Interpretation

This review aimed to evaluate the effect of immersive simulations on the engagement, motivation, and academic performance of nursing and midwifery students. The findings demonstrate that immersive simulations have been effectively used to moderately enhance students' engagement, motivation, and academic performance compared to traditional learning methods, including video-based approaches, vicarious approaches, and clinical simula-

tions. This conclusion is in line with a previous review [17].

Immersive simulation, an emerging approach in healthcare education, significantly enhances student engagement, motivation, and performance in nursing and midwifery education. This innovative pedagogical approach immerses students in authentic environments, providing concrete training opportunities that closely resemble real-life situations. It ensures that students experience safer, more motivating, and engaging learning scenarios, leading to higher satisfaction levels and better knowledge retention. The design of scenarios in immersive simulation allows students to learn in safer environments while prioritizing patient safety. The most promising outcome is the significant improvement in student performance, a testament to the effectiveness of this approach.

Comparison with previous studies

Regarding student engagement, most studies (80%) have shown a significant increase in post-test engagement scores when learning through immersive simulation compared to those trained using conventional methods. This finding aligns with previous research [35]. However, a study by Jensen and Konradsen [15] in 2017, which is of particular importance, found that immersive simulation may only sometimes be advantageous. They reported that it could even be counterproductive due to physical discomfort, technical issues, and distractions for students [15]. This study's findings are a crucial part of the broader discussion on the effectiveness of immersive simulation in student engagement, emphasizing the potential counterproductivity that educators and researchers should be concerned about [15].

The positive impact of virtual simulations on student engagement can be attributed to factors such as ergonomic design, ease of use, interactive features of virtual reality, and the shift from a passive to an active posture, thereby enhancing their autonomy and engagement [36,37]. Furthermore, immersive simulation facilitated by virtual reality plays a crucial role in bridging the gap between theoretical knowledge and practical application. It makes it possible to design scenarios that include authentic learning situations resembling real-life contexts [38]. It also ensures immersion in the virtual environment, providing a level of realism that enables students to connect their theoretical knowledge to authentic situations, effectively engaging them in their training process [39].

Only one study [30] included in our investigation reported a strong correlation between student engagement and the positive emotions generated by the use of virtual reality, corroborating the conclusions of a previous study [40].

Concerning motivation, the predominant trend in the reviewed

studies is significant. Five of the 6 studies revealed higher motivational scores among students using immersive virtual reality simulations than among those using conventional methods involving video technology and clinical simulation. This consistent trend underscores the positive effect of this approach on student motivation. Our conclusions align with previous studies [41,42]. However, a study by Parvaie et al. [43], which involved 36 dental students in Iran, is a significant outlier. It did not demonstrate the effectiveness of immersive simulation in improving student motivation compared to traditional lectures. Instead, the conventional method was found to be equally effective in motivation [43]. It is essential to acknowledge this outlier study as it highlights the diversity of findings in the field.

The positive impact of immersive simulation on student motivation can largely be explained by the ability of virtual reality to engage students in learning experiences within virtual environments. These environments offer hands-on training opportunities and allow detailed observations, providing a wealth of information in a safe learning context, thereby fostering positive attitudes and meeting educational expectations [44,45]. Among the studies reviewed in this investigation, the study conducted by Jung and Park [25] in 2019 demonstrated that immersive simulation significantly improved nursing students' intrinsic and extrinsic motivation. Furthermore, this study revealed a strong correlation between immersive simulation and students' intrinsic and extrinsic motivation levels. A second study in our review reported no significant difference in overall motivation between students using virtual reality and students using the traditional handout approach [25]. Despite the lack of statistical significance, the virtual simulation group exhibited improvements in motivation subdomains, particularly in attention and relevance. These results can be attributed to the satisfaction experienced by participants during the immersive simulation sessions [46].

Regarding academic performance, out of the 8 studies that investigated the effect of immersive simulation on this outcome, 5 reported a positive impact on student performance compared to traditional methods such as lectures, textbooks, and hands-on activities. These findings are consistent with those of previous studies [47]. However, 3 studies did not find significant differences between the 2 approaches (immersive simulation and traditional) [22,28,30]. The pre-test and post-test improvements were similar in both groups, corroborating the results of previous studies [17].

Immersion in interactive environments can improve theoretical knowledge and procedural skills. Learners can control situations, promoting the practical application of knowledge in contexts similar to clinical environments and high levels of student engagement and motivation [48,49]. Immersive simulation, with its em-

phasis on safety, provides experiences that are conducive to learning. It facilitates the visualization and manipulation of structures and interaction with virtual patients, which increases confidence and satisfaction and optimizes learning time [50].

Limitations

This study, while valuable, has several limitations. The inclusion of various virtual reality technologies introduced heterogeneity, making it challenging to conduct a meta-analysis. Variations in the duration, types of interventions, and methods of evaluating outcome indicators may have influenced the conclusions. Furthermore, the research focused on nursing students in high-income countries, neglecting other socio-economic contexts. Future research that addresses these limitations has the potential to significantly strengthen the evidence for the effectiveness of this educational approach, thereby impacting the field of nursing education.

Implications

Implications for policymakers:

The results of this review underscore the potential benefits of integrating immersive simulation into educational practices and curricula. Policymakers can consider these findings to support the adoption of innovative educational technologies that improve learning outcomes.

Implications for educators and practitioners:

For educators and practitioners, the findings indicate that immersive simulation can enhance educational experiences, particularly when thoughtfully integrated to complement existing pedagogical methods. This data supports the possibility that immersive simulation can be used as an adjunct rather than a complete replacement for traditional methods.

Conclusion

The review explored the impact of immersive simulation on nursing education and midwifery. It revealed that virtual reality technology moderately enhances nursing students' engagement, motivation, and performance. However, virtual reality shows no significant differences in certain aspects compared to traditional teaching methods. Despite the undeniable transformative potential of immersive simulation in nursing education and its extensive theoretical examination as an innovative pedagogical approach within this field, a persistent gap in substantial empirical research limits a definitive evaluation of its effectiveness and justification. The successful incorporation of virtual reality into nursing curricula requires detailed exploration and careful consideration. Fur-

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ther research is essential to enhance students' virtual reality proficiency effectively. To successfully integrate immersive simulation into nurse and midwife training, assessing its impact across diverse socio-economic contexts, including the Middle East and North Africa region, is imperative.

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Conflict of interest

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Supplementary materials

Supplement 1. Audio recording of the abstract.

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