Systematic Review: Effect of extended reality simulation intervention on midwifery students' anxiety

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Submitted to: Journal of Medical Internet Research
on: November 19, 2024

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Abstract

Background: Midwifery students often experience anxiety due to several factors such as the clinical experiences faced. Simulation-based learning in nursing and midwifery studies using extended reality (XR) tools offers the opportunity to better manage educational processes while reducing this anxiety.

Objective: This study aims to evaluate the current understanding of how the use of XR gesture-simulation-based tools allows a better understanding of the anxiety levels of midwives and nurses in educational settings.

Methods: We conducted a systematic review. A scientific literature search using PubMed, IEEE, Scopus, and Web of Science, up to March 2024, was performed to identify studies that reported the effectiveness of these technologies for gesture simulation in education and training on nursing and midwifery student anxiety.

Results: Seven articles, involving a total of 428 participants, were included in this review. The findings indicate that XR can effectively reduce anxiety in midwifery and nursing education.

Conclusions: However, the limited number of studies highlights a research gap in the field, particularly in the area of mixed reality, which warrants further exploration.

(JMIR Preprints 19/11/2024:68984)
DOI: https://doi.org/10.2196/preprints.68984

Original Manuscript

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KEYWORDS: Anxiety; extended reality; gesture simulation; nursing education; ; midwifery education

Introduction

Anxiety is an emotion or state characterized by worry, tension, and physical manifestations such as increased blood pressure. Anxiety is often experienced in midwifery students due to heavy course load, high expectations, and the clinical experiences faced [1].

According to a mental health survey conducted by the National French Association of Midwifery Students (ANESF), with responses from 2000 students, 47% of the respondents showed a probable generalized anxiety disorder (as indicated by the GAD-7 test, General Anxiety Disorder-7, with a score of ≥ 10)[2] [3].

Simulation-based learning is an important education modality because it allows students to learn from mistakes in a risk-free setting, acquire necessary competencies, practice decision-making, and significantly reduce potentially fatal medical errors [4]. More precisely, through gesture simulation, students can interact with virtual environments using hand movements and gestures, thereby reinforcing muscle memory and enhancing kinesthetic learning. This hands-on approach enables students to better grasp complex concepts, refine their motor skills, and simulate real-world scenarios with greater accuracy. Additionally, gesture simulation fosters active engagement and participation, allowing students to feel more connected to the learning process and empowering them to take ownership of their education [5].

Extended Reality (XR) is a general term encompassing Augmented Reality (AR), Virtual Reality (VR), Mixed Reality (MR), and any other related immersive technology.

- *AR* overlays digital information like images, text, or 3D models onto the real-world environment viewed through a device's camera. The digital content is superimposed on the real world, enhancing the user's perception of reality [6].
- *VR* completely immerses the user in a synthetic digital environment, replacing the real world with a simulated one. Users experience this artificial 3D environment through a headset that blocks out their physical surroundings [7].
- *MR* seamlessly blends and anchors digital objects into the real world, allowing users to interact with physical and virtual elements in real time. The virtual objects in MR are integrated into and responsive to the real environment, creating a unified, interactive experience [8].

These tools blend physical and virtual environments and over the last years, they have been in many fields, such as healthcare education or professional contexts, since they have the potential advantage of scalability, enhanced motivation, and cost savings [9].
By introducing XR simulation tools in midwifery education, the students can better understand complex concepts, practice skills in a safe environment, and build confidence in their abilities, reducing anxiety-inducing situations.

Methods

Research question

The first step was the formulation of the research question, aiming to explore the impact of extended reality gesture-simulation-based tools on the anxiety levels of midwives and nurses involved in educational training.

- How much do we know about the effectiveness of extended reality gesture-simulation-based tools on the anxiety levels of midwives and nurses involved in educational training?

To answer the question, we performed the systematic review using the PICO (population, intervention, control, and outcomes) framework, which is an evidence-based practice to frame and answer a scientific endeavor [10].

• *Population*: Midwives and nurses of any type
• *Intervention*: Extended reality gesture simulation-based training or simulation education intervention aimed at reducing anxiety
• *Comparison*: Standard training methods or absence of specific anxiety-reduction interventions. Pre- and post-intervention anxiety levels
• *Outcome*: Assessing anxiety levels or anxiety-related outcomes

Keyword search

The search query was defined according to the previously established PICO framework. The first category of keywords was related to the population, nurses or midwives, such as: ”midwife” OR ”obstetrics” OR ”nurse” OR ”nursing”.
The second category of keywords, related to the intervention, included: ”extended reality” OR ”XR” OR ”augmented reality” OR ”AR” OR ”virtual reality” OR ”VR” OR ”mixed reality” OR ”3D”.
The third and last category was related to the desired outcome, including: ”anxiety” OR ”anxious”.
The combination of all these keywords resulted in the final query:

- ("midwife" OR "obstetrics" OR "nurse" OR "nursing") AND (“mixed reality” OR “MR” OR "extended reality" OR "XR" OR "augmented reality" OR "AR" OR "virtual reality" OR “Simulation” OR “Simulated” OR “3D”) AND ("anxiety" OR "anxious")

Screening criteria

Different search tools, including PubMed, IEEE, Scopus, and Web of Science, were used to perform the systematic research with the previously defined keywords. The database search was performed on the 25 of March 2024. Besides, the articles retrieved from another similar systematic review were analyzed to see whether they could be included [11].
In total, 1005 articles were found. By screening the articles using the inclusion/exclusion criteria, 7 articles were selected for the review.

Relevance and topic proximity: inclusion and exclusion criteria

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology was used to search and screen articles [12]. The whole process is summarized in Figure 1.

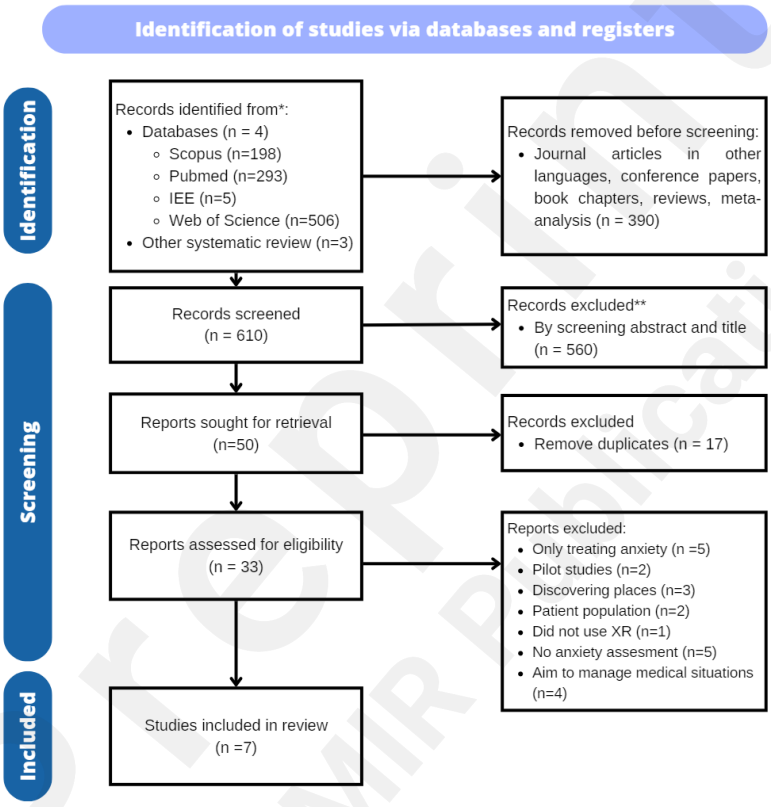

Figure 1: PRISMA 2020 flow diagram [12]

The initial choice was to narrow down the results by only selecting articles in English published in a peer-reviewed journal, randomized controlled trials (RCTs), non-randomized, non-controlled trials.
The second selection phase encompassed screening titles, keywords, and abstracts, followed by the removal of duplicate articles. Throughout the process, the inclusion and exclusion criteria explained in Table 1 were applied.

	Inclusion criteria	Exclusion criteria
Population	Nurses, midwives, and nursing and midwifery students of any kind	Any type of health professional or other students, any other population such as patients
Intervention	Any *virtual/ augmented/ extended reality simulation training tool* to perform a *procedure* (VR glasses such as HoloLens, Oculus Rift, or any other type of device as the CAVE) used to reduce	Any other tool or simulator not used in this setting

	anxiety	
Comparator	XR simulation vs other standard training methods, or pre- and post-intervention anxiety levels	-
Outcome	Anxiety assessment	-
Study design, type of publication	Articles in English published in a peer-reviewed journal, randomized controlled trials (RCTs), non-randomized, non-controlled trials	Journal articles in other languages, conference papers, book chapters, reviews, meta-analysis pilot studies, proof of concept

Table 1: Inclusion and exclusion criteria for article screening

Results

Summary of the Chosen Articles

Table 2 summarizes the results of the systematic review. Below is a brief summary of each of the articles included in the review.

TTITLE	Year	Author	Journal	Location	Learning Object	Population	Software and devices	Anxiety evaluation	Varibles
The effects of neonatal resuscitation gamification program using immersive virtual reality: A quasi-experimental study	2022	Yang et Al.	Nurse Education Today	South Korea	Simulating & performing procedures	Nursing Students (n=88)	HMD: Oculus Rift S (VR) - 50 min gamification program	STAI (State-Trait Anxiety Inventory)	Knowledge, problem-solving, clinical reasoning ability, self-confidence, anxiety, learning motivation
Immersive virtual reality (VR) training increases the self-efficacy of in-hospital healthcare providers and patient families regarding tracheostomy-related knowledge and care skills A prospective pre-post study	2021	Chiang et A	Medicine Op	Taipei, Tai	Simulating & performing procedures	Healthcare providers (n=60)	HMD-VR Web-based VR Desktop Tablet Smartphone - 2hour training with 15minute VR	Personalized Likert scale questionnaires	Familiarity Confidence Anxiety Knowledge Skills
Pediatric Chest Compression Improvement Via Augmented Reality Cardiopulmonary Resuscitation Feedback in Community General Emergency Departments: A Mixed-Methods Simulation-Based Pilot Study	2023	Kleinman et Al.	The Journal of Emergency Medicine	Baltimore, USA	Simulating & performing procedures	Nurses (n=36)	HMD (AR) - 18 minute course	Qualitative invdividual interviews post-intervention	Performance, Anxiety (quali)
Effects of virtual reality training on decreasing the rates of needlestick or sharp injury in new-coming medical and nursing interns in Taiwan	2020	Wu et Al.	Journal of Educational Evaluation for Health Professions	Taipei, Taiwan	Simulating & performing procedures	Medical & Nurses Interns (n=109)	Game-based VR training	Personalized Likert scale questionnaires	Performance, Anxiety (quali)
A mixed-methods feasibility study to assess the acceptability and applicability of immersive virtual reality sepsis game as an adjunct to nursing education	2021	Adhikari et Al.	Nurse Education Today	Edinburgh	Simulating & performing procedures	Nursing Students (n=19)	Three-dimensional computer-based simulation - VR 20-30minutes	NASC- CDM before and after intervention	Anxiety (NASC-CDM), self-efficacy, acceptability, applicability
Virtual versus face-to-face clinical simulation in relation to student knowledge, anxiety, and self-confidence in maternal-newborn nursing: A randomized controlled trial	2016	Cobbett et Al.	Nurse Education Today	Canada	Simulating & performing procedures	Nursing Students (n=56)	F2F high fidelity manikin simulation. VCS with a computer. 2x45 min VR sessions	NASC- CDM before and after intervention	Simulation Completion Questionnaire, Anxiety(NASC-CDM), Knowledge
Evaluation of practical exercises using an intravenous simulator incorporating virtual reality and haptics device technologies	2012	Jung et Al	Nurse Education Today	Korea	Simulating & performing procedures	First-year nursing students (n=60)	VR IV training simulator utilizing haptics skills - 10 minute session	Evaluated State Trait Anxiety using Visual Analogue Scale before and after intervention	State trait anxiety, VAS, Performance, Satisfaction

Table 2: Systematic review results

1. *The effects of neonatal resuscitation gamification program using immersive virtual reality: A quasi-experimental study* [13]

A non-randomized controlled simulation study with a pretest-posttest design evaluated a neonatal resuscitation gamification program using immersive VR. Prelicensure nursing students were divided into intervention and control groups. The study assessed outcomes such as neonatal resuscitation

nursing knowledge, problem-solving skills, clinical reasoning ability, self-confidence in practical performance, anxiety levels, and learning motivation. The simulation group presented lower anxiety levels, compared to the VR and control groups. Anxiety was measured with the STAI (State-Trait Anxiety Inventory), a commonly used questionnaire to asses an individual's tendency to suffer anxiety [14]. Limitations include the inability to assess long-term effects through follow-up surveys and the lack of measurement for actual intervention competency reinforcement, relying solely on self-reported questionnaires.

2. *Immersive virtual reality (VR) training increases the self-efficacy of in-hospital healthcare providers and patient families regarding tracheostomy-related knowledge and care skills A prospective pre-post study* [15]
A prospective pre-post study compared healthcare providers' tracheostomy care training using immersive VR with head-mounted displays and web-based modules versus traditional text materials. According to a personalized Likert-scale questionnaire, most providers in the VR group found that interactive visual demonstrations improved comprehension and reduced anxiety. Limitations included a small sample size, a short follow-up period, and reliance on self-reported feedback rather than quantitative measures of skill acquisition and patient outcomes. Larger, long-term studies with objective assessments are needed to evaluate the efficacy of VR training in improving tracheostomy care competency.

3. *Pediatric Chest Compression Improvement Via Augmented Reality Cardiopulmonary Resuscitation Feedback in Community General Emergency Departments: A Mixed-Methods Simulation-Based Pilot Study* [16]
An unblinded, randomized, crossover simulation-based study evaluated whether AR-CPR improves chest compression (CC) performance in non-pediatric-specialized community emergency departments. Participants performed CC with and without AR-CPR guidance in random order. Qualitative interviews suggested AR-CPR could be usable without device orientation, effective at cognitive offloading, and capable of reducing anxiety while boosting confidence. However, limitations included not excluding individuals with corrective eye lenses, which might affect the AR experience and the lack of feedback during non-AR-CPR cycles, unlike real-world scenarios where feedback devices are common.

4. *Effects of virtual reality training on decreasing the rates of needlestick or sharp injury in new-coming medical and nursing interns in Taiwan* [17]
The prospective cohort pre- and post-study evaluated a new VR game, designed to teach safe and unsafe behaviors regarding universal precautions on needlestick and sharp injury prevention among incoming medical and nursing interns in Taiwan. The game focused on making correct safety choices. Many participants reported reduced anxiety about preventing these injuries in the personalized Likert-scale questionnaires. However, the study's reliance on self-reported questionnaires could introduce reporting bias, and trainees might report behaviors aligning with their training, potentially skewing results.

5. *A mixed-methods feasibility study to assess the acceptability and applicability of immersive virtual reality sepsis game as an adjunct to nursing education* [18]
A two-stage sequential mixed-methods feasibility study assessed the impact of an immersive VR sepsis game on pre-registration nurses. The study examined its effect on self-efficacy and perceptions of its acceptability and applicability in nursing simulation education. In the first stage, pre- and post-intervention self-efficacy scores were collected from 19 pre-registration nurses using the Nursing Anxiety and Self-Confidence with Clinical Decision-Making Scale (NASC-CDM). The second stage used a descriptive qualitative approach to explore perceptions of the game. Results showed a

significant 23.4% decrease in anxiety. Limitations included the small sample size, the novelty of the educational approach, and the measurement of self-efficacy at a single time point.

6. *Virtual versus face-to-face clinical simulation in relation to student knowledge, anxiety, and self-confidence in maternal-newborn nursing: A randomized controlled trial* [19]
This randomized pretest-posttest study compared the effectiveness of two maternal newborn clinical simulation scenarios: virtual clinical simulation and face-to-face high-fidelity manikin simulation. Although no statistically significant differences were found in student knowledge and self-confidence between the two modalities, anxiety scores, measured by the NASC-CDM, were higher for students in the virtual simulation. Limitations included small sample size, potential intervening variables like student motivation, interest, and technological competence, and lack of orientation to the virtual platform, which may have influenced their responses.

7. *Evaluation of practical exercises using an intravenous simulator incorporating virtual reality and haptics device technologies* [20]
This randomized control trial assessed the educational effectiveness of practical exercises using IV simulators with VR/haptics technologies. First-year nursing students were assigned randomly to three groups: Group A (conventional IV arm), Group B (VR/haptics IV simulator), and Group C (both IV arm and IV sim). Group C scored highest in venipuncture procedures, while Group B excelled in injections. Group C completed venipuncture faster than Group B and slightly quicker than Group A. State-trait anxiety was measured using a Visual Analogue Scale before and after the intervention. All groups showed reduced anxiety post-venipuncture, with no significant differences. Limitations included insufficient practice time due to curriculum constraints and the study's single-school, single-country setting, which limits generalizability and cultural diversity.

Learning object

All of the papers had a common general learning objective: simulating and performing procedures. However, the clinical foci covered in the selected papers differed.
Two of the studies focused on reducing anxiety around newborn care. The first was a non-randomized controlled simulation with an immersive VR neonatal resuscitation gamification program, enabling hands-on experience in a virtual environment [13]. Similarly, a mixed-methods simulation-based pilot study used AR to teach pediatric chest compression [16].
Two pre- and post-comparison studies used serious games to teach and reduce anxiety in students. Occupational needle stick or sharp injury prevention was sought through a game of right and wrong choices for safe or unsafe universal precaution behaviors [17]. The other utilized a three-dimensional, computer-based simulation sepsis game [18].
Cobbett & Snelgrove-Clarke in [19], conducted a randomized experimental pretest-post-test research design to evaluate virtual clinical simulation, in preeclampsia and Group B streptococcus scenarios.
Another study was a randomized controlled trial that divided the first-year nursing students into three groups learning how to practice injections. A virtual reality IV training simulator utilizing haptics skills was evaluated, along with its effect on reducing students' anxiety towards this procedure [20].
Lastly, a pre-post comparative prospective study used a combination of head-mounted display VR and smartphone app VR in an environment for tracheostomy-related materials. The virtual teachings on how to dress the stoma or handle emergencies such as aspiration, aimed to reduce anxiety among healthcare providers [15].

Participants

All the selected articles included nurses, midwives, or nursing and midwifery students of any kind. In total, 428 individuals participated in the studies and 332 were nursing students, mixed with other

medical students. Only two studies included 96 professional healthcare providers [15], [16].
Exclusion criteria varied across the studies. In one case, they excluded those with prior clinical or VR experience, recruiting 88 prelicensure nursing students (VR group = 31, simulation group = 28, control group = 29) [13]. The groups were homogeneous in sex, satisfaction with the nursing major, clinical practice training, and demand for XR education, but differed in anxiety levels.

Two studies included third-year nursing students, with 56 and 19 participants respectively[18][19]. The age ranges and gender proportions were similar: 20-44 years, mostly female (84%), with no previous degree (81%) in the former study, and 25-45 years, with 74% female in the latter. No statistical differences were found between the types of simulation groups.
One invited both 50 medical and 59 nursing interns [17]. Nursing interns were aged 17-22, and medical interns 20-29. Female representation was 85% in nursing and 52% in medicine. The previous deep occupational experience was 34% in nursing and 61% in medicine.
In one study, 36 professional nurses (18 per group, AR and no AR) evenly distributed by age, sex, clinical role, and experience participated, with participants excluded based on their medical specialty [16]. Also involving 60 professional health care providers, including physicians, nurses, and respiratory therapists, in the study they randomly divided participants into regular and intervention groups, excluding those with incomplete training or questionnaires [15]. A similar exclusion criteria was applied to the same number of nursing students, ensuring homogeneity in age, gender, anxiety, and IV knowledge [20].

Devices used to create the extended reality scenarios and duration of the intervention

Six articles used VR interventions, while one employed AR [16]. Three studies used a Head-Mounted device [13], [15], [16], three relied on computer-based simulations [18], [19], [20], and one used a mobile-device application [17].
The duration of the training sessions varied minimally across the studies, ranging from a 10-minute VR session [20], to a 50-minute gamification program [13]. Notably, only one conducted two sessions [19], while the others performed a single XR experiment.

Analysis and Anxiety Assessment Methods, Variables evaluated

Throughout the studies, common elements were analyzed. The seven articles evaluated anxiety using various methods, such as personalized Likert scale questionnaires [17], [15]. Two of the articles [18], [19] employed a specific tool to measure anxiety pre-test and post-test, the Nursing Anxiety and Self-Confidence with Clinical Decision Making Scale (NASC-CDM), which aims to provide insight into the emotional aspects of clinical decision-making, which can impact nursing performance and patient care outcomes [22].
One evaluated state-trait anxiety by distinguishing between temporary anxiety influenced by environmental factors and the more stable, underlying trait anxiety[20]. The transient anxious state was assessed using the Visual Analogue Scale, which consists of a 10-cm horizontal line with marked points corresponding to different levels of worry, such as “Not worried at all,” “Worried a little bit” and “Very worried,”. Each selected point is converted into its corresponding numeric score for quantitative analyses. This analysis was performed and compared pre- and post-test.
Lastly, in [16] they assessed anxiety by performing qualitative individual interviews while evaluating the rate and depth of chest compressions to provide AR feedback and therefore measure performance simultaneously.
Other aspects of the studies were evaluated, including knowledge pretest and post-test related to preeclampsia and group B strep, a Simulation Completion Questionnaire [19], knowledge related to neonatal resuscitation [13], or an MCQ on tracheostomy care and skills [15]. Another qualitative approach explores student nurses' perceptions of the game [18], while others evaluated only the

performance of the subjects, regardless of the knowledge acquisition [17], [16].

Anxiety outcomes after XR intervention

After assessing and analyzing the results, most of the articles reported positive outcomes concerning anxiety reduction. Four studies reported decreased anxiety levels after the XR intervention. In [16], participant feedback supported that AR-CPR could be effective for cognitive offloading, reduction in performer anxiety, and increase of performer confidence in the care delivered. In the case of [17], 68% of nursing and 58% of medical interns reported that the extended reality intervention significantly decreased their anxiety about occupational needle injury prevention, and also in [18] the participants reported a 23.4% decrease in anxiety. Additionally, in [15] intervention group trainees reported that they “strongly agree” or “somewhat agree” with the statement of experiencing reduced anxiety for tracheostomy-related knowledge and care skills (93 ± 2% and 75 ± 6%, P = .002) compared to the regular group.

In [20], no statistical differences among the three groups were found. State anxiety and VAS for anxiety decreased in all groups after venipuncture.

Two studies reported higher anxiety in the intervention group. In [13] the anxiety score of the three groups decreased from pre-intervention to post-intervention (VR group: 59.14 ± 9.62 to 56.72 ± 7.50; simulation group: 66.46 ± 8.60 to 57.65 ± 10.35; and control group: 59.50 ± 8.35 to 57.65 ± 6.86). However, the VR group did not show significant improvement compared to the simulation and control groups, with the highest difference observed in the simulation one.

Also, anxiety scores were higher for students in the virtual clinical simulation than for those in the face-to-face simulation [19]. However, the new technology rather than the VR simulation itself might have caused the increased anxiety. Additionally, students were more comfortable with the mannequin, as they had prior exposure to this type of exercise.

Authors’ opinions and main limitations of the studies

The authors consider that the studies provided improvement in knowledge [13], demonstrated feasibility [15], improved educational quality [16], presented a promising pedagogical approach [18], and were educationally and cost effective, as they allowed for repeated simulations [19]. This characteristic among others, contributes to the reduction of anxiety [20].

Nevertheless, even if the results were positive, all the studies included in this review performed small sample, single-school or medical center, single-country sessions, which is a significant limitation as it is not very representative. The authors suggest using larger sample sizes with random selection to increase generalizability and conducting multi-center studies.

Moreover, in three studies the evaluation method was qualitative and self-reported, which might also lead to report bias [17][15] [16]. Additionally, the long-term effect was not evaluated in any of the articles and often the evaluation was only made at one time point [18].

Several limitations were related to the use of new technologies, in the study by [19], students preferred face-to-face simulations, citing the similarities to practicing in a ‘real’ situation and the immediate debriefing. Students who did not like the virtual clinical simulation often cited technological issues, such as “online program was slow”, or “didn't know where to find things. Similarly, in [20] they noted that the results might have been affected by the students' IT expertise, while [13] pointed out that the unfamiliar VR environment could be a factor. In [18], they suggested that students more comfortable with technology might have been more willing to participate in the experiments.

An orientation activity built into the study design would be useful so that when the XR scenario is presented, students will not be focused on learning the software. Moreover, the studies were often performed in a single session; multiple sessions would increase students' familiarity with the tools. On the other hand, [13] suggest that it would be better to establish a MR environment, using hand

tracking and physically practicing the skills, rather than using the HMD controllers. This approach would also reduce learner's burden owing to unfamiliar environments, enabling experiences similar to reality.
Lastly, none of the studies they engaged with the focus group (nurses and midwives) to identify and prioritize their real needs. A better approach would have been to perform a systematic conception method to translate their needs into tangible project objectives and features aligned with user expectations, rather than imposing the technological approach without working and thinking about the solution with them first.

Discussion and Limitations

The systematic review had several limitations. The research results could vary depending on the databases, languages, or types of articles included. Furthermore, the review focused on the use of extended reality for gesture simulation to reduce anxiety. Not many articles were found on this specific topic, highlighting a research gap. The results would differ if we included the use of these tools in other procedures, such as management of medical situations, or the treatment of anxiety with calming scenarios.

Future research directions

This systematic review was conducted in preparation for a follow-up study on XR gesture simulation educational training for midwifery students' anxiety management in the Midwifery Department at the Grenoble Alpes University during the next academic year. The limited articles found in this review and their positive results highlight the research gap and underscore the importance of further exploring gesture simulation using XR tools to reduce student anxiety. Moreover, the limitations found in the studies could be addressed by implementing a long-term follow-up with questionnaires, choosing a larger sample size, including diversity by testing in different centers, using MR, or engaging with the focus group.
The next intended study will focus on MR gesture simulation in an educational midwifery or nursing procedure. Collaboration with educators and users is essential to make an appropriate demonstrator, and the use a pre-test and post-test evaluation with diverse, evenly distributed participants from different centers and countries, to measure anxiety levels will be evaluated.
The first demonstrator prototype will be as follows:

- *Learning object*: The learning object will be defined later on the development of the project, after discussing with the educators and students of the midwifery course.
- *Participants*: All of the 147 students at the Midwifery Department of the Grenoble Alpes University will be invited to participate in the study. The exclusion criteria will be incomplete training or questionnaires. Furthermore, depending on the learning object, only the promotion following the specific course will be included in the study, excluding the rest of the students. A posterior international demonstrator will be performed to validate the results obtained.
- *Device*: To interact with the virtual environment, Microsoft HoloLens 2 will be used, as the goal is to develop a MR tool. By seeing their hands, the students can physically practice the gestures to simulate and learn the procedure.
- *Anxiety Assessment Methods, Variables*: Before and after the intervention, anxiety will be evaluated with the NASC-CDM [22], [23], as it is specially designed for nursing students to measure stress and anxiety related to clinical procedures and academic responsibilities. Additionally, slight modifications specific to our learning object will be added to the questionnaire.

Conclusion

The results of the systematic review encourage the development of an extended reality gesture or

procedure simulation system to evaluate and manage anxiety for nurses and midwives. Positive outcomes have been achieved as an improved learning experience, educational effectiveness, feasibility examples, and anxiety reduction. However, the search revealed limited research addressing this issue globally and a potential gap in the MR field, since it has not been used in any of the studies, and could meet the requirements and needs of midwifery and nursing students.
Furthermore, there were some limitations to the systematic review, including variability in results due to database selection and a narrow focus on gesture simulation. Expanding the scope to include other uses of XR, such as in medical procedures or calming scenarios, could provide broader insights.

Acknowledgements

The authors would like to thank the Multidisciplinary Institute of Artificial Intelligence (MIAI) of Grenoble Alpes for the financial support of this research. This work was funded by the French National Research Agency (ANR) in the framework of the Investissements d'avenir program (ANR-10-AIRT-05) and the MIAI @ Grenoble Alpes (ANR-19-P3IA-0003).

Conflicts of interest

The authors declare no personal financial interests related to the subject matter discussed in this manuscript. If applicable, any potential conflicts would be disclosed accordingly. In this case, none declared.

Abbreviations

AR: Augmented reality
MR: Mixed reality
PICO: population, intervention, control, and outcomes
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
VR: Virtual reality
XR: Extended reality

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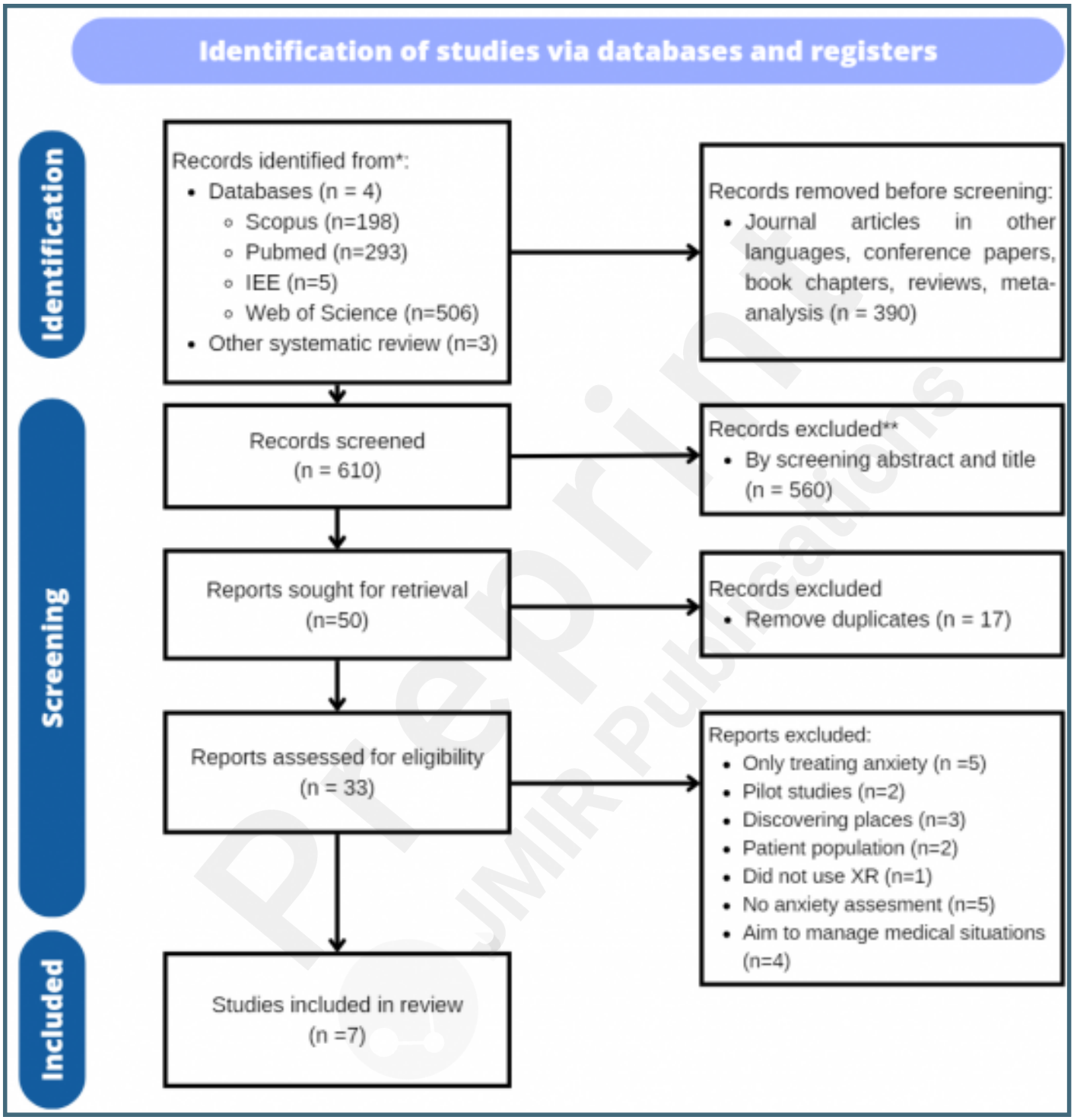
Supplementary Files

Figures

PRISMA 2020 diagram.



Systematic review results.

TTITLE	Year	Author	Journal	Location	Learning Object	Population	Software and devices	Anxiety evaluation	Varibles
The effects of neonatal resuscitation gamification program using immersive virtual reality: A quasi-experimental study	2022	Yang et Al.	Nurse Education Today	South Korea	Simulating & performing procedures	Nursing Students (n=88)	HMD: Oculus Rift S (VR) - 50 min gamification program	STAI (State-Trait Anxiety Inventory)	Knowledge, problem-solving, clinical reasoning ability, self-confidence, anxiety, learning motivation
Immersive virtual reality (VR) training increases the self-efficacy of in-hospital healthcare providers and patient families regarding tracheostomy-related knowledge and care skills A prospective pre-post study	2021	Chiang, et /	Medicine Op	Taipei, Tai	Simulating & performing procedures	Healthcare providers (n=60)	HMD-VR Web-based VR Desktop Tablet Smartphone - 2hour training with 15minute VR	Personalized Likert scale questionnaires	Familiarity Confidence Anxiety Knowledge Skills
Pediatric Chest Compression Improvement Via Augmented Reality Cardiopulmonary Resuscitation Feedback in Community General Emergency Departments: A Mixed-Methods Simulation-Based Pilot Study	2023	Kleinman et Al.	The Journal of Emergency Medicine	Baltimore, USA	Simulating & performing procedures	Nurses (n=36)	HMD (AR) - 18 minute course	Qualitative invdividual interviews post-intervention	Performance, Anxiety (quali)
Effects of virtual reality training on decreasing the rates of needlestick or sharp injury in new-coming medical and nursing interns in Taiwan	2020	Wu et Al.	Journal of Educational Evaluation for Health Professions	Taipei, Taiwan	Simulating & performing procedures	Medical & Nurses Interns (n=109)	Game-based VR training	Personalized Likert scale questionnaires	Performance, Anxiety (quali)
A mixed-methods feasibility study to assess the acceptability and applicability of immersive virtual reality sepsis game as an adjunct to nursing education	2021	Adhikari et Al.	Nurse Education Today	Edinburgh	Simulating & performing procedures	Nursing Students (n=19)	Three-dimensional computer-based simulation - VR 20-30minutes	NASC- CDM before and after intervention	Anxiety (NASC-CDM), self-efficacy, acceptability, applicability
Virtual versus face-to-face clinical simulation in relation to student knowledge, anxiety, and self-confidence in maternal-newborn nursing: A randomized controlled trial	2016	Cobbett et Al.	Nurse Education Today	Canada	Simulating & performing procedures	Nursing Students (n=56)	F2F high fidelity manikin simulation. VCS with a computer. 2x45 min VR sessions	NASC- CDM before and after intervention	Simulation Completion Questionnaire, Anxiety(NASC-CDM), Knowledge
Evaluation of practical exercises using an intravenous simulator incorporating virtual reality and haptics device technologies	2012	Jung et Al	Nurse Education Today	Korea	Simulating & performing procedures	First-year nursing students (n=60)	VR IV training simulator utilizing haptics skills - 10 minute session	Evaluated State Trait Anxiety using Visual Analogue Scale before and after intervention	State trait anxiety, VAS, Performance, Satisfaction