The Use of Clinical Simulation in Medical Education

Lilia Giselle Cano-García[1].

[1] Universidad del Valle de México Querétaro Campus, Querétaro, México.

Corresponding author: Lilia G. Cano-García, giss.cano@outlook.com
Received: May 14, 2026. | Accepted: May 30, 2026.

ABSTRACT

Clinical simulation has become established as one of the most relevant pedagogical strategies in contemporary medical education due to its ability to strengthen clinical competencies in safe and controlled environments. This essay critically analyzes the role of clinical simulation in the training of healthcare professionals, emphasizing its pedagogical foundations, implementation methods, documented benefits, and main challenges. Drawing on recent scientific literature, it examines theories such as experiential learning, deliberate practice, and cognitive load theory, as well as the importance of debriefing as the core of reflective learning. It also describes the different levels and models of simulation, including low- and high-fidelity simulators, standardized patients, virtual reality, and hybrid simulation, highlighting the importance of its longitudinal curricular integration. The reviewed evidence demonstrates that simulation promotes the acquisition and retention of technical and non-technical skills, improves teamwork, and contributes to patient safety by allowing training in highly complex scenarios without real risk. However, its effectiveness depends on pedagogical rigor, teacher training, and proper integration with supervised clinical practice. Finally, the need to conceive of simulation as a means for the comprehensive and ethical training of future healthcare professionals, and not merely as a technological innovation, is discussed.

Keywords: clinical simulation, medical education, competencies.

INTRODUCTION

Contemporary medicine faces a formative paradox that few disciplines share with the same intensity: to learn to heal, the student needs to practice on someone who may be affected by that practice. For decades, the hospital-based learning model based on observation and the progressive repetition of procedures on real patients was the norm. However, the growing complexity of clinical practice, expanding ethical standards, and accumulated evidence on preventable medical errors have demanded a rethinking of the foundations of medical education [1].

It was in this context that clinical simulation emerged as a systematic alternative that allows students to approach clinical reality without compromising patient safety. Its development has been driven by the confluence of pedagogical frameworks centered on active learning, the technological revolution in simulation devices, and a global health safety agenda that places medical error as a priority public health problem. Over the past two decades, the use of simulation has grown exponentially, and it currently constitutes the leading practical training strategy in multiple health sciences programs worldwide [2].

Clinical simulation can be defined as a pedagogical technique that uses designed scenarios to replace or expand real experiences in order to interactively evoke substantive aspects of the clinical world. Simulation aligns with new paradigms in education and is consistent with theories of experiential learning, as it promotes the development of psychomotor skills and strengthens executive functions in a controlled environment [1].

Its relevance in contemporary medical education is multifaceted. From an ethical perspective, it allows error to occur in a safe environment, with no real consequences for any patient. From a pedagogical perspective, it offers deliberate repetition, immediate feedback, and gradual control of scenario complexity. From an institutional perspective, it facilitates the objective evaluation of competencies and contributes to the standardization of training processes, which is especially valuable in health systems with high variability in the quality of clinical education [3].

Despite its growing adoption, clinical simulation is not free of criticism and limitations. Its implementation demands considerable financial investment, requires faculty with specific pedagogical competencies, and carries the risk of becoming an end in itself, disconnected from real clinical practice. Moreover, its incorporation into the medical curriculum is far from homogeneous: while some institutions have integrated it longitudinally and coherently, others employ it sporadically and disjointedly, thereby compromising its formative potential. This landscape raises a question that organizes the present essay:

To what extent does clinical simulation, when implemented with pedagogical rigor and curricular integration, contribute to the training of more competent and safer health professionals?

Therefore, the objective of this essay is to analyze, from a critical perspective and grounded in recent scientific literature, the role of clinical simulation as a pedagogical tool in undergraduate and graduate medical education. To this end, its theoretical foundations, the different models and technologies

available, the documented benefits, and the challenges that condition its effectiveness are examined. This work is aimed at students and health professionals interested in educational innovation and the continuous improvement of quality in clinical training, and is written from the perspective of a medical student who has gone through simulation experiences at different stages of her training.

PEDAGOGICAL FOUNDATIONS OF CLINICAL SIMULATION

- **Experiential learning**

The most widely cited theoretical foundation for clinical simulation is David Kolb's experiential learning model, which posits that knowledge is generated through a four-stage cycle: concrete experience, reflective observation, abstract conceptualization, and active experimentation. Simulation offers an ideal setting for navigating this cycle in a controlled and repeatable manner. Herrera-Aliaga and Estrada draw on Kolb to point out that when students experience simulated situations, they must reflect on what they have experienced, construct abstract concepts, and test what they have learned in new situations; in this sense, debriefing—which will be discussed later—acts as the mechanism that transforms the experience into genuine learning [2].

This alignment between Kolb's cycle and the operational characteristics of well-implemented simulation explains why this strategy has gained so much ground in contemporary medical education. Alonso-Peña and Álvarez-Álvarez reviewed 43 studies on simulation in health sciences education and confirmed that programs incorporating structured feedback, repetitive practice, and progressive variation in difficulty—all dimensions of the experiential cycle—produce the most consistent and lasting learning outcomes [4].

- **Deliberate practice**

Ericsson's theory of deliberate practice suggests that expertise does not result simply from repeated exposure to a task, but rather from conscious practice that is goal-oriented and accompanied by high-quality feedback. Felix and Schertzer describe mastery learning as the direct application of this principle to medical simulation: in this approach, progress depends not on the amount of time elapsed but on the level of performance demonstrated, and the student repeats the scenario until reaching a previously established minimum standard of competence [5].



Figure 1. Dr. Mary D. Patterson trains medical students using a human patient simulator at UF's Center for Experiential Learning and Simulation.

> *"The simulation environment represents an ideal opportunity for the deliberate practice of complex skills to the point of mastery, both in routine procedures and in low-frequency, high-severity situations." (Felix & Schertzer, 2022, p. 1)*

The results of this approach are especially significant in invasive procedures and emergency situations. Mitzman and colleagues implemented a simulation-based mastery curriculum for pediatric emergency medicine residents and found substantial improvements in the execution of high-risk procedures, with a documented reduction in performance variability among participants, supporting the usefulness of this approach in reducing formative inequity within a single program [6].



Figure 2. A group of students observes the execution of a simulated procedure through screens, while an instructor directs the session from a central console.

- **Cognitive load theory**

Cognitive load theory distinguishes between intrinsic load, determined by the complexity of the material; extrinsic load, generated by instructional design; and relevant load, which is directed toward effective learning. In a real clinical setting, the total cognitive load can be so high that novice students devote most of their cognitive resources to avoiding serious errors, leaving little room for reflection and consolidation of learning. Simulation can reduce extrinsic load by eliminating the uncertainty of real-world consequences and adjusting the complexity of the scenario to the learner's level.

This principle has direct implications for the design of simulation programs: a gradual progression in complexity is not only pedagogically desirable but also cognitively necessary. Tokuno and colleagues applied cognitive load theory to the analysis of virtual reality simulation programs for invasive procedures and confirmed that the cognitive load perceived by students decreases progressively with practice, freeing

up attentional resources that are then redirected toward clinical decision-making [7]. This finding supports the design of tiered curricula that begin with low-complexity scenarios before introducing high-fidelity, time-pressured situations.

- **Debriefing as a pedagogical core**

If there is one element that distinguishes pedagogically rigorous clinical simulation from mere exposure to a scenario, it is debriefing. Abulebda *et al.* define it as the intentional discussion following the simulation that allows participants to clearly understand their actions and thought processes in order to promote learning and improve future clinical performance [8]. Without a structured debriefing, simulation can lead to errors or reinforce inappropriate behaviors without the student realizing it.

> *"Debriefing after simulation is one of the most effective components of simulation-based education and the cornerstone of the learning experience in the medical simulation setting." (Abulebda et al., 2022, para. 1)*

Duff and colleagues conducted a systematic review that included 70 studies on debriefing methods in health simulation and found that, while there is a wide variety of models and techniques, the most effective frameworks share characteristics such as exploring the student's mental model, using open-ended questions, and explicitly linking the simulated experience to real-world clinical practice [9]. This review also notes that the empirical evidence is still insufficient to recommend a single debriefing model over others, underscoring the need for further research in this field.

TYPES, LEVELS, AND CURRICULAR INTEGRATION

- **Low-fidelity simulators**

Low-fidelity simulators include static anatomical models, arms for venous access, suture pelvises, or basic cardiopulmonary resuscitation manikins. Their main advantage is their low cost and accessibility, characteristics that make them particularly useful for teaching specific procedural skills in the early stages of training. Elendu *et al.* argue that the choice of fidelity level should be guided by learning objectives rather than by the availability of technology, since high fidelity does not in itself guarantee superior results when the goal is the acquisition of an isolated technical skill [2].

This distinction is particularly relevant in resource-limited settings. Alonso-Peña and Álvarez-Álvarez report that in Latin American institutions with limited access to high-fidelity technology, low-fidelity models—when combined with deliberate practice and structured feedback—produce learning outcomes comparable to those obtained with more sophisticated devices in the acquisition of basic procedural skills [4]. This evidence challenges technological determinism in medical education and suggests that pedagogical rigor is a more decisive factor than investment in equipment.



Figure 3. Close-up of an intravenous catheter being inserted into the arm of a training manikin, with a tourniquet and gauze pads placed on the surface.

- **High-fidelity simulators**

High-fidelity simulators are computerized manikins capable of replicating complex physiological responses: a palpable pulse, spontaneous breathing, reactive pupil dilation, crying, and responses to medications. Their use focuses on simulating emergency scenarios, highly complex situations, and training multidisciplinary teams. Elendu *et al.* note that high-fidelity simulation significantly improves clinical decision-making, team communication, and safety during invasive procedures, particularly in low-frequency, high-severity scenarios that residents may not encounter frequently enough during their hospital training [2].

However, high technological fidelity does not automatically guarantee superior learning. The concept of functional fidelity, which is gaining acceptance in the literature, proposes that what truly matters is not how closely the simulator resembles a real patient, but rather the extent to which the scenario triggers the same cognitive and decision-making processes as a real clinical situation. A well-designed scenario using a medium-fidelity simulator can be more educational than a poorly structured one using state-of-the-art technology.

- **Standardized patients**

Standardized patients (SPs) are individuals trained to consistently and reproducibly portray patients with specific clinical conditions. Their use is particularly valuable in teaching and assessing communication skills, clinical interviews, physical examinations, and the management of emotionally complex situations, such as delivering bad news. Unlike mannequin simulators, SPs offer genuine human interaction that triggers the same emotional and communicative responses as a real clinical encounter, which is irreplaceable for training so-called "soft skills" or relational competencies.

Herrera-Aliaga and Estrada highlight that simulation with standardized patients is one of the most widely used methods in undergraduate programs for assessing communication competencies through objective

structured clinical examinations (OSCE) [1]. Its pedagogical advantage lies in the ability to reproduce identical scenarios for multiple students, ensuring equitable assessment conditions—something that is difficult to achieve in a real clinical setting, where patient cases are inherently variable.



Figure 4. A clinical team performs a procedure on a pediatric mannequin in a simulated operating room setting. Imaging studies can be seen in the background.

- **Virtual reality and hybrid simulation**

Virtual reality (VR) and augmented reality technologies represent the latest frontier in medical simulation. Han *et al.* conducted a systematic review with a meta-analysis that included 45 randomized controlled trials on the use of VR in health education and found significant improvements in knowledge, skills, and attitudes, with a moderate-to-large effect size compared to traditional methods [10]. Moll-Khosrawi *et al.* demonstrated in a randomized controlled trial that first-year medical students trained in basic life support using VR performed cardiopulmonary resuscitation maneuvers with higher quality compared to those who received exclusively online training [11].

Birrenbach *et al.* published a randomized trial on the use of VR for Advanced Trauma Life Support (ATLS) training and found that the VR-trained group performed significantly better in post-training assessment scenarios, with shorter response times in managing treatment priorities [12]. Hybrid simulation, which combines SPs with partial manikins or VR environments, represents the highest level of simulated integration available and offers scenarios that replicate the multidimensional complexity of real clinical encounters, although its cost and logistical complexity are considerable.

- **Integrated curriculum**

The effectiveness of any simulation modality depends on how it is integrated into the medical curriculum. Alonso-Peña and Álvarez-Álvarez found that programs that incorporate simulation in a longitudinal manner and integrate it with theoretical content and clinical practice produce significantly better results than those that use it in isolation or on an episodic basis [4].

Curricular integration means that simulation scenarios are aligned with the learning objectives of each stage of training, that there is a progression in complexity, and that performance in simulation has implications for student evaluation.

Elendu *et al.* propose that simulation should be part of a broader and more coherent training system, in which the simulated experience prepares the student for the real clinical encounter and vice versa: supervised clinical practice informs the design of simulation scenarios [2]. This two-way interaction between the simulation lab and the clinical setting is the feature that distinguishes truly integrated simulation programs from those that merely incorporate technological devices without transforming the curricular framework.

EVIDENCE-BASED BENEFITS

- **Technical competencies**

The strongest evidence in favor of clinical simulation comes from the area of technical skills. Ajemba *et al.*, in a systematic review that analyzed randomized controlled trials and quasi-experimental studies published between 2008 and 2023, concluded that simulation-based training is an effective educational strategy for the acquisition and retention of clinical skills, with outcomes superior to no intervention and, in several studies, to traditional training methods [3]. The review identifies program duration, frequency of practice, and the quality of debriefing as moderating factors.

Comparable results have been reported in specific contexts. McInerney *et al.*, in a systematic review on the effect of simulation training on medical students' performance, confirmed consistent improvements in procedural skills, with learning retention documented up to twelve months after training when the program included reinforcement sessions [13]. This finding has relevant practical implications: well-designed simulation not only teaches but also ensures that what is learned persists long enough to be transferred to actual clinical practice.

- **Non-technical skills**

Non-technical skills, such as communication, teamwork, situational leadership, stress management, and decision-making under pressure, can also be trained through clinical simulation, although measuring them is methodologically more complex. Sezgin and Bektas conducted a systematic review with a meta-analysis that included eight randomized controlled trials with 819 participants and found that interprofessional simulation programs significantly improve teamwork (Hedges' $g = 0.41$; $p < 0.001$) and communication ($g = 0.54$; $p < 0.001$) among students from different health disciplines [14].

Pitiris *et al.*, in a systematic review of the literature published between 2013 and 2023, analyzed 22 studies on the development of nontechnical skills in interprofessional teams through simulation experiences and found that teamwork and cooperation

were included as learning objectives in all of the included studies [15]. This consensus reflects the growing recognition that nontechnical skills are just as critical to patient safety as technical skills, and that simulation offers an ideal setting for their systematic training.

- **Patient safety**

The most significant contribution of clinical simulation to contemporary medical education is, without a doubt, its impact on patient safety. By allowing errors to occur and be analyzed outside of a real-world context, simulation makes it possible to identify and correct behaviors before they cause harm. Bennion and Mansell analyzed the role of simulation-based education in the management of deteriorating patients and concluded that well-structured simulation programs improve early recognition of clinical deterioration and timely team response—two competencies directly linked to the reduction of serious adverse events [16].

This evidence takes on special significance in low-frequency, high-severity situations—such as cardiopulmonary arrest, anaphylaxis, and obstetric hemorrhage, among others—which residents may not encounter frequently enough during their hospital training. For these scenarios, simulation does not merely complement clinical experience; it necessarily replaces it. The scoping review by Kubin *et al.* on the influence of simulation on patient outcomes and nursing safety confirmed that simulation has a positive impact on clinical performance, patient safety, and care outcomes, although it highlights the need for further research with rigorous designs to more accurately quantify the effect size [17].

- **Educational equity**

A less-explored but increasingly important benefit is simulation's contribution to equity in medical education. In the traditional hospital-based learning model, opportunities for hands-on practice are unequal: they depend on the caseload of the department, the preferences of the supervising physician, and the student's availability at key moments. Simulation, by replicating scenarios in a standardized manner, ensures that all students have access to the same training experiences, regardless of the department in which they rotate or the hospital where they are trained.



Figure 5. A standardized patient is examined with an otoscope by a health professional, while a second observer witnesses the interaction.

This aspect is particularly relevant in health systems with high variability in the quality of clinical training, such as those prevalent in Latin America. Ajemba *et al.* note that standardizing simulation experiences can help reduce competency gaps among students from different training centers, provided that programs are designed with accessibility in mind and are aligned with standardized assessment processes [3]. In this sense, simulation can serve as a powerful equalizer of educational opportunities.



Figure 6. A student uses a virtual reality headset and a robotic device connected to a screen to practice spinal surgical intervention for scoliosis. An experienced physician guides the simulation.

CHALLENGES AND LIMITATIONS

- **Implementation costs**

The main barrier to the widespread adoption of clinical simulation is its cost. High-fidelity simulators can cost more than 50,000 dollars per unit, and their maintenance, calibration, and updating require significant ongoing investments. Added to this is the cost of the necessary infrastructure, including simulation centers, debriefing rooms, video recording systems, and specialized technical staff. For many medical schools in low- and middle-income countries, these figures are prohibitive [2].

However, this argument must be put into perspective. On the one hand, low-fidelity simulators are equally effective for many learning objectives. On the other hand, available cost-effectiveness analyses suggest that the reduction in complications and adverse events associated with simulation training can generate hospital savings that justify the initial investment. The discussion about the cost of simulation cannot be separated from the human, institutional, and economic costs of clinical errors that could have been prevented.

- **Facilitator training**

Clinical simulation requires facilitators to possess specific pedagogical skills that go beyond expert

clinical knowledge. Scenario design, debriefing facilitation, formative assessment, and curriculum integration are skills that are not acquired automatically simply by being an experienced physician. Al-Khayat *et al.* implemented the DASH (Debriefing Assessment for Simulation in Healthcare) tool to train simulation instructors and found that most of the physicians evaluated demonstrated deficiencies in conducting debriefings before receiving formal training, with significant improvements following the intervention [18].

Ajemba *et al.* agree that the quality of the facilitator is one of the most important determinants of simulation's educational impact and that a lack of instructor training is one of the most common reasons why programs fail to produce the expected results [3]. This implies that any institutional investment in simulation should include, as a necessary condition, a systematic program for training and continuing education of its facilitators.

- **The risk of oversimulation**

A less-discussed but equally relevant risk is that of "oversimulation": the tendency to excessively substitute real clinical experience with simulated scenarios. While simulation can prepare students for practice, it cannot fully replace it. Encountering genuine uncertainty, individual patient variability, and the emotional burden of real human suffering are dimensions of medical training that simulation cannot and should not attempt to fully replicate.

Elendu *et al.* note that there are legitimate concerns about the realism of simulations and the transferability of acquired skills to the real clinical context [2]. Some programs that have disproportionately increased the number of simulation hours at the expense of supervised clinical practice have reported that graduates, although technically competent, show a reduced ability to handle the unpredictability and emotional complexity of real clinical encounters. The balance between simulation and genuine clinical practice must be an explicit and thoughtful criterion in curriculum design.

- **Transfer of skills to the real-world context**

The central question surrounding clinical simulation—whether what is learned in the simulator is effectively transferred to real-world practice—remains a subject of debate. Transfer is neither automatic nor guaranteed: it depends on the functional fidelity of the scenario, the quality of the debriefing, the opportunity to practice the acquired skills in a real-world context, and longitudinal performance monitoring. Ajemba *et al.* [3] note that the available evidence, while positive, remains heterogeneous in methodological quality, which limits the ability to draw definitive conclusions about the magnitude of the transfer effect.

This limitation does not invalidate the use of simulation, but it does require epistemological humility: simulation is a powerful tool within a broader educational system, not a self-sufficient solution. Its effectiveness depends on the coherence of the instructional design, the competence of the facilitator, and, fundamentally, its integration with the subsequent supervised clinical practice.



Figure 7. A team of medical professionals works together to provide emergency medical care to a simulated patient at the 88th Medical Group's simulation center.

REFLECTION

- **Simulation as a means, not an end**

As medical students who have participated in clinical simulation experiences at various stages of our training, we share a view supported by the academic literature: simulation transforms learning only when those who design and implement it view it as a means to achieve real clinical competencies, not as an end in itself. The danger of fetishizing technology—of valuing the simulator for its sophistication rather than its educational utility—is a trap into which both institutions and instructors can fall.

We have participated in simulation sessions where the time spent operating the equipment or "acting out the scenario" far exceeded the time allocated for subsequent reflection. The result was an intense but scarcely educational experience. We contrasted these experiences with others in which a relatively simple scenario—such as communicating an unexpected diagnosis to a standardized patient—was followed by an in-depth debriefing that confronted us with our communication biases and our automatic response patterns in the face of clinical uncertainty. In those moments, simulation fulfilled its pedagogical promise. This distinction between simulation as an experience and simulation as learning is precisely what Herrera-Aliaga and Estrada identify as the differentiating factor between effective programs and those that merely incorporate technology without transforming pedagogy [1].

- **Debriefing as the core of learning**

A review of the literature and our own experience as students converge on one point: debriefing is the element that most consistently determines the educational quality of a simulation session. When the facilitator skillfully leads the debriefing—exploring the student's mental framework, validating emotions without ignoring mistakes, and linking the simulated experience to future practice—the simulation transcends a technical exercise and becomes a genuine space for building professional identity.

The evidence from Duff *et al.* on the critical importance of debriefing, along with the observation that many facilitators "learn by doing" without formal training in

this skill, directly challenges us as stakeholders in the educational system [9]. Training instructors in the art and science of debriefing should be a top institutional priority, at least as important as acquiring simulation equipment. Without this investment in the pedagogical capital of facilitators, investment in technology loses much of its transformative potential.



Figure 8. Students practice with pediatric simulators to understand the treatment protocols that prevent pediatric emergencies.

- **The importance of curricular integration**

Finally, we reflect on the need for simulation to occupy an explicit and integrated place in the medical curriculum—not as an extracurricular activity or an optional supplement available only to those who have the time and motivation to take advantage of it. The curricular fragmentation that characterizes many medical programs—in which simulation appears as an isolated event, disconnected from theoretical content and clinical practice—drastically reduces its educational potential.

An integrated simulation curriculum, as proposed by Alonso-Peña and Álvarez-Álvarez, requires coordination among faculty members from different disciplines, agreement on learning objectives for each stage of training, and an assessment system that recognizes performance in simulation as a legitimate indicator of competence [4]. This implies a cultural shift within the institution that goes far beyond the acquisition of manikins or access to virtual reality platforms. Ultimately, it involves a collective decision regarding the type of physicians we wish to train and the conditions we must provide to achieve this goal.

CONCLUSIONS

Clinical simulation has proven to be a highly valuable educational tool in the training of healthcare professionals, with a documented positive impact on the acquisition of technical and non-technical competencies, and a significant contribution to patient safety. Its foundation in sound pedagogical theories—such as experiential learning, deliberate practice, cognitive load theory, and reflective debriefing—and its ability to provide reproducible, standardized, and safe experiences position it as an essential component of contemporary medical education.

However, its effectiveness does not stem from the technological device used, but rather from the pedagogical rigor with which it is designed and implemented. A simulation without structured debriefing, without curricular integration, and without trained facilitators is, at best, a memorable experience; at worst, an opportunity to reinforce errors without reflection. An institution that invests in simulators without simultaneously investing in the training of its faculty and the coherence of its curriculum is purchasing technology without pedagogy.

The future of clinical simulation points in three particularly significant directions. The first is interprofessional simulation, which brings together students of medicine, nursing, pharmacy, and other disciplines in a single scenario to train the collaborative skills required by contemporary models of health care [14]. The second is the integration of artificial intelligence for automated performance analysis, personalized feedback, and dynamic adjustment of the scenario's complexity [2]. The third is telesimulation, which allows for the remote replication of training experiences and can help democratize access to this educational modality in contexts of high geographic dispersion or limited resources [10].

As medical students, we conclude with a message that speaks directly to us: simulation offers us the privilege of learning to care for others without anyone paying the price for our learning. This opportunity carries an ethical responsibility that falls on all of us—students, faculty, and institutions alike—to make the most of it with commitment, rigor, and a willingness to confront our own mistakes before they affect a real patient. Ultimately, clinical simulation is not just an educational tool; it is a statement of values about the kind of physicians we want to become.



Figure 9. Professionals at Sant Joan de Déu Barcelona Hospital conducting a clinical simulation session with SIMTest to detect risks in the medical procedure.



Figure 10. Tulane School of Medicine faculty lead a high-stakes simulation training session from the control room, assessing the competencies demonstrated by the students.

Funding

This work did not receive external funding.

Conflict of interest

The author declares no conflicts of interest.

Ethical considerations

This work did not involve the participation of human beings or animals, nor the collection of primary data, and therefore did not require approval by a research ethics committee. All data used come from previously published secondary sources that are publicly accessible.

REFERENCES

1. Herrera-Aliaga E, Estrada LD. Trends and innovations of simulation for twenty-first century medical education. Front Public Health. 2022;10:619769. https://doi.org/10.3389/fpubh.2022.619769
2. Elendu C, Amaechi DC, Elendu TC, Jingwa KA, Okoye OK, John Okah M, et al. The impact of simulation-based training in medical education: A review. Medicine (Baltimore). 2024;103(27):e38813. https://doi.org/10.1097/MD.0000000000038813
3. Ajemba MN, Ikwe C, Iroanya JC. Effectiveness of simulation-based training in medical education: Assessing the impact of simulation-based training on clinical skills acquisition and retention: A systematic review. World J Adv Res Rev. 2024;21(1):1833-1843. https://doi.org/10.30574/wjarr.2024.21.1.0163
4. Alonso-Peña M, Álvarez-Álvarez C. Clinical simulation in health education: A systematic review. Investig Educ Enferm. 2023;41(2):e08. https://doi.org/10.17533/udea.iee.v41n2e08

5. Felix HM, Schertzer K. Mastery learning in medical simulation. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022. Available from: https://www.ncbi.nlm.nih.gov/books/NBK555918/
6. Mitzman J, Reynolds M, Panchal A, Yee J. A pilot study of a simulation-based mastery learning procedural curriculum for pediatric emergency medicine fellows. Pediatr Emerg Care. 2024;40(12):924-930. https://doi.org/10.1097/PEC.0000000000003273
7. Tokuno J, Knobovitch RM, Botelho F, Fried HB, Carver TE, Fried GM. Immersive virtual reality simulation for medical student procedural training: Assessment of cognitive load and usability. Simul Healthc. 2025. https://doi.org/10.1177/15533506251339920
8. Abulebda K, Auerbach M, Limaiem F. Debriefing techniques utilized in medical simulation. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022. Available from: https://www.ncbi.nlm.nih.gov/books/NBK546660/
9. Duff JP, Morse KJ, Seelandt J, Gross IT, Lydston M, Sargeant J, et al. Debriefing methods for simulation in healthcare: A systematic review. Simul Healthc. 2024;19(1S):S112-S121. https://doi.org/10.1097/SIH.0000000000000765
10. Han E, Kim M, Park J, Hwang Y. Effectiveness of virtual reality in healthcare education: Systematic review and meta-analysis. Sustainability. 2024;16(19):8520. https://doi.org/10.3390/su16198520
11. Moll-Khosrawi P, Falb A, Pinnschmidt H, Zöllner C, Issleib M. Virtual reality as a teaching method for resuscitation training in undergraduate first year medical students during COVID-19 pandemic: A randomised controlled trial. BMC Med Educ. 2022;22:483. https://doi.org/10.1186/s12909-022-03533-1
12. Birrenbach T, Stuber R, Müller CE, Sutter PM, Hautz WE. Virtual reality simulation to enhance advanced trauma life support trainings: A randomized controlled trial. BMC Med Educ. 2024;24:666. https://doi.org/10.1186/s12909-024-05645-2
13. McInerney N, Nally D, Khan MF, Heneghan H, Cahill RA. Performance effects of simulation training for medical students: A systematic review. GMS J Med Educ. 2022;39(5):51. https://doi.org/10.3205/zma001572
14. Sezgin G, Bektas H. Effectiveness of interprofessional simulation-based education programs to improve teamwork and communication for students in the healthcare profession: A systematic review and meta-analysis of randomized controlled trials. Nurse Educ Today. 2023;120:105619. https://doi.org/10.1016/j.nedt.2022.105619
15. Pitiris A, Constantinou C, Sezgin G. Development and improvement of non-technical skills in interprofessional healthcare teams through simulation-based experiences: A systematic review. Clin Simul Nurs. 2025;100:101677. https://doi.org/10.1016/j.ecns.2025.101677
16. Bennion J, Mansell SK. Management of the deteriorating adult patient: Does simulation-based education improve patient safety? Br J Hosp Med (Lond). 2021;82(8):1-8. https://doi.org/10.12968/hmed.2021.0293
17. Kubin L, Shreffler MJ. The influence of nursing simulation on patient outcomes and patient safety: A scoping review. Clin Simul Nurs. 2022;68:7-17. https://doi.org/10.1016/j.ecns.2022.04.004
18. Al-Khayat T, Carter S, Mauger M, Patel A, Patel K, Chavarria L. Implementing the Debriefing Assessment for Simulation in Healthcare (DASH) tool for training medical faculty. Cureus. 2024;16(9):e69290. https://doi.org/10.7759/cureus.69290