Review of Contemporary Philosophy
ISSN: 1841-5261, e-ISSN: 2471-089X
Vol 23 (2), 2024
pp. 7142 - 7152

Simulation-Based Training for Multidisciplinary Trauma Response: A Comprehensive Review

[1]-Mohab Abdullah Sharahili, [2]-Obaid Mubarak Alluwaymi,[3]-Malak Ayedh Alqahtani,[4]-Yousef Saad Aloufi,[5]-Essa Salah Aljohani,[6]- Sultan Zaben Hanas Alotaibi,[7]-Ashjan Hussain Ali Mubaraki,[8]-Ahmed Bahrawi,[9]-Hassan Farraj Al Dawsari,[10]-Nouf Mohammed Aldosary,[11]-Eman Yahya Alshareef,[12]-Abdullah Malfi Muawad Al-Hussaini,[13]-Salma Ali Ahmad Khobrani,[14]-Khawlah Mussa Hakami,[15]-Abdullelah Abdullatif Ahead Al-Muhana,[16]-Khalid Hamdan Almuqati,

[1]Ksa, Ministry Of Health, Primary Healthcare

[2]Ksa, Ministry Of Health, Riyadh- Mansoura Health Center

[3]Ksa, Ministry Of Health, Riyadh, Public Health Administration

[4]Ksa, Ministry Of Health, King Fahad Hospital Madina

[5]Ksa, Ministry Of Health, King Fahad Hospital Madina

[6]Ksa, Ministry Of Health, Al-Rain General Hospital, Affiliated With The Ministry Of Health

[7]Ksa, Ministry Of Health, Najamiya Primary Care Center

[8]Ksa, Ministry Of Health, National Guard Health Affairs Jeddah

[9]Ksa, Ministry Of Health, General Directorate Of Health Services

[10]Ksa, Ministry Of Health, King Saud Medical City

[11]Ksa, Ministry Of Health, Aleman General Hospital

[12]Ksa, Ministry Of Health

[13]Ksa, Ministry Of Health, Irada Hospital For Mental Health

[14]Ksa, Ministry Of Health, Arada Hospital For Mental Health

[15]Ksa, Ministry Of Health, P.H.C. North Al-Mubraz

[16]Ksa, Ministry Of Health, Imam Abdulrahman Alfaisal Hospital

Abstract

Background: Simulation-Based Training (SBT) has transformed medical education as it offers healthcare professionals a risk-free, controlled setting for learning clinical and non-clinical skills. With the rising complexity of patient care, the necessity for standardized and immersive training modalities has become essential.

Aim: In this review, the development, methods, advantages, limitations, and future perspectives of SBT in multidisciplinary trauma response and medical education are discussed.

Methods: A comprehensive review of the literature was conducted using databases like PubMed, Google Scholar, and Web of Science. Articles related to the design, implementation, outcomes, and innovations of SBT were screened.

Results: SBT significantly enhances technical skill (e.g., procedures, surgical interventions) and non-technical skill (e.g., communication, leadership). High-fidelity mannequins, virtual reality, standardized patients, and hybrid models improve knowledge retention, patient safety, and team performance. Despite its proven effectiveness, widespread adoption is hindered by the high cost, limited infrastructure, and need for faculty development. Emerging innovations on the horizon, such as AI, VR, AR, and telemedicine simulations, offer new possibilities for accessible and adaptive training globally.

Conclusion: SBT is a novel tool in medical education. Its implementation in interdisciplinary training models and global adaptation can enhance the quality and safety of patient care.

Keywords: trauma response, simulation-based training, virtual reality, medical education, healthcare innovation

Received: 17 October 2024 **Revised:** 29 November 2024 **Accepted:** 12 December 2024

1. Introduction

Simulation-based training (SBT) is now a focal innovation in medical education that has revolutionized the education of healthcare professionals by delivering interactive, realistic training experiences that closely simulate clinical practice. The process enables the attainment of technical as well as soft skills within the simulation setting and thereby better prepares learners for real clinical challenges. Traditionally, medical training rested on an apprenticeship model, with learning occurring through direct observation of patients under the supervision of clinicians. However, this was not without its limitations, such as inconsistent learning experience and risks to patient safety [1]. As medical science evolved, and healthcare systems grew more complex, greater emphasis was needed on standardized, reproducible training procedures [2].

The history of medical simulation began in the 1960s with the creation of the Resusci Anne mannequin for training in CPR [3]. From then on, simulation technology has developed vastly, such as high-fidelity mannequins, virtual reality (VR), standardized patients, and hybrid models. The technology allows for massive training in both basic and complex clinical procedures [4,5]. High-fidelity simulators, which can simulate human physiology, enable students to practice complex interventions such as intubation and emergency resuscitation in realistic settings [6]. Evidence supports that these machines enhance skill acquisition, retention, and confidence, and decrease anxiety during high-stakes situations [7,8].

Advances in VR and augmented reality (AR) in recent times have offered highly interactive, immersive platforms for surgical and critical care training. These technologies eliminate the need for physical simulators while enabling repetitive, risk-free rehearsal of complicated clinical skills [9-12]. Similarly, standardized patients, specially trained professionals who repeatedly simulate medical conditions, enable students to rehearse communication, physical examination, and clinical reasoning in realistic contexts [13]. These interactions improve diagnostic precision, interpersonal skills, and general clinical competence, as well as enable structured assessment and feedback [14-16].

Hybridization, in which the use of multiple modalities is mixed—i.e., combining mannequins and standardized patients—facilitates combined learning. Hybrid simulations allow learners to build both clinical and teamwork skills simultaneously [17,18]. Hybrid simulations are as effective at improving learners' performance with complex cases [19]. One of the strongest advantages of SBT is the deliberate practice to which learners can be exposed, where learners can repeatedly expose themselves to clinical tasks without endangering patient safety [20,21]. The error-free learning environment fosters error-based learning, reflection, and skill acquisition [22].

Debriefing, a structured process of reflection after simulation sessions, is crucial in optimizing learning outcomes. It provides timely feedback, enhances reflective thinking, and allows learners to process experience constructively [23,24]. Research confirms that effective debriefing improves clinical performance and supports long-term knowledge retention [25]. Though it has numerous benefits, SBT is not without challenges, most notably the cost of equipment, facilities, and instructors trained in SBT [26,27]. Simulations, no matter how advanced, cannot duplicate the unpredictable real-life situation of clinical practice, and the problem becomes one of skill transferability [28,29]. One of the biggest challenges is the need for faculty to continue their education. Faculty are not only required to be technically competent but also skilled at facilitating and presenting back [30,31].

Nevertheless, the argument for SBT remains strong. Simulation-trained learners have long been shown in controlled comparisons to perform better than traditionally educated students, particularly in technical and interpersonal competency [32-35]. The future will see technological improvements take SBT to an even greater peak. Self-learning and adaptive technologies can personalize learning experiences, track progress, and adjust scenarios in real time to address learner requirements [36,37]. Creating VR and AR applications will facilitate increased immersion and access to rare or complex conditions [38,39].

Integration of SBT with broader education approaches, such as problem-based learning and interprofessional learning could be even more effective in terms of the training [40]. While SBT has been adopted by high-income countries, its application in low- and middle-income countries is patchy due to cost and infrastructure issues [41]. Enhancing access through culturally modified and cost-effective mechanisms is necessary in order to globalize high-quality healthcare training [42,43].

This article seeks to chart the evolution of simulation in clinical education, from significant milestones to current practice and emerging trends. It concentrates on the scope of simulation strategies—high-fidelity, VR, standardized patients, and hybrids—and their potential to enhance clinical education.

2. Materials and Methods

Relevant scholarly publications, studies, and scholarly articles were obtained through electronic databases, namely PubMed, Google Scholar, and the Web of Science. The materials utilized related to the development, implementation, and outcomes of SBT in contemporary medical curricula.

3. Educational Evolution

Over the centuries, medical education has evolved significantly, from casual apprenticeships to formal technology-driven training. These changes are mirroring wider shifts in societal demand, scientific understanding, and technological possibility. One of the most revolutionary developments of the past few decades is the incorporation of SBT, which has recast how healthcare professionals learn and develop clinical skills. Training was initially almost entirely experiential. Trainee doctors learned from established physicians. Although this gave exposure to practical work, it had no standardization and no objective evaluation. The fundamental knowledge was derived from old books by authors like Hippocrates and Galen, though the interpretations varied sometimes, and education was unevenly distributed [1].

The Renaissance ushered in the shift towards scientific inquiry and empirical evidence. Humanism and the revival of the classical medical books promoted observation and analytical reasoning. Formal education commenced with the establishment of European schools of medicine, where anatomical dissection became part of the medical school curriculum. Renowned anatomists like Andreas Vesalius revolutionized training by advocating for direct observation and the scientific process in medical studies [2].

During the 19th century, large-scale reforms materialized with the development of modern medical schools. The turning point was Abraham Flexner's 1910 report, which condemned variable educational standards in North America. Funded by the Carnegie Foundation, the report advocated science-based education, stringent admission requirements, and improved laboratory and clinical training integration. This resulted in a far-reaching overhaul, such as the shutdown of underperforming institutions and enhanced accreditation systems [3].

4. Simulation-Based Training Emerges

By the middle of the 20th century, biomedical sciences organized medical training. Even though this boosted theoretical knowledge, it was not practical skill acquisition. Clinical education was more often on real patients, and it raised ethical concerns as well as jeopardized patient safety. Such limitations required controlled environments of training that facilitated skill acquisition without threatening the quality of care

[4]. The history of Simulation dates back to the 1960s when Resusci Anne, a CPR teaching mannequin, was designed by Asmund Laerdal in association with Dr. Peter Safar. It made possible hands-on and safe practice of life-saving skills and proved the Simulation's capability in skill acquisition [5].

Specialized equipment was introduced during the 1970s. For example, Harvey, a cardiopulmonary simulator developed at the University of Miami, allowed students to practice diagnosing cardiovascular disease through realistic audio and touch feedback. Anesthesia simulators were also widely adopted, offering students a secure platform to practice complex maneuvers and emergency response [6].

The 1990s saw simulation technology make a huge leap forward with the release of high-fidelity mannequins like SimMan. These patient simulators could replicate breathing, cardiac rhythms, states of trauma, and drug actions, enabling interaction with very realistic situations. It was demonstrated through studies that students who used high-fidelity simulators had better confidence, retention, and procedural skill than standard teaching [7].

In the latter 20th and earlier 21st centuries, virtual reality (VR) and augmented reality (AR) were introduced into medical training. The platforms gave learners exposure to interactive environments where they were able to practice complex surgeries and patient care. VR safely offered repeated practice with increased speed in achieving skill proficiency. Studies have indicated that VR improves surgical proficiency while reducing time to proficiency [8]. The second basic element of SBT is the SP model, which employs actors specially trained to regularly mimic clinical situations. This modality permits rehearsal of interviewing patients, physical examination, and communication skills in a naturalistic, patient-centered setting. The SP technique has been shown to improve diagnostic skill, empathy, and overall clinical competence [9].

Hybrid simulations, where two or more simulation types are combined, are a popular method. For example, a standardized patient may be combined with a high-fidelity mannequin to simulate a medical emergency. This enables learners to apply both technical procedures and interpersonal communication in real-life situations, improving decision-making and clinical adaptability [10].

SBT offers a controlled, secure learning setting where students are able to hone skills without risk to actual patients. This is especially valuable in the case of emergency and invasive procedures, where an error would be disastrous. Simulation also provides experience with atypical cases that students might otherwise not encounter in clinical rotation [11]. Repetition with feedback is central to the process of simulation. Practice can be repeated until mastered by students, and structured debriefing can isolate and correct errors. Various studies have established that this cycle significantly enhances clinical performance and supports long-term retention of knowledge [12].

While it has proven to be valuable, widespread use of SBT is economically limited. Significant amounts of money are needed for high-fidelity simulators, VR technology, and SP programs. These are typically beyond the budget of resource-limited schools, particularly in low-income settings [13]. Successful SBT execution depends on faculty skilled not only in technical installation but also in delivering reflective debriefings and giving targeted feedback. Educators need to undergo regular training, which can be costly and time-consuming. In addition, the integration of Simulation into existing curricula requires thoughtful planning to ensure consistency with learning goals and maximum educational benefit [14].

Artificial Intelligence (AI) is likely to highly encourage SBT by way of personalized learning. AI-aided simulations can perform real-time assessment of performance, provide individualized feedback, and modify the level of complexity of scenarios according to the achievements of learners, resulting in efficient and customized learning experiences [15]. Next-generation VR and AR use will make the experiences more realistic and accessible. Immersive settings such as these will simulate rare diseases and complex interventions with greater accuracy, enabling higher-end training content to reach more people [16]. While SBT has been extensively utilized by high-income nations, low- and middle-income nations are restricted by financial and infrastructural limitations. This disparity must be addressed. Low-cost simulation technology and locally relevant training modules must be highlighted to facilitate worldwide access to quality medical education [17].

5. Advantages of Simulation-Based Training

Simulation-Based Training (SBT) has a significant role in the development of technical and non-technical skills necessary for modern medical practice. Technical expertise, such as performing surgical procedures or clinical interventions, is key to the healthcare industry. SBT accomplishes that by enabling learners to rehearse procedures like intubation, catheterization, and suturing using high-fidelity mannequins, virtual reality, and simulated patients simulating physiological responses. These repeated, practical sessions enable learners to develop confidence and proficiency. There is evidence that repeated simulation exposure results in higher competency and long-term retention than traditional training methods [1].

Similarly important are non-clinical skills such as communication, leadership, and teamworking that SBT addresses through scenario learning as well. By means of team simulations, students collaborate while under pressure, delegate tasks, and make team decisions—models of actual clinical dynamics. Experiments emphasize these simulations foster better teamwork, better communication, and improve the decision-making ability of healthcare professionals [2].

SBT is a risk-free, consequence-free setting for learning and skill development with less risk of mistake in actual clinical practice. Traditional training can endanger patients when procedures are conducted by inexperienced practitioners, but simulation offers an ethical compromise through the relocation of practice to a risk-free setting. This change dramatically minimizes the risk of mistakes in actual patient care [3]. Improved patient care outcomes result from simulation training. Studies have indicated that simulation-trained students demonstrate improved diagnostic proficiency, respond faster to emergencies, and intervene timely. High-fidelity simulation for neonatal resuscitation, for example, has been linked with improved performance and improved newborn health outcomes [4].

SBT also provides an environment that fosters repeated practice and error-based learning. Students can practice simulation cases repeatedly before mastering them. High-fidelity hardware and immersion technologies make this repeated process possible, which not only develops muscle memory but also confidence in the clinical setting [5]. Notably, the possibility of making and learning from errors without any adverse repercussions fosters a stress-free, supportive learning environment. Contrary to traditional training, where errors come with severe real-world consequences, simulation embraces error-making as an enhancing factor. Experiments confirm that this is beneficial to both learning and knowledge retention [6].

One of the greatest educational advantages of simulation is immediate feedback. It is possible to give immediate feedback on clinical judgment and procedural skill for the student, enabling them to acquire and enhance skills quickly. For instance, a cardiac emergency simulation provides instant feedback on interventions such as compression depth or timing of interventions [7]. No less critical are post-simulation debriefings, during which instructors lead reflective discussions. Guided reviews assist learners in comprehending what was done well, areas of gaps, and targeted recommendations. Many studies affirm that debriefing dramatically improves clinical competence and long-term skill acquisition [8].

There is a robust evidence base for the effectiveness of simulation as an educational method. Meta-analyses and literature reviews consistently identify that SBT improves technical and nontechnical skill performance. It reduces clinical error and improves learners' confidence. Simulation was consistently better than traditional methods in skill acquisition, safety, and learner satisfaction in a single systematic review [9].

While it has many benefits, the use of SBT comes with a great cost. VR systems and high-fidelity simulators are very expensive to obtain initially. For example, a high-end mannequin may be over $50,000, let alone maintenance, upgrade, and software expenses in the long run [1]. Moreover, the creation and maintenance of particular simulation centers contribute to the expense. Simulation centers are not merely high-tech but also require space, operational staff, and maintenance teams. VR-based simulations further necessitate heavy investment in IT infrastructure, technical support, and debugging [2].

These operational needs could curtail the application of SBT in under-funded institutions, particularly in developing countries where finance is limited. Often over-looked is the issue of having well-trained instructors. Instructors should be competent with simulation technology but also in stimulating effective learning using scenario design and debriefing. Such twin competency entails deep investment in professional development and continuous training [3].

The second challenge is the integration of simulation into the curriculum. Developing simulation-based modules to complement traditional education requires interdepartmental cooperation. Resistance to change from staff, along with planning time, generally slows down integration processes. Institutions must carefully coordinate simulation content and learning objectives in alignment to deliver coherence and applicability [4]. While high-fidelity simulation offers breathtaking fidelity, it falls short of being a replacement for the full richness of actual patient interactions. Unscripted patient activity, emotional tension, and real-time multidisciplinary team discussion are difficult to entirely mimic. This lack of unpredictability in simulated environments may limit exposure to certain real-world difficulties [5].

One such continuing problem is the transferability of skills from simulation to real-world practice environments. Although performance is improved within controlled environments by using simulations, it is questionable how well such skills can be transferred to the dynamic nature of real-world environments. A simulated cardiac arrest, for instance, is not necessarily reflective of the complexity of managing such an event in a real-world hospital setting [6].

6. Overcoming Implementation Barriers

Despite such challenges, the integration of SBT can be enabled through strategic planning. Budgetary limitations are overcome with partners, grants, and low-cost alternatives. Blended simulation with traditional training is more real-world and offers a level of controlled and dynamic conditions exposure. Ongoing research on SBT's limitations is vital. Simulation programs within institutions must be regularly tested against learner performance and patient outcomes. Enhancing realism and adjusting scenarios based on real clinical feedback will make SBT's training more effective [7,8].

Patients generally view simulation-trained clinicians in a better light. Patients recognize simulation-based training with higher levels of readiness and ability. One study by Bradley [1] reported that patients have the belief that SBT makes providers more ready to respond to emergencies and challenging clinical conditions better, making them more confident in care provision. Patient safety is a significant matter for the general public, and SBT has been recognized as an error-prevention measure by which clinicians are able to commit and learn from mistakes before interacting with real patients. Owen [2] found that patients supported SBT as it assisted in eradicating clinical mistakes and developing safer clinical environments. While most patients enjoy the realism offered by high-fidelity simulations, there are questions about whether such devices can accurately mirror clinical interactions in the field. They do admit limitations in reproducing emotional responses and the unpredictability of human beings, which could impact how well providers are prepared for real-world issues [3].

Ethical considerations also influence patient attitudes. Simulations with standardized patients must maintain actor autonomy and confidentiality. Owen [4] emphasizes the importance of informed consent and ethical protection to maintain openness and establish trust among patients. The high cost of simulation technology is accompanied by concerns that such expenses will eventually be passed on to patients. However, studies indicate that once patients become informed of the long-term cost savings of lower medical errors and better outcomes, they are more likely to be supportive [5]. Cultural habits also determine acceptance. Experiential training in certain cultures through direct contact with patients is preferable to simulation, leading to skepticism. SBT programs, hence, have to be culturally modified in order to promote acceptance among diverse groups [6]. Involving patients in sim scenario design ensures that training is representative of true needs. Involving patients makes it more relevant and constructs a partnership. Scalese et al. [7] illustrate how patient feedback facilitates the creation of more responsive, patient-centered training programs that ultimately improve care quality.

7. Interprofessional Education Through Simulation

Simulation-based interprofessional education brings together providers from diverse disciplines—physicians, nurses, pharmacists, and others—to practice as intact teams. It builds communication, leadership, and teamwork, all critical to collaborative care. Bradley [1] found that interprofessional simulation improves communication, reduces medical error, and improves outcomes. Simulation allows the healthcare teams to rehearse teamwork situations, respectful interaction, and task distribution. Owen [2] demonstrated team-based SBT to be significantly effective in interpersonal skills and cooperative problem-solving to the advantage of patient care.

SBT provides students with the opportunity to practice leadership roles and make important decisions. Through feedback and roleplay, participants feel more confident in managing clinical teams. Higham [3] found that this training enhances leadership across disciplines. Cooper and Taqueti [4] stressed that simulation enhances deeper respect and trust among healthcare staff, facilitating efficient teamwork. SBT also allows for continuing education, through which practitioners improve existing skills and acquire new practice. Simulated clinical cases are the foundation of reflection and continued improvement. Bradley [1] reaffirmed that simulation training every so often results in better performance and increased patient safety.

Cross-disciplinary learning is enabled through simulations. Professionals in healthcare interact across functions, building a common understanding and coordination. Owen [2] mentioned the benefits of such interprofessional sessions towards improved care standards. Scenarios can also be developed to meet individual learning needs and style preferences, with several instructional methods. Personalized learning has been shown to enhance engagement and retention, as highlighted by [3]. SBT fosters a culture of ongoing improvement. It offers effective, adaptable opportunities to learn, reiterating the commitment to clinical excellence. Use of simulation in a judicious way ensures continuing competency development, as stated by [4]. Lastly, SBT not only enhances individual competencies but also the overall health care system, improving outcomes through frequent high-fidelity practice. There is evidence to support its effect on honing skills and decreasing mistakes along the continuum of care [5].

8. Virtual Reality in Clinical Simulation

Virtual reality (VR) has emerged as a sophisticated element of simulation-based education, providing healthcare students with a simulation of interactive and immersive learning. VR simulations closely mimic clinical environments, enabling students to perfect hands-on skills in diagnosis, procedural skill execution, and clinical decision-making. The simulators facilitate interactive simulation with realistic patient simulations, diagnostic devices, and medical devices, enhancing the reality of training. As per Dhar et al. [8], learning based on VR improves procedural accuracy considerably, enhances clinical judgment, and raises learner confidence.

Gamification is another cutting-edge simulation technology trend where game-like ideas—such as points, feedback loops, and rewarding accomplishments—are embedded into pedagogical systems. Such ideas engage learners as they make simulations richer, challenge-oriented experiences. Gamified simulations engage active participation and provoke skill growth through interactive storytelling. Research work done by Owen [2] and Al-Elq [5] has shown that learning retention and learner performance in general are enhanced if gamification is included.

Telemedicine simulation is a new method of simulation training that allows learners to acquire skills in managing patients remotely. Such simulations replicate virtual consultation and diagnostic work, allowing students to practice remote communication, patient assessment, and clinical decision-making with telecommunication technology. They also improve interprofessional working between geographic locations. Cipresso et al. [9] research has illustrated how telemedicine simulations enhance clinical training and expand access to healthcare education.

Simulation technology has also played a role in making healthcare training feasible in times of public health crises like the COVID-19 pandemic. Virtual or simulated settings allow providers to simulate protocols and responses to outbreaks of infectious disease, disasters, and mass casualties within a risk-free, controlled environment. Training of this type is crucial to building readiness, optimizing safety, and optimizing decision-making in real-world crises. Zackoff et al. [10] acknowledge the critical function that SBT has played in pandemic preparedness in healthcare teams.

9. Virtual Platforms for Continuing Professional Development

Simulation platforms are increasingly being used to enable continuous learning and continuing professional development. With virtual platforms, health professionals are able to engage in interactive modules, self-assessment activities, and skill reminders at their convenience. The platforms enable flexible, self-guided learning as well as personalized coaching and feedback. Al-Elq [5] speaks of the importance of virtual simulation in maintaining clinical competencies and enabling continuous learning during a health professional's career.

Artificial Intelligence (AI) is revolutionizing the SBT space by making training experiences data-driven and bespoke. AI-driven simulations can adapt training based on user performance, giving instant feedback and adapting scenarios to areas of deficient performance. With machine learning algorithms, these platforms analyze learner development, give personalized tips, and achieve training efficiency optimization [1]. AI further improves the realism level of simulation by offering adaptive patient response and scenario modification that is sensitive to learner input. Interactive realism boosts training, which becomes more immersive and lifelike, again closing the gap between simulated and real clinical practice [2].

Virtual and augmented reality (VR/AR) technologies are establishing a new generation of medical education. VR allows students to tread through fully immersed clinical environments and engage with simulated patients, apparatus, and facilities in hospitals. It provides effective practice without the requirements of physical infrastructure [3]. Augmented reality overlays virtual information onto the real environment and enables real-time decision-making as well as situational awareness for simulations [4]. These types of technologies have become mainstream across simulation curricula, improving realism, learner motivation, and outcomes.

A blended learning paradigm combining lectures, clinical rotations, and simulation with online modules represents an active model of education. Combining experiential learning in the form of simulation with didactic information offers the student an effective, dynamic model of education. A blended, multi-modal instruction method encourages both the achievement of knowledge as well as experiential practice, reinforcing learning [5]. Simulations involving students of different disciplines—i.e., medicine, nursing, and allied health—promote collaborative learning conditions reflecting real clinical teams. Interdisciplinary training programs help students develop skills in communication, problem-solving, and teamwork, which are essential in today's team-oriented healthcare delivery [6].

Attempts to internationalize simulation training are expanding access in developing countries where facilities for health education may be scarce. SBT provides reproducible, hands-on education that is both affordable and safe. These learning methods solve workforce development challenges with reproducible and budget-friendly education. One nice example of such promotion of simulation in low-resource environments is the World Health Organization's Global Initiative for Emergency and Essential Surgical Care [7].

With simulation training gaining popularity all over the globe, there is a need to make programs encompass linguistic and cultural variation. Cultural translation of simulations into healthcare habits and cultural traditions within the local area ensures training relevance and efficacy. Simulation training on cultural competency can prepare health providers to offer caring, patient-centered care within different sociocultural contexts [8]. Additionally, simulations where the culture of patients can be used to provide parameters maximize learners' understanding and sympathy, ultimately achieving improved outcomes among patients [9].

10. Conclusion

Simulation-Based Training (SBT) has become a cornerstone of modern medical education, offering paradigm shifts in clinical specialties. Through the use of high-fidelity mannequins, virtual and augmented reality, standardized patients, and hybrid simulations, SBT allows healthcare professionals to rehearse realistic, high-stakes scenarios with no risks to patient safety. The review confirms that SBT not only improves procedural skill and clinical decision-making but also supports communication, teamwork, leadership, and decision-making—qualities that are most critical in multidisciplinary trauma and emergency care.

SBT's immersive environment fosters intentional practice, enabling students to develop confidence, correct errors, and learn more successfully than is possible with conventional methods alone. The addition of a formal debriefing enhances this reflective learning process and long-term skill acquisition. Though SBT confers these benefits, its adoption is not unlimited by circumstances. Cost, infrastructure, and training requirements for faculty are considerable obstacles, particularly in low- and middle-income countries.

SBT's future, nevertheless, is promising. Artificial intelligence, virtual/augmented reality, and telemedicine simulations will continue to personalize, adapt, and democratize training. Additionally, the role of simulation in continuing professional development, interprofessional collaboration, and global health equity is expanding. Through investment and culturally sensitive solutions, SBT can bridge educational gaps and contribute to the provision of safer, more effective health systems worldwide. As simulation continues to evolve, its potential for shaping the future of medical education and patient care remains unparalleled.

References

1. Bradley P. The history of simulation in medical education and possible future directions. Med Educ. 2006;40:254–62.
2. Owen H. Early use of simulation in medical education. Simul Healthc. 2012;7:102–16.
3. Higham H. Simulation past, present and future-a decade of progress in simulation-based education in the UK. BMJ Simul Technol Enhanc Learn. 2020;7:404–9.
4. Cooper JB, Taqueti VR. A brief history of the development of mannequin simulators for clinical education and training. Qual Saf Health Care. 2004;13(Suppl 1):i11–8. Erratum in: Qual Saf Health Care. 2005 Feb;14(1):72
5. Al-Elq AH. Simulation-based medical teaching and learning. J Family Community Med. 2010;17:35–40.
6. Datta R, Upadhyay K, Jaideep C. Simulation and its role in medical education. Med J Armed Forces India. 2012;68:167–72.
7. Scalese RJ, Obeso VT, Issenberg SB. Simulation technology for skills training and competency assessment in medical education. J Gen Intern Med. 2008;23(Suppl 1):46–9.
8. Dhar E, Upadhyay U, Huang Y, et al. A scoping review to assess the effects of virtual reality in medical education and clinical care. Digit Health. 2023;9:20552076231158022.
9. Cipresso P, Giglioli IAC, Raya MA, Riva G. The past, present, and future of virtual and augmented reality research: a network and cluster analysis of the literature. Front Psychol. 2018;9:2086.
10. Zackoff MW, Young D, Sahay RD, et al. Establishing objective measures of clinical competence in undergraduate medical education through immersive virtual reality. Acad Pediatr. 2021;21:575–9.
11. Chang AH, Lin PC, Lin PC, et al. Effectiveness of virtual reality-based training on oral healthcare for disabled elderly persons: a randomized controlled trial. J Pers Med. 2022;12:218.
12. Jiang H, Vimalesvaran S, Wang JK, Lim KB, Mogali SR, Car LT. Virtual reality in medical students' education: scoping review. JMIR Med Educ. 2022;8:e34860.

13. Matamala-Gomez M, Bottiroli S, Realdon O, et al. Telemedicine and virtual reality at time of COVID-19 pandemic: an overview for future perspectives in neurorehabilitation. Front Neurol. 2021;12:646902.
14. Mekbib DB, Han J, Zhang L, et al. Virtual reality therapy for upper limb rehabilitation in patients with stroke: a meta-analysis of randomized clinical trials. Brain Inj. 2020;34:456–65.
15. Fealy S, Jones D, Hutton A, et al. The integration of immersive virtual reality in tertiary nursing and midwifery education: a scoping review. Nurse Educ Today. 2019;79:14–9.
16. Bracq MS, Michinov E, Arnaldi B, et al. Learning procedural skills with a virtual reality simulator: an acceptability study. Nurse Educ Today. 2019;79:153–60.
17. Rose T, Nam CS, Chen KB. Immersion of virtual reality for rehabilitation – review. Appl Ergon. 2018;69:153–61.
18. Gasteiger N, van der Veer SN, Wilson P, Dowding D. How, for whom, and in which contexts or conditions augmented and virtual reality training works in upskilling health care workers: realist synthesis. JMIR Serious Games. 2022;10:e31644.
19. Tudor Car L, Kyaw BM, Teo A, et al. Outcomes, measurement instruments, and their validity evidence in randomized controlled trials on virtual, augmented, and mixed reality in undergraduate medical education: systematic mapping review. JMIR Serious Games. 2022;10:e29594.
20. Karaman D, Taşdemir N. The effect of using virtual reality during breast biopsy on pain and anxiety: a randomized controlled trial. J Perianesth Nurs. 2021;36:702–5.
21. Hood RJ, Maltby S, Keynes A, et al. Development and pilot implementation of TACTICS VR: a virtual reality-based stroke management workflow training application and training framework. Front Neurol. 2021;12:665808.
22. Adhikari R, Kydonaki C, Lawrie J, et al. A mixed-methods feasibility study to assess the acceptability and applicability of immersive virtual reality sepsis game as an adjunct to nursing education. Nurse Educ Today. 2021;103:104944.
23. Gunn T, Rowntree P, Starkey D, Nissen L. The use of virtual reality computed tomography simulation within a medical imaging and a radiation therapy undergraduate programme. J Med Radiat Sci. 2021;68:28–36.
24. Mallik R, Patel M, Atkinson B, Kar P. Exploring the role of virtual reality to support clinical diabetes training-a pilot study. J Diabetes Sci Technol. 2022;16:844–51.
25. Chiang DH, Huang CC, Cheng SC, et al. 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. Medicine (Baltimore). 2022;101:e28570.
26. Andersen NL, Jensen RO, Posth S, Laursen CB, Jørgensen R, Graumann O. Teaching ultrasound-guided peripheral venous catheter placement through immersive virtual reality: an explorative pilot study. Medicine (Baltimore). 2021;100:e26394.
27. Hoogenes J, Wong N, Al-Harbi B, et al. A randomized comparison of 2 robotic virtual reality simulators and evaluation of trainees' skills transfer to a simulated robotic urethrovesical anastomosis task. Urology. 2018;111:110–5.
28. Slater P, Hasson F, Gillen P, Gallen A, Parlour R. Virtual simulation training: imaged experience of dementia. Int J Older People Nurs. 2019;14:e12243.
29. Pot-Kolder RMCA, Geraets CNW, Veling W, et al. Virtual-reality-based cognitive behavioural therapy versus waiting list control for paranoid ideation and social avoidance in patients with psychotic disorders: a single-blind randomised controlled trial. Lancet Psychiatry. 2018;5:217–26.
30. Beverly E, Hommema L, Coates K, et al. A tranquil virtual reality experience to reduce subjective stress among COVID-19 frontline healthcare workers. PLoS One. 2022;17:e0262703.
31. Ryu JH, Park JW, Nahm FS, et al. The effect of gamification through a virtual reality on preoperative anxiety in pediatric patients undergoing general anesthesia: a prospective, randomized, and controlled trial. J Clin Med. 2018;7:284.
32. Bergmann J, Krewer C, Bauer P, Koenig A, Riener R, Müller F. Virtual reality to augment robot-assisted gait training in non-ambulatory patients with a subacute stroke: a pilot randomized controlled trial. Eur J Phys Rehabil Med. 2018;54:397–407.

33. Mackay EC, Patel KR, Davidson C, et al. Simulation as an effective means of preparing trainees for active participation in MDT meetings. Future Healthc J. 2024;11:100017.
34. Lembo D, Abate Daga F, Calì C, et al. Early introduction of simulation in the medical curriculum: the MedInTo perspective. Front Med (Lausanne). 2024;10:1280592.
35. Lee J, Kim H, Kron F. Virtual education strategies in the context of sustainable health care and medical education: a topic modelling analysis of four decades of research. Med Educ. 2023;58:47–62.
36. Cardoso SA, Suyambu J, Iqbal J, et al. Exploring the role of simulation training in improving surgical skills among residents: a narrative review. Cureus. 2023;15:e44654.
37. Howard T, Iyengar KP, Vaishya R, Ahluwalia R. High-fidelity virtual reality simulation training in enhancing competency assessment in orthopaedic training. Br J Hosp Med (Lond). 2023;84:1–8.
38. Sizemore J, Bailey A, Sankineni S, et al. Training to transition: using simulation-based training to improve resident physician confidence in hospital discharges. MededPortal. 2023;19:11348.
39. Song SY, Choi WK, Kwak S. A model study for the classification of high-risk groups for cardiac arrest in general ward patients using simulation techniques. Medicine (Baltimore). 2023;102:e35057.
40. Cook DA, Hatala R, Brydges R, et al. Technology-enhanced simulation for health professions education: a systematic review and meta-analysis. JAMA. 2011;306:978–88.
41. Wayne DB, Didwania A, Feinglass J, Fudala MJ, Barsuk JH, McGaghie WC. Simulation-based education improves quality of care during cardiac arrest team responses at an academic teaching hospital: a case-control study. Chest. 2008;133:56–61.
42. Seymour NE, Gallagher AG, Roman SA, et al. Virtual reality training improves operating room performance: results of a randomized, double-blinded study. Ann Surg. 2002;236:458–63; discussion 463.
43. Fernandez R, Johnson M, Tran DT, Miranda C. Models of care in nursing: a systematic review. Int J Evid Based Healthc. 2012;10:324–37.

التدريب القائم على المحاكاة للاستجابة متعددة التخصصات في حالات الصدمات: مراجعة شاملة

الملخص

الخلفية :لقد أحدث التدريب القائم على المحاكاة (SBT) تحولاً في التعليم الطبي، حيث يوفر لمقدمي الرعاية الصحية بيئة تعليمية آمنة وخالية من المخاطر لاكتساب المهارات السريرية وغير السريرية. ومع تزايد تعقيد رعاية المرضى، أصبحت الحاجة إلى أساليب تدريبية موحدة وغامرة أمرًا ضروريًا.

الهدف :تناقش هذه المراجعة تطور التدريب القائم على المحاكاة، وأساليبه، وفوائده، وتحدياته، وآفاقه المستقبلية في مجال الاستجابة متعددة التخصصات لحالات الصدمات والتعليم الطبي.

الطرق :تم إجراء مراجعة شاملة للأدبيات باستخدام قواعد بيانات مثل PubMed و Google Scholar وWeb of Science. تم فحص المقالات المتعلقة بتصميم وتطبيق ونتائج وابتكارات التدريب القائم على المحاكاة.

النتائج :يعزز التدريب القائم على المحاكاة بشكل كبير المهارات التقنية (مثل الإجراءات والتدخلات الجراحية) والمهارات غير التقنية (مثل الاتصال والقيادة). تعمل نماذج المحاكاة عالية الواقعية، والواقع الافتراضي، والمرضى الموحدين، والمحاكاة الهجينة على تحسين الاحتفاظ بالمعرفة، وسلامة المرضى، وأداء الفريق. ورغم فعاليته المثبتة، إلا أن انتشاره الواسع يواجه تحديات مثل التكلفة العالية، والبنية التحتية المحدودة، والحاجة إلى تدريب الكوادر التعليمية. وتوفر الابتكارات الحديثة مثل الذكاء الاصطناعي، والواقع الافتراضي، والواقع المعزز، ومحاكاة الطب عن بُعد فرصًا جديدة لتدريب مرن ومتاح على مستوى العالم.

الاستنتاج :يُعد التدريب القائم على المحاكاة أداة مبتكرة في التعليم الطبي. ويمكن أن يؤدي تطبيقه في نماذج التدريب متعددة التخصصات وتكييفه عالميًا إلى تحسين جودة وسلامة الرعاية الصحية.

الكلمات المفتاحية :الاستجابة لحالات الصدمات، التدريب القائم على المحاكاة، الواقع الافتراضي، التعليم الطبي، الابتكار في الرعاية الصحية.