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Review Article

Smart skills for a smarter India: the role of simulation in education

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ABSTRACT

The revised curriculum introduced by the national medical commission mandates comprehensive training in communication and procedural skills for medical students. This makes simulation-based education (SBE) an imminent necessity across disciplines. Simulation offers a computer-generated representation of real-world systems, providing learners with an opportunity for practice, feedback, reflection, and immersion without the risks inherent in real-life scenarios. Over the years, the scope of simulation in medical education has expanded significantly, ranging from basic task trainers for fundamental skills to high-fidelity human patient simulators. India has begun recognizing the critical role of SBE in enhancing core clinical skills and teamwork. However, its widespread implementation is fraught with challenges, including resource limitations and the need for trained educators. The dualistic outcomes of simulation-based education necessitate a structured evaluation of its viability and utility in the Indian healthcare education system. This review employs "skills acquisition theory" as a framework, emphasizing the development of clinical skills through deliberate practice.

Keywords: Education, Medical, Practice, Skill, Simulation-based learning, Experiential training, Healthcare innovation

INTRODUCTION

India hosts one of the largest medical education sectors globally, producing thousands of healthcare professionals annually. Medical simulation aims to provide medical students with realistic simulations to enhance their understanding of complex medical scenarios. These simulations offer interactive education and real-time feedback without impacting patient safety. Simulation represents an organized approach to experiential learning and is widely accepted in industrialized healthcare systems as a training tool.

However, simulators remain underutilized in India, where they are not yet fully embraced as effective teaching-learning methods. This underutilization persists despite their ability to enhance confidence and knowledge in specific medical cases, allowing repeated practice as needed. Surgical techniques, artificial lens implantation, and simulated medical procedures like cataract surgery exemplify the scope of these tools.[1-3] In controlled environments, simulation evaluates non-technical skills, including behavioural attributes such as communication and crisis management. Rare medical events, like malignant hyperthermia, are well-suited to simulation-based training, where new methods and tools can also be tested and verified. Debriefing, a critical component of simulation lessons, enhances the learning derived from simulated scenarios.

Historically, simulation techniques were utilized in combat zones for strategic planning and stress relief, where debriefing helped mitigate soldiers' emotional burdens.[4,5] Similarly, simulation debriefing sessions in medical education alleviate stress and foster reflective learning. India is steadily progressing toward achieving the outcomes defined by the "MCI Vision 2015" for medical graduates. The National Medical Commission (NMC) has also made it mandatory for medical institutions to establish skill labs, ensuring that students gain hands-on experience in a structured and safe environment. Recognizing the necessity of SBME (simulation-based medical education) and its role in competency development is critical. Efforts must focus on optimizing SBME's educational advantages, as summarized in Table 1, which categorizes simulators by type and function.[6,7]

SIMULATION-BASED EDUCATION FOR SKILL TRAINING IN INDIA

The simulation idea was adopted by medical disciplines, particularly anaesthesiology, from the aviation sector. Advancements in the two professions are recognized, valued, and responded to similarly. The concern for patient safety was one of the factors that prompted anaesthesiology to utilize simulation. A consistent reason found to accept the importance of simulators in India is that there is "plenty patient material" for residents to learn. Medical disciplines, particularly anaesthesiology, adopted the idea of simulation from the aviation sector. However, the general public's growing awareness of patient safety problems is expected to change this. The medical community is aware of this understanding as well. Another reason for using simulation is to close the gap between training opportunities and requirements. Training facilities often promote simulators, particularly high-end ones, as an additional benefit to their curriculum.

Using simulators in training more often can cause problems. The educational backgrounds of students in India are quite different from those of their counterparts in the West. In American and European educational systems, part-playing and problem-based learning are taught from an early age, and pupils naturally transfer to studying on simulators. This is not only with some students, who continue to distinguish between the "real" and the "unreal," and who sometimes struggle to put the lessons they have learned on the simulator into practice. The lack of qualified academics to lead a simulated session only worsens matters. In the Indian context, money, labour, and time resources are also a big problem.[8]

Table 1: Types of simulation in education.

Type	Description	Examples
Task trainers	Equipment focused on practicing specific skills or procedures.	Intravenous insertion arms, suturing pads.
High-fidelity simulators	Advanced systems replicating complex human physiology for realistic scenarios.	Human patient simulators for cardiopulmonary resuscitation.
Standardized patients	Actors trained to simulate real patients for clinical examinations and communication practice.	Osce scenarios for history taking and diagnosis.
Virtual reality (VR)	Immersive digital environments for training with minimal physical resources.	Vr modules for surgical techniques and anatomy learning.
Hybrid simulations	A combination of task trainers and standardized patients to provide holistic learning experiences.	Using mannequins with actor interactions in trauma scenarios.
Screen-based simulations	Computer-based programs focusing on decision-making and theoretical knowledge.	Pharmacology simulations for drug interactions.
Simulation games	Interactive scenarios designed to engage learners in team-based and individual problem-solving.	Serious games for crisis management.
Compiler driven simulations	Specific task trainers replicating certain body components for detailed practice.	Airway management heads, urinary catheter trainers, intravenous insertion arms, and central line installation torsos.
Event-driven standardized patients	Role-playing patients evaluated by specially trained professionals in structured scenarios.	Simulated clinical situations.

Table 2: Comparative analysis of simulation-based studies.

Aspect	Global	India
Focus areas	STEM disciplines, advanced systems for decision-making, and problem-solving in complex systems.	Medical education, including anaesthesiology, paediatric care, and emergency management.
Use of simulation tools	Well-designed hands-on activities, games, and advanced software enhance intrinsic motivation.	Simulations adapted from aviation for certification and safety in medical procedures.
Challenges	Balancing dynamism and unpredictability of real-world systems.	Dual challenges of abundant patients in some institutions and limited access in others.
Retention of skills	Long-term efficacy enhanced with structured programs and serious games.	Performance decline observed six months post-training; complete deterioration without regular retraining.
Implementation	Supported by institutions like Universidad de Cantabria and Trinity College Dublin.	Varies across institutions; resource constraints and high costs limit widespread adoption.
Technological advancements	Integrating VR, AR, and real-time simulations in learning processes.	Beginning to incorporate advanced simulation methods, though accessibility remains a concern.

Table 3: Advantages and disadvantages of various types of simulation.

Type of simulation	Disadvantages	Advantages
Synthetic	Poor tissue representation, sometimes not reusable	Portable, reusable, pathology simulation possible
Cadaveric (human/animal)	Need for additional staff and laboratory space, ethical concerns, not reusable, high cost, rare pathology	Accurate tissue representation, anatomic fidelity (human)
Virtual Reality (VR)	Haptic response still less realistic (but improving), high cost, technical maintenance, software subscriptions	Reusable, pathology simulation possible

The emergence of simulation is essential and is here to be, making this such an exciting period for training in anaesthesiology. The benefits of including them in routine training are considerable. They assist us in learning how to handle high-stakes, life-threatening circumstances inside little room for mistakes and in retraining scenarios when skill retention is crucial since patients' conditions are known to deteriorate rapidly in ACLS (adult cardiac life support).[9] In a controlled environment, nontechnical abilities, which include behavioural characteristics of healthcare personnel like communication, may be evaluated. A simulated setting is well suited for applying the ideas of crisis resource management. Malignant hyperthermia, a rare event, readily submits to training via simulation. It is possible to evaluate and verify novel methods and devices. At the moment, simulations are employed for skill learning and evaluation. According to Ghazwa B. Korayem et al., SBE (simulation-based education) is a crucial teaching strategy that enhances conventional teaching modalities. In undergraduate pharmacy education, SBE has increased students' knowledge, comprehension, and a broad range of crucial abilities, just like conventional teaching techniques. But SBE is now essential for helping students in improving their cooperation, decision-making, and communication abilities. Even though the SBE in IPE (interprofessional education) and the first IPPE (introductory pharmacy practice experience) have been recognized as benefits by the ACPE "Accreditation Council for Pharmacy Education." They provide evidence that SBE can be more effective than that.

The research on SBE modalities and techniques for evaluating student learning outcomes in the undergraduate pharmacy curriculum is the main subject of this review. SBE is a useful teaching strategy that might be used within the pharmacy curriculum. The evaluation may also aid pharmacy educators in selecting the optimal method and location for incorporating patient simulation into the pharmacy curriculum. The most effective strategy to help students understand the material that is intended for them may be to combine several simulation techniques.[10]

To evaluate how simulation-based training affects these factors, Ellen Nelissen et al, evaluated the degree of knowledge, skills, and confidence in obstetric care before, immediately after, and nine months later. Knowledge, abilities, and confidence all immediately increased because of the instruction. At 9 months, confidence and simulated obstetric emergency abilities were mostly intact, but knowledge and fundamental delivery simulation skills started to deteriorate. Their results indicate that more training is required. Future investigations should concentrate on the timing and volume of follow-up training.[11]

SIMULATION-BASED STUDIES IN INDIA AND GLOBALLY

Simulation-based education (SBE) has demonstrated significant educational and clinical benefits globally, particularly in STEM disciplines. STEM students are required to work with precise models of real-world systems, making simulation an essential tool for understanding complex interconnections, whether in supply chains, computer systems, or infrastructure systems.[12] These real-world systems often exhibit dynamism and unpredictability, which can be effectively replicated and studied using simulation tools.[13]

Juan et al, emphasize that well-designed hands-on activities using simulation software, tools, and games enhance practical understanding and promote intrinsic motivation.[14,15] This form of learning, guided by instructors, not only fosters intellectual growth but also aligns with the interests of academic and industry stakeholders who aim to prepare students for professional challenges. Research from institutions like Universidad de Cantabria in Spain and Trinity College Dublin in Ireland highlights the transformative potential of simulation-based learning through serious games and innovative teaching practices.[16] Over the past decades, advancements in technology and programming have enhanced the realism and usability of simulations, making them integral to modern education.[17,18] The competition-based challenges within simulations improve critical skills such as decision-making, problem-solving, and teamwork.[19,20]

In India, simulation-based studies are equally promising but face unique challenges. In the aviation sector, simulations are well-established for certification and retraining, primarily due to their emphasis on safety. Medical education has adopted similar methodologies, using simulation to bridge gaps in clinical exposure. India presents dual challenges: while some institutions boast abundant patient material, others struggle with limited patient availability or patients unwilling to participate in teaching exercises. In such cases, simulation provides an invaluable alternative for skill acquisition and evaluation.

Long-term retention of skills through simulation has been a key focus of research. However, evidence regarding the benefits of continued simulation sessions remains limited. For example, studies on paediatric technical procedures show that performance declines six months post-training and deteriorates completely after four years without retraining.[26] This underscores the need for structured and recurrent simulation-based training to sustain skill levels. Addressing these gaps through targeted research and optimized implementation strategies will enhance the efficacy of simulation-based education in India and beyond.[27] Table 2 shows the differences in simulation-based studies between global practices and those in India.

NATIONAL MEDICAL COUNCIL, INDIA RULE FOR SKILL LAB

The recent declaration by “Indian Medical Council” has provided specific guidelines to achieve “the Skills of the MBBS graduate.” They provide recommendations for qualified medical graduates with expertise in public, and population health systems, research, ethics, and knowledge administration. The Indian Medical Council has mandated all medical schools in the nation to incorporate the same in their academic curriculum, undergraduate and PG.[27]

Developing a skills lab in medical colleges should follow these guidelines: Students must have access to a skills laboratory at every medical institution to develop the predetermined abilities specified in the curriculum. The primary goal of these labs is to create a secure environment where students can learn, practice, and be observed using specific skills in a controlled setting. This reduces the risks associated with direct patient exposure without adequate training or supervision. Additionally, skills labs strive to accurately replicate clinical environments and the activities that aspiring medical professionals are expected to perform. Through these simulations, students can enhance their clinical, motor, communication, and teamwork skills effectively.

The following should be included in the skills lab that satisfies the standards of the outcomes derived UG curriculum: a. A minimum of 4 patient examination rooms are required for each student to examine real or standardized/simulated patients. They must include a method for recording and watching videos. A small group demonstration space for skills. An evaluation or debriefing space. Appropriate-sized cubes for group or individual skill practice. To acquire the abilities listed in the competence UG paper, trainers or mannequins are needed. Enough storage space for mannequins and/or other equipment. A space designated for the faculty coordinator and support personnel. Institutions are urged to increase their capability above and beyond these minimal demands. Institutions within a region or governing body might develop common facilities and resources to save expenses.

NEED FOR SKILL LABS IN INDIA

Rapid advancements in medical technology have had a significant impact on medical education both in India and all over the world. The conventional approach to teaching, training, and developing clinical skills has been challenged using the same methods in medical fields. A decline in clinical skills has also been attributed in health care delivery to current leanings, such as the promotion of (outpatient/day) care and other problems like hospital shortening stays by enhancing clinicians' skills in quick/early diagnosis, proper practicing concerns on actual patients and their rights, and an unbalanced evolution in many students compared to the number of teaching staff. Along with reducing health care delivery, these factors have constrained medical education's teaching ability.

The development of skill and simulation centers is becoming an essential educational instrument for promoting and acquiring essential medical skills—which may be healthcare continuum, subject-specific, and problem-based, motivated prompted by these developments and trends in clinical situations.[28] Debate, practical procedures, technical and effective examination, leadership, teamwork, decision-making, patient management, professionalism, and administration are "clinical skills".[29-31] Moreover, it involves interpreting, presenting, recording, and legal assessing clinical data.

The “state-of-the-art skill and simulation” facility allows working clinicians and medical students to acquire and perfect clinical abilities in a prepared and controlled setting. In performance testing or training, for example, the pretended portrayal of a challenging real-world process is accurate enough to accomplish the desired outcome.[32] To generate competent medical professionals, medical education must include skill- and simulation-based training in addition to conventional bedside clinical teaching approaches and independent healthcare professionals, ultimately enhancing patient care and safety.

It provides a variety of advantages, such as exposure to unusual, adaptable circumstances, freedom to make mistakes without repercussions, and the opportunity to improve and gain more self-assurance. The abilities acquired via the simulation centers and their use in the medical treatment of actual patients have continued to be a topic of debate and further research. Even several studies have shown that students who received training in simulation and skill laboratories were more professional and were able to complete operations more quickly. They also had improved interaction skills and provided patients with better care overall. Recent research has shown that procedural skills are improved while medical mistakes are significantly reduced through training at simulation and skill centers.[33-37]

CHALLENGES IN SIMULATION-BASED EDUCATION

Simulators have long been utilized to help students understand specific skills or problems within real-world contexts. Historically, simulation has been employed in scenario planning for millennia, providing a structured way to examine authentic challenges, acquire essential knowledge, and evaluate significant professional issues.[38] Sophisticated training programs now allow even experienced professionals to refine their skills, making simulation a critical tool across various disciplines, including medical, social sciences, and management fields.[39-40]

Future graduates often operate in high-risk environments where decisions can directly impact patient mortality. Simulation-based education helps participants experience real-world hazards and strains, preparing them for critical scenarios like natural disasters and medical emergencies.[41] However, achieving success with simulation depends significantly on the human agents involved teachers and students. Effective communication of the simulation's purpose is crucial for trainers, and determining which elements are central versus peripheral often presents challenges.

One major issue is the exclusion of emotional components in some simulation sessions. This oversight can disconnect learners from the emotional realities of patient care, particularly during medical diagnoses, where emotional connections are integral to understanding patient needs. Feedback, reflection, and participation are key mechanisms for addressing these gaps, helping students connect previously learned knowledge with new insights. Timely and constructive feedback is considered one of the most critical elements of SBE, fostering introspection, group discussion, and meaningful learning.[42]

Creating a risk-free learning environment is essential for promoting experimentation and allowing failure without repercussions. Simulations provide a secure space for learners to analyze mistakes and improve clinical reasoning skills through guided reflection and repetition.[43,44] However, overemphasis on assessment in simulations can detract from its value as a learning tool. For instance, students may feel vulnerable showcasing insufficient knowledge in front of peers and instructors, highlighting the importance of well-defined rules and educational goals to reduce performance-related stress.[45]

Educators must balance the complexity of simulations to match students' experience levels. Pushing students beyond their comfort zones without diminishing confidence is a delicate task requiring expertise. For inexperienced learners, overly challenging simulations may lead to anxiety and reduced learning outcomes. Designing simulations that align with the learner's functional level fosters positive learning experiences and helps prevent frustration or disengagement.[46,47]

Another significant challenge is the high cost associated with acquiring, maintaining, and upgrading simulation technology. Simulators quickly become outdated as technology evolves, and the continuous need for training educators to use these tools effectively adds to the financial burden. Institutions may struggle to justify these expenses, especially in resource-limited settings, discouraging widespread adoption.

By addressing these challenges through strategic planning, faculty training, and consistent updates, SBE can unlock its full potential as an innovative and effective educational approach for preparing professionals across various domains. Another critical challenge is the maintenance and upgrading of simulation technology. Simulators require regular updates to remain relevant, and the associated costs can be prohibitive for many institutions. Furthermore, the lack of standardized guidelines for implementing SBE across institutions leads to inconsistencies in training quality. Developing a national framework for SBE can help address these challenges and ensure uniformity in its application.[40,41]

BENEFITS TO STUDENTS

Simulation-based education (SBE) has yet to be fully integrated into clinical education models for speech-language pathology and audiology, despite its widespread acceptance across various disciplines. This approach presents a novel avenue for enhancing clinical training in these fields, offering significant advantages to key stakeholders, including clinical supervisors, academic institutions, training programs, students, and, critically, the patients who benefit from improved care. The advantages of SBE have been extensively documented in both professional and interdisciplinary contexts, showcasing its potential to transform traditional learning paradigms.

SBE facilitates the development of reliable deductive reasoning among students, enabling them to hypothesize and evaluate potential outcomes in controlled scenarios. It provides a safe and supportive learning environment where learners can practice and refine their skills without jeopardizing their own safety or that of others. This adaptability extends to various educational levels, from primary to tertiary education, allowing simulations to be tailored to the specific needs of each learner cohort. The cost-effectiveness of simulation-based learning is another critical benefit, as it allows instructors to deliver complex, real-world scenarios efficiently and safely. Simulators effectively replicate real-world conditions, providing learners with opportunities for repeated practice and feedback, which are essential for skill mastery. Additionally, SBE supports deliberate practice, exposure to rare and complex cases, and risk-free treatment scenarios, ensuring learners are prepared for real-world challenges.

Educational advantages of SBE include replicability, exposure to unusual occurrences, minimized patient risk, and the possibility of student evaluation through structured feedback mechanisms. Studies have consistently shown that simulation training improves performance in subsequent clinical and simulated tasks. For instance, research comparing traditional ward training to simulation-based practice using the "Harvey Cardiology Patient Simulator" revealed that students receiving simulation training achieved superior outcomes in half the time.[48] Further evidence from Devita et al, highlights the effectiveness of simulations in enhancing team collaboration and task execution, leading to better patient outcomes during simulated scenarios.[49]

However, SBE also presents challenges, such as high costs and maintenance requirements for advanced simulation technologies, as outlined in Table 3.[50] It allows students to make reliable deductions. Students may utilize simulations to create detailed hypotheses about prospective outcomes and situations.

It is advantageous for learning. Simulators properly represent real-world conditions so students can practice without fear of endangering themselves, others, or their environment. They may try as many times as required to succeed if they fail. It is suitable for use at all levels of instruction and learning. All students' needs, whether in elementary, middle, high school, or college, may be met by modifying learning simulations. It may be used for studying and teaching at all levels. Whether students are in elementary, middle, high school, or college, learning simulations may be modified to match their needs. Cost-saving learning simulations provide a unique method for instructors to impart knowledge to pupils. Simulation is an excellent method for imparting these results safely and efficiently since real-life scenarios have many possible outcomes.

Replicability, exposure to unusual occurrences, lack of patient hazards, deliberate practice with feedback, risk-free treatment for patients, possibility of evaluating students is some of the educational advantages of simulation in medical education. Sometimes, complications may be fatal. Selecting the influence of simulation on patient outcomes might be challenging since most institutions have quality improvement strategies in place. Even so, there is substantial information and proof that simulation training improves educational achievements. After a simulation, students do better on future simulated exams and activities.

SIn a cohort study including medical students from five institutions, one group had 4 weeks of standard ward training, whereas the other received 2 weeks of purposeful practice using the "Harvey Cardiology Patient Simulator" followed by 2 weeks of regular ward labor. Only half of the training time, the simulation group outperformed the ward group twice.[48] Devita et al, demonstrated that physicians who were educated to collaborate by successfully carrying out preassigned responsibilities during a simulator exercise had superior results for simulated patients.[49] Some drawbacks are also the part of simulation as shown in Table 3.[50]

FUTURE SCOPE OF SIMULATION-BASED LEARNING IN INDIA

Simulation-based learning offers a controlled environment for practicing high-risk procedures and decision-making. As advancements in technology continue to refine simulation fidelity, its integration into medical education will enhance clinical competencies, patient safety, and interdisciplinary collaboration. The use of virtual reality (VR) and augmented reality (AR) in simulation is expected to revolutionize medical training by providing immersive experiences that closely mimic real-life scenarios. These technologies also enable remote learning, making high-quality training accessible to students in rural and underserved areas.

Long-term studies are needed to optimize the frequency and structure of simulation training sessions to ensure sustained learning outcomes. Additionally, partnerships with international organizations and industries can provide Indian institutions with access to cutting-edge simulation technologies and best practices. By leveraging these opportunities, India can establish itself as a leader in simulation-based medical education.[51,52]

CONCLUSION

Simulation-based education represents a transformative approach to medical training, offering immersive and interactive learning experiences that enhance clinical skills, decision-making, and patient safety. Its adoption in India, while nascent, has the potential to address disparities in clinical training and improve educational outcomes. However, its successful implementation requires a coordinated effort to address resource constraints, train educators, and develop standardized guidelines. Future research should focus on optimizing simulation methodologies, ensuring resource availability, and evaluating its impact on patient outcomes. With sustained investment and innovation, SBE can play a pivotal role in shaping the future of medical education in India.

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