Effectiveness of combined virtual and clinical simulation compared with other active teaching strategies on health students' learning: a systematic review protocol

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ABSTRACT

Objective: The objective of this review is to synthesize the available evidence on the effectiveness of combined virtual and clinical simulation compared with other active teaching strategies on health students' learning.

Introduction: Current evidence indicates that both virtual simulation and clinical simulation are effective in assisting students to acquire clinical skills. However, there is a knowledge gap regarding the effectiveness of the combined use of both teaching strategies, which could enhance health students' learning.

Inclusion criteria: This review will consider experimental, quasi-experimental, and observational studies that address the combined use of virtual simulation with clinical simulation compared with other active teaching strategies in learning, clinical reasoning, clinical decision-making, and/or clinical competencies of health students. Combining different hybrid simulators to form a new one will not be considered for inclusion in the review.

Methods: The databases to be searched include Cochrane Library, MEDLINE (PubMed), CINAHL (EBSCOhost), Scopus, LILACS (VHL), Web of Science Core Collection, Embase (Elsevier), ERIC, and gray literature sources. Two independent reviewers will perform the study selection, critical appraisal, and data extraction using JBI tools. A narrative synthesis will be performed and, if possible, meta-analysis and risk assessment of publication bias. TheGrading of Recommendations, Assessment, Development, and Evaluations (GRADE) approach will be used to assess the certainty of the findings.

Review registration: PROSPERO CRD42023422410

Keywords: clinical simulation; combined simulation; virtual simulation

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Introduction

Education to become a health professional is a process that involves theory and clinical practice. It is in clinical practice where knowledge comes to life through direct experience.[1] Educators utilize active teaching methods, merging computer tools, simulations, and student-focused strategies, to enhance traditional lectures and patient interactions.[2] Clinical simulation has emerged as a prominent strategy, fostering active learning in environments that are controlled and safe. These simulations offer standardized, reproducible scenarios that, while invaluable, don't replace authentic patient interactions.[3] Their primary role is to enhance health students' learning.[4]

Advancements in technology paved the way for virtual simulation teaching. According to the *Healthcare Simulation Dictionary*, *virtual simulation* is defined as "the recreation of reality represented on a screen."[5(p.56)] The concept is quite broad as it includes virtual models of patients, virtual reality, augmented reality, and computer simulation, and refers to any simulation that is performed using technology.

Virtual models can be designed to allow exploration and analysis of rare or complex clinical cases, as well as simulate situations that are difficult to reproduce in a physical environment.[6] Recent studies,

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such as Plackett *et al*.[7] and Foronda *et al*.,[8] highlighted the growing utility of various virtual tools and their effectiveness in medical education. However, they also emphasized the limited evidence on the combined use of virtual simulation with other strategies, such as high fidelity or standardized (actor) patients. In a systematic review, Bracq *et al*.[9] found that screen-based virtual reality simulators and virtual worlds dominate the landscape. They highlighted that, while many studies prioritize assessing the usability and acceptability of virtual simulations, research into the combined application of these strategies remains limited.[9]

Combined simulations are not about devices, but about blending different modalities; for example, students might begin with a virtual simulation and later engage with mannequins in a different setting.[10] Clinical simulation offers the opportunity to practice clinical skills in a controlled environment, with the ability to interact with a simulator that resembles a real patient. However, this technique has limitations in terms of its ability to re-create complex or rare situations, and it can also be costly and logistically challenging to implement. Virtual simulation offers the opportunity to practice clinical skills in a virtual environment that can re-create a variety of situations and pathologies more realistically than simulators; is more flexible and less costly to implement; and allows for repeated opportunities for autonomous testing.[11] Thus, by combining these 2 techniques, the strengths of each can be leveraged to provide a more comprehensive and realistic learning experience for health science students. In a recent quasi-experimental study, Goldsworthy *et al*.[10] assessed the sequential use of virtual and clinical simulations for postpartum hemorrhage education. They concluded that this combined approach might enhance students' self-confidence when managing critical situations.

Both strategies (clinical simulation and virtual simulation), while distinct in their structure and educational potential, have showcased clear advantages in educational outcomes. On their own, each method has demonstrated strong benefits.[12] Yet, merging them presents a fresh and potentially groundbreaking perspective in clinical education. The synergy from combining virtual with clinical simulation might offer a richer and more diverse learning experience.[12]

While there are primary studies on combined virtual and clinical simulation in the existing literature, a systematic evaluation comparing the effectiveness of this strategy with other active teaching methods is lacking. A preliminary search of PROSPERO, MEDLINE, the Cochrane Database of Systematic Reviews, and *JBI Evidence Synthesis* was conducted and no current or in-progress systematic reviews on the topic were identified. The aim of this proposed systematic review is to gather and synthesize the best available evidence on the effectiveness of combined virtual and clinical simulation compared with other active teaching strategies in the education of health care students.

Review question

What is the effectiveness of a strategy that combines virtual simulation with clinical simulation compared with other active teaching strategies on health students' learning?

Inclusion criteria

Participants

This systematic review will focus on health students from university programs in medicine, nursing, midwifery, pharmacy, premedical, physiotherapy, public health, occupational therapy, nutrition and dietetics, psychology, biomedical sciences, and dentistry. These disciplines were chosen due to their established international qualifications and health care impact. The study will include learners across all age groups, from the beginning of their undergraduate education through to their postgraduate training, to deliver a complete overview of health science education's role in professional health care development.

Interventions

This systematic review will assess the combined use of virtual and clinical simulations in the education of health students. Virtual simulation involves software-based learning applications on electronic devices, while clinical simulation includes practice-based learning with physical simulators or standardized (actor) patients in a controlled setting. The focus will be on the intentional integration of these modalities to achieve specific learning outcomes. Qualified health profession educators must conduct the sessions to ensure educational validity, and the studies must specify the frequency and duration of the simulations. Studies of hybrid simulators, combining 2 simulation devices to form a new one, will be excluded.

Comparators

This review will consider studies that compare the intervention with other active teaching strategies. Active learning strategies are pedagogical techniques that actively and participatively involve students in the learning process, rather than being mere recipients of information.[13] Some of the most common active learning strategies include:

- problem-based learning, which involves students in practical projects that require research, collaboration, and problem-solving
- cooperative learning, which involves students in small groups performing activities and tasks together, fostering collaboration and social interaction
- game-based learning, a technique that uses games and simulations to promote learning, problem-solving, and decision-making
- case-based learning, which uses real or fictional cases to teach concepts and skills and foster critical thinking and decision-making
- clinical simulations, in which students role-play as health care professionals in simulated patient care situations, allowing them to practice clinical, communication, and decision-making skills; this includes virtual simulation alone, clinical simulation alone, or a combined simulation
- practical and laboratory activities, in which students practice clinical and diagnostic skills, and learn to use medical equipment and tools
- clinical practice, students can interact with patients and health care staff, perform clinical assessments, practice skills, and make real-time decisions.

This review will not impose restrictions on the range of frequencies or durations for the educational strategies examined, aiming to encompass a broad spectrum of approaches in health student education and to comprehensively understand their impact on learning outcomes.

Outcomes

The primary outcome of this study will be learning, which refers to the process of acquiring new knowledge, skills, or abilities, measured, for example, in a self-assessment or by the teaching facilitator. The secondary outcomes will include:

- clinical reasoning, which involves the cognitive processes that clinicians use to collect and interpret patient data, identify problems, and develop hypotheses about possible diagnoses or treatment options that can be measured; for example, by case-based discussions, problem-based learning exercises, or the analysis of patient scenarios or case studies
- clinical decision-making, which involves the process of selecting an appropriate course of action based on the patient's clinical presentation and available evidence, which can be measured, for example, by the number and appropriateness of diagnostic tests ordered, accuracy, and timeliness of diagnosis or the treatment plan
- clinical competence, which refers to the ability of a clinician to perform tasks and responsibilities related to patient care in a safe and effective manner, and can be measured, for example, by clinical skills assessments or competency exams, the observation and evaluation of clinical performance, or the development of performance improvement plans.[14]

Studies to be included in this review must capture at least the primary outcome, which can be measured at any point during the intervention using instruments with well-documented validity evidence. Research employing instruments specifically crafted for study purposes will also be considered, provided they have undergone a process of content validation.

Types of studies

This review will consider both experimental and quasi-experimental study designs, including randomized controlled trials, non-randomized controlled trials, before and after studies, and interrupted time-series studies. Analytical observational studies, including prospective and retrospective cohort studies, case-control studies, and analytical cross-sectional studies, will be considered for inclusion. This review will also consider descriptive observational study designs, including case series, individual case reports, and descriptive cross-sectional studies for inclusion. Opinion papers, conference abstracts, letters, case reports, and study protocols will be excluded.

Methods

The proposed systematic review will be conducted in accordance with the JBI methodology for systematic reviews of effectiveness evidence.[15] This protocol has

been registered with PROSPERO (CRD4202342 2410).

Search strategy

The search strategy will aim to locate both published and unpublished studies. A 3-step search strategy will be utilized in this review. First an initial limited search of MEDLINE (PubMed) and CINAHL (EBSCOhost) was undertaken on October 16, 2023, to identify articles on the topic. The text words contained in the titles and abstracts of relevant articles and the index terms used to describe the articles were used to develop a full and initial search strategy for MEDLINE via PubMed (see Appendix I).

In the second stage, a more specific search using the identified keywords and index terms from the initial search will be conducted for all databases included in this review: the Cochrane Library, MEDLINE (PubMed), CINAHL (EBSCOhost), Scopus, LILACS (VHL), Web of Science Core Collection, Embase (Elsevier), and ERIC.

Finally, the reference list of all included sources of evidence will be manually searched to identify additional studies. We will also search for gray literature studies across CAPES Thesis Bank, DART-E, Networked Digital Library of Theses and Dissertations, and Google Scholar. The first 100 results will be considered according to relevance. The search strategy, including all identified keywords and index terms and use of Boolean/phrase operators, will be adapted for each included information source. Published and unpublished studies (with no restriction on time or language) will be considered for inclusion in this review. Titles and abstracts and the full text of studies that are not published in a language the researchers are proficient in will be retrieved and translated with the aid of scientific translators.

Study selection

Following the search, all identified citations will be collated and uploaded into Rayyan (Qatar Computing Research Institute, Doha, Qatar), and duplicates removed. Following a pilot test, titles and abstracts will be screened by 2 independent reviewers for assessment against the inclusion criteria. Potentially relevant studies will be retrieved in full, and their citation details imported into the JBI System for the Unified Management, Assessment and Review of Information (JBI SUMARI; JBI, Adelaide, Australia).[16]

The full text of selected citations will be assessed in detail against the inclusion criteria by 2 independent reviewers. Reasons for exclusion of full-text studies that do not meet the inclusion criteria will be recorded and reported in the systematic review. Any disagreements that arise between the reviewers at each stage of the selection process will be resolved through discussion or with an additional reviewer. The results of the search and the study inclusion process will be reported in full in the final systematic review and presented in a Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) flow diagram.[17]

Assessment of methodological quality

Eligible studies will all be critically appraised for methodological quality by 2 independent reviewers. For this critical appraisal, standardized instruments from JBI will be utilized across all study types.[15] Authors of papers will be contacted up to 2 times to request missing or additional data for clarification, where required. Any disagreements that arise will be resolved through discussion or with a third reviewer. The results of critical appraisal will be reported in a table along with a narrative description. All studies, regardless of the results of their methodological quality, will undergo data extraction and synthesis.

Data extraction

Data will be extracted from studies included in the review by 2 independent reviewers using JBI SUMARI.[16] The data extracted will include specific details about the population characteristics (eg, country, setting, sample size), study methods, details of interventions (eg, type of virtual simulation platform combined with traditional simulation scenario), comparator (eg, active strategies used), and outcomes of significance to the review objective (eg, learning, clinical competence, clinical reasoning, and clinical decision-making). Any disagreements between the reviewers will be resolved through discussion or with a third reviewer. Authors of papers will be contacted up to 2 times to request missing or additional data, where required.

Data synthesis

Studies will be pooled (where possible) in a statistical meta-analysis, using JBI SUMARI. Effect sizes will be expressed as either relative risk (for dichotomous

data) or standardized mean differences (for continuous data) and their 95% CI will be calculated for analysis. Statistical analyses will be performed using a model (random or fixed effects) defined according to the number and characteristics of the studies included and their results.[18] Subgroup or sensitivity analyses will be carried out according to the different designs, methodological quality of the studies, types of students, types of active strategies, and outcomes, if applicable. Heterogeneity will be statistically assessed using the standard χ^2 and I^2 tests. A funnel plot will be generated to assess publication bias if there are 10 or more studies included in a meta-analysis. Statistical tests for funnel plot asymmetry (eg, Egger test, Begg test, Harbord test) will be performed, where appropriate. Where meta-analysis is not possible to describe the included studies, the findings will be presented as a narrative synthesis, including tables and figures to aid in data presentation, where appropriate.

Assessing certainty in the findings

The Grading of Recommendations, Assessment, Development and Evaluation (GRADE) approach for grading the certainty of evidence will be followed[19] and a Summary of Findings (SoF) will be created using GRADEpro GDT (McMaster University, ON, Canada). This will be undertaken by 2 independent reviewers at the outcome level. Any disagreements that arise between the reviewers will be resolved through discussion or with a third reviewer. Authors of papers will be contacted up to 2 times to request missing or additional data for clarification, where required. The SoF will present the following information where appropriate: relative risks for the treatment and control; estimates of relative risk; ranking of the quality of the evidence based on the risk for dichotomous outcome; standardized mean differences for continuous measures outcomes; and a ranking of the quality of the evidence based on a graduation of high, moderate, low, or very low, according to the factors that influence the strength of evidence, such as risk of bias, directness, heterogeneity, precision, inconsistency of evidence, and risk of publication bias of the review results. The outcomes reported in the SoF will be: learning, clinical reasoning, clinical decision-making, and clinical competence. The results may contribute to academic development, but also have a potential impact on the quality of care that future professionals will be able to offer to society.

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Author contributions

All authors contributed to the study design. AL and MZ collected data. AL wrote the original draft of the manuscript. MZ, LSN, and VdBP reviewed and edited the manuscript.

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Appendix I: Search strategy

MEDLINE (PubMed)

Search conducted: November 3, 2023

Search	Query	Records retrieved
#1	((students, health occupations[MeSH Terms]) OR (students, health occupations [Text Word])) OR (Health Occupations Students[Text Word])) OR (Health Occupations Student[Text Word])) OR (Occupations Student, Health[Text Word])) OR (Occupations Students, Health[Text Word])) OR (Student, Health Occupations[Text Word])) OR (Students, Dental[MeSH Terms])) OR (Students, Dental[Text Word])) OR (Dental Students[Text Word])) OR (Student, Dental[Text Word])) OR (Dental Student[Text Word])) OR (Students, Medical[MeSH Terms])) OR (Students, Medical[Text Word])) OR (Medical Students[Text Word])) OR (Student, Medical[Text Word])) OR (Medical Student[Text Word])) OR (Students, Nursing[MeSH Terms])) OR (Students, Nursing[Text Word])) OR (Pupil Nurses[Text Word])) OR (Student, Nursing[Text Word])) OR (Nurses, Pupil[Text Word])) OR (Nurse, Pupil[Text Word])) OR (Pupil Nurse[Text Word])) OR (Nursing Student[Text Word])) OR (Nursing Students[Text Word])) OR (Students, Pharmacy[MeSH Terms])) OR (Students, Pharmacy[Text Word])) OR (Pharmacy Students[Text Word])) OR (Student, Pharmacy[Text Word])) OR (Pharmacy Student[Text Word])) OR (Students, Premedical[MeSH Terms])) OR (Students, Premedical[Text Word])) OR (Premedical Students[Text Word])) OR (Student, Premedical[Text Word])) OR (Premedical Student [Text Word])) OR (Students, Public Health[MeSH Terms])) OR (Students, Public Health[Text Word])) OR (Health Student, Public[Text Word])) OR (Health Students, Public[Text Word])) OR (Public Health Student[Text Word])) OR (Student, Public Health[Text Word])) OR (Public Health Students[Text Word])) OR (Students, Midwifery[Text Word])) OR (Midwifery Student[Text Word])) OR (Midwifery Students[Text Word])) OR (Student Midwifery[Text Word])) OR (Physiotherapy Student[Text Word])) OR (Physiotherapy Students[Text Word])) OR (Students, Physiotherapy[Text Word])) OR (Student Physiotherapy[Text Word])) OR (Students, Occupational Therapy[Text Word])) OR (Occupational Therapy Student[Text Word])) OR (Occupational Therapy Students [Text Word])) OR (Student Occupational Therapy[Text Word])) OR (Students, Biomedical[Text Word])) OR (Biomedical Student[Text Word])) OR (Biomedical Students[Text Word])) OR (Student Biomedical[Text Word])) OR (Students, Psychology[Text Word])) OR (Psychology Student[Text Word])) OR (Psychology Students[Text Word])) OR (Student Psychology[Text Word])) OR (Students, Nutrition[Text Word])) OR (Nutrition Student[Text Word])) OR (Nutrition Students[Text Word])) OR (Student Nutrition[Text Word])	167,086
#2	((((((((((((((((((((((((((((((((((((Virtual Reality[MeSH Terms]) OR (Virtual Reality[Text Word])) OR (Reality, Virtual[Text Word])) OR (Virtual Reality, Educational[Text Word])) OR (Educational Virtual Realities[Text Word])) OR (Educational Virtual Reality[Text Word])) OR (Reality, Educational Virtual[Text Word])) OR (Virtual Realities, Educational[Text Word])) OR (Virtual Reality, Instructional[Text Word])) OR (Instructional Virtual Realities[Text Word])) OR (Instructional Virtual Reality[Text Word])) OR (Realities, Instructional Virtual[Text Word])) OR (Reality, Instructional Virtual[Text Word])) OR (Virtual Realities, Instructional[Text Word])) OR (Simulation Training[MeSH Terms])) OR (Simulation Training[Text Word])) OR (Training, Simulation[Text Word])) OR (Interactive Learning[Text Word])) OR (Learning, Interactive[Text Word])) OR (High Fidelity Simulation Training[MeSH Terms])) OR (High Fidelity Simulation Training[Text Word])) OR (Patient Simulation[MeSH Terms])) OR (Patient Simulation[Text Word])) OR (Patient Simulations[Text Word])) OR (Simulation, Patient[Text Word])) OR (Simulations, Patient[Text Word])) OR (simulation-based learning[Text Word])) OR (simulation-based medical education[Text Word])) OR (virtual simulation[Text Word])) OR (clinical simulation[Text Word])) OR (hybrid simulation[Text Word])) OR (combined simulation[Text Word])) OR (mixed simulation[Text Word])) OR (combining simulation[Text Word])) OR (hybrid medical simulation[Text Word])) OR (hybrid virtual simulation[Text Word])) OR (blended simulation[Text Word])	36,008
#3	#1 AND #2	5462
#4	((((((((((((((((((((((((((Learning[MeSH Terms]) OR (Learning[Text Word])) OR (Clinical Competence[MeSH Terms])) OR (Clinical Competence[Text Word])) OR (Competency, Clinical[Text Word])) OR (Competence, Clinical[Text Word])) OR (Clinical Competency [Text Word])) OR (Clinical Competencies[Text Word])) OR (Competencies, Clinical[Text Word])) OR (Clinical Skill[Text Word])) OR (Skill, Clinical[Text Word])) OR (Skills, Clinical[Text Word])) OR (Clinical Skills[Text Word])) OR (Clinical Decision-Making[MeSH Terms])) OR (Clinical Decision-Making[Text Word])) OR (Clinical Decision Making[Text Word])) OR (Decision-Making, Clinical[Text Word])) OR (Medical Decision-Making[Text Word])) OR (Decision-Making, Medical[Text Word])) OR (Medical Decision Making[Text Word])) OR (Clinical Reasoning[MeSH Terms])) OR (Clinical Reasoning[Text Word])) OR (Reasoning, Clinical[Text Word])) OR (Clinical Judgement[Text Word])) OR (Clinical Judgements[Text Word])) OR (Judgement, Clinical[Text Word])) OR (Judgements, Clinical[Text Word])	968,805
#5	#3 AND #4	4295