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REVIEW ARTICLE

Bridging theory and practice: enhancing medical education through simulation-based training methods

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ABSTRACT

Introduction. With the complexities of contemporary healthcare systems and the paramount importance of high-quality patient care, Simulation-Based Medical Education (SBME) has emerged as a pivotal innovation in the process of training healthcare professionals. This study explores the integration of SBME in undergraduate medical education to bridge the gap between theoretical knowledge and clinical practice, thereby preparing students with the necessary competencies for effective healthcare delivery.

Material and methods. Employing a narrative review approach, this study meticulously examined relevant literature from multiple databases, including Google Scholar, PubMed, and MedEdPublish. Following objectives, we chose the sources that were best suited to explore our research questions, focusing on keywords such as „simulation", „undergraduate medical education", „simulation-based medical education", „theoretical frameworks", „procedural framework" „curriculum design", „training efficacy", and „training evaluation" with no restriction for the date of publications.

Results. The review identified foundational educational theories underpinning SBME, such as Experiential Learning Theory and Adult Learning Theory, and traced the evolution of simulation methods from simple anatomical models to sophisticated high-fidelity simulators and virtual reality technologies. Various simulation techniques, including task trainers, manikins, and standardized patients, were analyzed for their educational value. Significant benefits of SBME, such as enhanced safety, repeatability, and adaptability, were highlighted alongside challenges like high costs and limited access. Comparative analysis revealed SBME's advantages over traditional clinical education, particularly in learning efficiency and scalability.

Conclusions. SBME represents a transformative approach in undergraduate medical education, offering a dynamic and interactive learning environment that significantly enhances clinical skills, critical thinking, and confidence. Despite its challenges, the integration of simulation-based methodologies into medical curricula is essential for addressing the evolving needs of medical training and improving patient care outcomes. Future research should focus on longitudinal studies to assess the long-term impact of SBME on clinical practice and explore the integration of emerging technologies to enhance the efficacy and accessibility of simulation-based training.

Keywords: simulation-based medical education (SBME), undergraduate medical education, clinical skills development, educational technologies, healthcare training.

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Key messages

What is not yet known on the issue addressed in the submitted manuscript

The manuscript identifies gaps in understanding the long-term im-

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pacts of simulation-based medical education on clinical outcomes. It calls for more research on integrating technologies like virtual reality and artificial intelligence to evaluate their efficiency and cost-effectiveness.

The research hypothesis

The article suggests that adding Simulation-Based Medical Education to medical curricula can enhance the connection between theory and practice, improving learning and patient care.

The novelty added by the manuscript to the already published scientific literature

The article outlines frameworks merging simulation with medical education to build flexible competencies, showing their benefits for learning and patient care, and emphasizing the transformative role of technologies like virtual reality and artificial intelligence.

Introduction

Simulation-based medical education (SBME) has emerged as a cornerstone in training healthcare professionals, offering a dynamic and interactive learning environment that mirrors clinical realities without risking patient safety. It allows learners to practice procedures, make decisions, and manage patient encounters in a controlled setting, thereby enhancing their clinical skills, critical thinking, and confidence before transitioning to real-world practice. The significance of SBME lies in its ability to bridge the gap between theory and practice, providing a platform for experiential learning that is essential in preparing competent and efficient healthcare providers [1, 2].

This paper discusses the integration of simulation-based methodologies within undergraduate medical education to address the evolving needs of medical training. The complexity of modern healthcare systems and the imperative for high-quality patient care necessitate innovative educational approaches that can adequately prepare medical students for the challenges of clinical practice. Simulation-based approaches are pivotal in this regard, as they offer a versatile and effective means of teaching clinical skills, enhancing decision-making abilities, and fostering professional competencies in a safe and supportive environment [3, 4]. By using this approach, we can address current educational challenges, such as the need for safe, effective, and patient-centered training methodologies that can adapt to the rapid advancements in medical science and technology.

This study aims to facilitate the identification of optimal strategies for the integration of simulation-based training into university curricula. This work aims to improve the quality and effectiveness of medical education by creating a framework that uses effective simulation techniques, resulting in graduates with versatile and widely applicable professional skills. [5, 6]. Furthermore, it seeks to explore the various simulation techniques and methodologies, while also assessing their respective merits and drawbacks. Ultimately, the study aims to improve understanding of how to customize simulations to meet specific needs, considering available facilities and training goals. The relevance of this research lies in its potential to transform medical education by aligning teaching methods with the demands of contemporary clinical practice, ultimately improving patient care outcomes.

Material and methods

This article is a narrative review of the literature to explore crucial elements pertaining to our topic of interest – the application of simulation methods in undergraduate medical education. Our research started by identifying and choosing relevant sources of information. We employed specific keywords pertaining to the realm of medical education and meticulously examined the titles and abstracts of articles discovered in scholarly databases such as Google Scholar, PubMed, and MedEdPublish. Subsequently, we selected sources that proved to be most appropriate for addressing our research inquiries, including „simulation", „undergraduate medical education", „simulation-based medical education", „theoretical frameworks", „procedural framework", „curriculum design", „training efficacy", and „training evaluation", without imposing any restrictions on the publication date. We extracted and analyzed relevant data, identifying patterns and trends in the literature. It is noteworthy to mention that this literature review is non-systematic in nature, signifying that the selection of sources was conducted in accordance with our research objectives, but without the inclusion of a formal and rigorous selection process, as would be the case in a systematic review.

Results

Our exploration sheds light on the foundational theories underpinning medical simulation, exploring the diverse array of methods and techniques currently available and discussing their respective advantages and disadvantages in educational settings. It delves into the management of the professional training process, presenting a detailed view on procedural framework for simulation-based training. Towards the conclusion, it engages in discussions that synthesize the findings and draws conclusions, thereby providing a comprehensive overview of the state of medical simulation in professional training and education. Through this review, we aim to offer insights into how SBME can be effectively in-

tegrated and managed within medical education curricula, highlighting its potential benefits and challenges.

Theoretical framework

Simulation-based education in medical training is underpinned by several foundational theories that explain its effectiveness and importance. *Experiential Learning Theory*, posited by Kolb [7], argues that learning is a process where knowledge is created through the transformation of experience. SBME provides a direct experience which is reflective, supporting the cycle of learning from concrete experiences to reflective observation, abstract conceptualization, and active experimentation. Similarly, *Adult Learning Theory* [8], or *Andragogy*, emphasizes the importance of self-directed learning and bringing life experiences into the learning process, which is intrinsic to simulation-based education as it allows learners to engage in realistic clinical scenarios that mirror their future responsibilities.

The evolution of simulation-based methods in medical education has been significant over the decades, from simple anatomical models in the Renaissance to the sophisticated high-fidelity simulators and virtual reality technologies of today. One of the key milestones was the development of the first life-sized manikin in the 1960s, known as "Resusci Anne," for CPR training. Since then, the field has seen rapid advancements with the introduction of computer-based simulations in the 1980s, the proliferation of high-fidelity simulators in the 2000s, and the recent integration of augmented and virtual reality technologies [9]. These developments have been driven by the increasing need for safe, effective, and efficient ways to teach complex clinical skills and procedures [10].

The pedagogical foundation of simulation in education are deeply rooted in its ability to bridge theoretical knowledge and practical skills. Simulation acts as a critical bridge between classroom learning and real-world clinical practice, offering a controlled environment where students can apply theoretical knowledge to practical situations without the risk of harming patients. This pedagogical approach is supported by the *Constructivist Theory*, which posits that learners construct new knowledge based on their experiences. Simulation allows for the application of this theory by providing realistic clinical scenarios that require students to use critical thinking, clinical reasoning, and decision-making, thereby facilitating deep learning and the integration of knowledge into practice [2].

Simulation-based methods in medical education

SBME employs a variety of techniques, each designed to target specific learning objectives and competencies. Task trainers are devices that simulate specific parts of the human body, allowing students to practice procedures such as injections, suturing, or catheterization. They are beneficial for initial skill acquisition, offering repetitive practice without the need for a full-body manikin [2, 11]. High-fidelity manikins simulate full-body clinical scenarios, including vital sign changes, vocal responses, and physical findings. They are used for complex scenario-based training, such as emergency response, surgical procedures, and patient management, providing a realistic and immersive learning environment [10]. Standardized Patients (SPs) are trained actors who simulate patient scenarios in a consistent manner, allowing students to practice history-taking, physical examination, and communication skills [12]. SPs offer a unique opportunity for feedback and assessment of interpersonal skills in a clinical context [13, 14].

Simulation-based education has emerged as a pivotal tool in medical training, providing numerous benefits that enhance the learning experience. Central to its value is the provision of a risk-free environment, where learners can make mistakes and learn from them without the fear of causing harm to patients, thereby reinforcing the importance of safety in learning [3, 15]. This educational approach allows for the repeatability of procedures and scenarios, ensuring that learners can practice as many times as needed to achieve competence. Another significant advantage is the immediate feedback provided to learners, which is critical for their learning and ongoing improvement. Furthermore, the adaptability of simulation-based education means it can be customized to meet the diverse needs of learners and accommodate varying levels of complexity [16, 17].

Despite these benefits, SBME faces several limitations that challenge its widespread implementation. One of the primary concerns is the cost associated with high-fidelity simulations, such as advanced manikins and virtual reality (VR) technology, which can be prohibitive for many institutions. These simulations are also resource-intensive, requiring skilled personnel for scenario development, operation, and debriefing, which adds to the operational costs. Additionally, while high-fidelity simulations strive to replicate real-life scenarios accurately, they may still fall short in capturing the full spectrum of patient interactions and the unpredictability of real-life medical situations. Another significant issue is the limited access to these high-quality educational tools for some learners, particularly in resource-constrained environments, potentially exacerbating educational disparities [18].

Simulation-based methods and traditional clinical education approaches each have distinct advantages and roles in medical education [19]. Traditional approaches provide authentic patient interactions with real-time unpredictability, a key aspect that high-fidelity simulations strive to emulate but may not fully capture [4]. Simulation-based methods eliminate the ethical concerns and potential risks to patients that can arise with students practicing skills for the first time on actual patients [1]. Speaking about learning efficiency, simulations can be designed to target specific learning objectives and allow for immediate feedback and debriefing, which are not always feasible in a busy clinical setting. Some scholars assert that individuals who were exposed to simulation-based instruction for management of diverse medical scenarios and the execution of different diagnostic, therapeutic, and surgical processes exhibited superior acquisition compared to those who were provided with conventional education and training [20]. Traditional training approaches are constrained by the need for appro-

priate patients and clinical environments, while simulations offer the flexibility to accommodate large numbers of students through scalable, simulated scenarios of rare and critical conditions [21].

Management of the professional training process

Integrating simulation methods into the medical curriculum requires a systematic approach that encompasses curriculum design, execution, and evaluation. Designing a curriculum that incorporates simulation involves aligning simulation activities with learning objectives, ensuring that simulation experiences are integrated in the curriculum specifically where they will have the most impact. Execution requires logistical planning, including scheduling, resource allocation, and faculty training. Evaluation involves both formative and summative assessment of students, as well as evaluation of the simulation activities themselves to ensure they meet educational objectives. Effective integration also requires a feedback loop where outcomes from simulation activities inform curriculum development and refinement [2, 4].

The literature supports the effectiveness of simulation in achieving learning outcomes and improving patient safety [22]. SBME has been shown to improve knowledge, skills, and behaviors in a safe and controlled environment, leading to better preparedness for clinical practice [23-25]. Furthermore, simulation has been linked to improvements in patient safety [22], with studies demonstrating reductions in medical errors and adverse events as a result of simulation training. The deliberate practice within simulations allows for the refinement of clinical skills, critical thinking, and decision-making, which are crucial for patient care [1, 3].

Implementing simulation-based training in medical education presents several management challenges, including resource allocation, faculty development, and ensuring fidelity and realism in simulation scenarios. Solutions to these challenges include investing in technology to reduce costs, such as virtual and augmented reality simulations, and developing faculty expertise in simulation through targeted professional development programs. Additionally, creating partnerships with other institutions and sharing resources can alleviate some of the financial and logistical burdens. Ensuring fidelity in simulations involves not only the use of high-quality equipment and software but also the careful design of scenarios that accurately reflect clinical reality. Continuous evaluation and adaptation of simulation programs are essential for addressing these challenges and enhancing the effectiveness of simulation-based education [10, 26].

Procedural framework for simulation-based training

Existing frameworks for designing and implementing simulation-based training programs in medical education emphasize a structured approach to curriculum development, integrating simulation activities that align with educational objectives. One prominent model is the Kern six-step approach to curriculum development, which provides a systematic process for educational program design, including problem identification and needs assessment, setting objectives, selecting educational strategies (such as simulation), implementing these strategies, evaluation and feedback, and program refinement [27, 28]. There are several initiatives aimed at developing strategies for implementing simulation into the medical curriculum based on Kern's model. These include a stepwise model developed by Nehal N. Khamis *et al.*, which consists of problem identification and general needs assessment, targeted needs assessment, formulation of goals and objectives, selection of educational strategies, provision of individual assessment/feedback, and finally, program evaluation and implementation [29]. Similarly, a 7-step model implemented by Siyu Yan *et al.* employs a comparable approach [30]. Another framework was developed by International Nursing Association for Clinical Simulation and Learning, outlining key elements in designing and delivering simulation best practices in nursing education, including simulation design, outcomes and objectives, facilitation, debriefing, evaluation, and professional integrity [31]. The authors David Gent & Ranjev Kainth, from Faculty of Life Sciences and Medicine, King's College London, UK presents a comprehensive blueprint for designing effective simulation-based procedure training (SBPT) programs, emphasizing the integration of educational theory and practical design considerations for rarely performed medical procedures [32].

A potential enhancement in the efficiency of SBME could be achieved by implementing procedural frameworks that encompass a methodology relying on efficient techniques [33, 34]. These frameworks entail the acquisition of practical skills through a four-step process which involves demonstration, deconstruction, comprehension, and execution [35]. Additionally, the provision of feedback and the utilization of authentic medical environment are also crucial components in enhancing the effectiveness of SBME [36]. This approach aligns with experiential learning theory, emphasizing active engagement and reflection in the learning process. The use of real medical equipment and consumables further enhances the realism of the simulation, allowing students to gain hands-on experience that closely mirrors clinical practice. This methodology supports the development of transferable skills and competencies, bridging the gap between the simulated environment and real-world clinical settings.

Studies demonstrating the application and effectiveness of procedural frameworks in medical education highlight the positive impact of structured simulation-based training on learner outcomes. A systematic review by Cook *et al.* found that SBME with deliberate practice improves clinical skills, knowledge, and patient outcomes when compared to traditional clinical education [4]. Another study by McGaghie *et al.* demonstrated that using high-fidelity simulators and structured debriefing significantly enhances the acquisition and retention of clinical skills [1]. These studies underscore the value of a structured approach to simulation-based training, emphasizing the importance of realism, deliberate practice, and feedback in enhancing educational outcomes.

Discussion

The literature review highlights the significant impact of simulation-based methods on enhancing the profession-

al training process in medical education. Studies, including those by Issenberg *et al.* and Cook *et al.*, have demonstrated that simulation improves knowledge acquisition, technical skills, and professional competencies [1, 2, 4]. The integration of simulation into medical curricula supports a safe, controlled learning environment where students can practice and refine clinical skills without risk to patients [37]. These findings underscore the necessity for medical education programs to incorporate simulation-based training as a central component of curriculum design, emphasizing the development of transferable and generalizable skills that are critical for effective clinical practice [1]. While the benefits of simulation-based education are well documented, gaps remain in understanding the long-term impact of these methods on clinical practice and patient outcomes. There is a need for longitudinal studies that trace the professional development of medical students who have undergone simulation training into their clinical careers to assess the sustainability of competencies and the effect on patient care quality. Further research should also explore the integration of emerging technologies, such as virtual reality and artificial intelligence, in simulation-based training, evaluating their effectiveness in comparison to traditional methods. Additionally, studies on the cost-effectiveness of simulation-based education could provide valuable insights for institutions facing resource constraints [2, 4].

The potential of simulation-based methods to revolutionize undergraduate medical education is immense. By providing a realistic, immersive, and safe learning environment, simulation allows for the development of critical clinical skills, from technical procedures to decision-making and teamwork. The adaptability of simulation-based training to incorporate advances in medical science and technology further enhances its value, ensuring that medical education remains aligned with the demands of contemporary clinical practice. As medical education continues to evolve, the integration of simulation into curricula represents a pivotal shift towards more dynamic, effective, and patient-centered training approaches, promising to significantly improve learning outcomes and ultimately, patient care quality [1, 3].

Conclusions

Our literature review demonstrates the transformative impact of simulation-based methods on medical education. These methods not only enhance knowledge and skills acquisition but also ensure a safe environment for clinical practice without risking patient safety. The call for simulation's integration into medical curricula is clear, aiming to foster skills that are both transferable and applicable in real-world settings. However, the journey does not end here, future research directions is needed, including longitudinal studies to evaluate the long-term effects of simulation training on clinical practice, the exploration of new technologies like virtual reality, and analyses on the cost-effectiveness of such educational interventions. The promise of simulation-based education in revolutionizing medical training, by marrying technological advancements with the core demands of medical practice, heralds a new era of dynamic, effective, and patient-centered education. This evolution in teaching methodologies not only aims to enhance learning outcomes but also aspires to elevate the quality of patient care, marking a significant leap forward in the preparation of future medical professionals.

Competing interests

None declared.

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Authors' contributions

All persons listed as authors in the manuscript significantly contributed to the work. Substantial contribution to conception and design of the work (AR, IS). Drafting the article (AR, IS, IA, GR, OD, LS). Reviewing the article for important intellectual content (AR, IS, IA, GR, OD, LS). The final version of the manuscript was read and approved by all authors.

Ethics approval

Not needed for this study.

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