Narrative Review

Simulation in contemporary medical education: Current practices and the way forward

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ABSTRACT

Integration of theoretical knowledge and practical skills is critical for effective medical education. Simulation is crucial in bridging the gap to prepare medical professionals for high-quality patient care in a safe environment. Simulation-based teaching has become the standard practice in medical education, especially in postgraduate courses like Anaesthesia. However, undergraduate medical education and other doctoral courses are still nascent. In line with the current National Medical Commission guidelines, it is imperative to complement the existing curriculum with a simulation-based approach as early as the first year of medical school. This review focuses on the current practices related to simulation-based medical education during undergraduate and postgraduate courses, particularly on anaesthesiology. We aim to discuss different types of simulation, the advantages of integration, students' perspectives, and the role of simulation in assessment and feedback. Finally, recommendations for future advancements of simulation in medical education and the way forward will be laid.

Key words: Anaesthesiology, postgraduate medical education, simulation, undergraduate medical education

INTRODUCTION

Medical education is driven by a complex coaction between the teacher, student, societal needs, and technology. A worldwide paradigm shift has emphasised the 'experiential approach' in medical education incorporating cognitive, psychomotor, and affective learning.[1] The reforms are catered to students to provide competent patient care with timely management through various clinical experiences in a safe environment. Healthcare simulation is a robust educational instrument that allows students to explore the practical application of theoretical knowledge.[2] It has been well documented that increased exposure to clinical skills improves competency, improving patient care.[3,4] However, training on actual patients is challenging due to ethical issues and practical limitations. Thus, the need of the hour is to facilitate learning in an environment close to real-time situations to acquire the required competent skills. New teaching methods, including simulation-based medical education, have emerged to overcome this.[5]

In this focused review, we aim to delineate the contemporary trends in employing simulation-based methodologies for teaching and assessing medical students at both the undergraduate and postgraduate levels, specifically emphasising anaesthesiology. The review will also delve into the current practices in integrating simulation into the medical curriculum and identify potential areas of improvement. Based on the findings of this review, recommendations for further research and improvement will be provided.

METHODS

To map and summarise the existing knowledge, key search terms related to simulation in medical education

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for undergraduate ((“simulation”[Title/Abstract] OR “simulated” [Title/Abstract] OR “Simulation-based” [Title/Abstract]) AND (“training”[Title/Abstract] OR “education” [Title/Abstract] OR “Medical education” [Title/Abstract] OR “Education” [Title/Abstract])) AND (“undergraduate”[Title/Abstract]) and for postgraduate education (((“simulation”[Title/Abstract] OR “simulated” [Title/Abstract] OR “Simulation-based” [Title/Abstract]) AND (“training”[Title/Abstract] OR “education” [Title/Abstract] OR “Medical education” [Title/Abstract] OR “Education” [Title/Abstract])) AND (“postgraduate”[Title/Abstract])) AND (“anaesthesia”[Title/Abstract] OR “anaesthesia”[Title/Abstract] OR “anaesthesiology”[Title/Abstract] OR “anesthesiology”[Title/Abstract]) were searched in multiple databases, including PubMed, Medline, and Scopus. The review has been synthesised by incorporating studies published in the past five years to ensure relevance rather than a comprehensive systematic review and meta-analysis.

RESULTS

The authors screened 103 publications based on a database search performed from PubMed and Scopus with the MESH terms described in the Methodology. Of these, 20 were duplicates; the remaining records were screened after selecting only articles. A total of 17 studies were excluded after reading the titles and abstracts, and the remaining 60 were sought for retrieval. Eligibility of 62 articles was assessed, and 11 studies were excluded based on other specialities in postgraduation, except for Anaesthesia. A total of 41 studies were finally included.

DISCUSSION

Simulation-based medical education

Simulation-based medical education (SBME) involves using various tools and techniques to replicate real-life clinical scenarios in a controlled environment. It allows students to practise and enhance their clinical skills safely and standardised.[6] Simulation-based teaching (SBT) is a valuable tool in medical education. Various types and classifications of simulators cater to different needs or learning objectives [Tables 1 and 2].

Table 1: Classification of simulators

Based on	Type of Simulators		
Fidelity	Low fidelity	Intermediate fidelity	High fidelity
Technology	Computer-based	Physical simulators	Virtual reality simulators
Purpose	Procedural/task trainers	Decision making	Communication simulators

Table 2: Examples of different types of simulators

Fidelity	Examples
Low-fidelity (or part/skill trainer)	Intubation mannequin, cannulation arm
Intermediate fidelity task trainers	Airway trainer model with tracheobronchial tree, CPR mannequins (with/without feedback)
High-fidelity trainers	METI® Human Patient Simulator (HPS)
Virtual reality trainers	ORSIM® bronchoscopy simulator
Computer-based simulator	Gas Man® Anesthesia computer gas model

Eleven key dimensions that aid in applying simulation in medical education have been described.[7] These dimensions include the purpose and aim of the simulation activity (education, training, assessment, clinical rehearsal, research, etc.), a unit of participation (individual, team, organisational, etc.), level of experience (initial professional training, residency or continued education or training, etc.), healthcare domain (imaging, primary care, procedural, dynamic, etc.), personnel participating (students, allied health technicians, nurses, physicians), type of knowledge, skill, attitudes, or behaviour (knows, does, metacognition), age of the patient being simulated (child, teen, adult, old age), the technology required for simulation (role play, actor, computer application, or electronic patient), site of simulation participation (laboratory, replica clinical environment, actual working unit), the extent of the involvement (viewing only, verbal interaction, hands-on participation, immersive participation), and the feedback method (none, delayed, real-time, debriefing). The combinations of these dimensions could propel the use of simulation in various aspects of medical education as needed.[7] A recent review by Bienstock and Heuer has explored the timeline of the history of evolution, emphasising that the very idea of the benefit of using simulations in health care has been highlighted even by Aristotle and Hippocrates and mentioned in Sushruta Samhita.[8] Around the 1960s, low-cost mannequins (SimOne, Resusci Anne, Harvey) were used as effective simulators.[9] During the 1980s, Gaba developed a Comprehensive Anaesthesia Simulation Environment (CASE), re-creating the task environment of the operating room, including the manual and cognitive tasks involved.[10] This was a stepping stone towards the present-day knowledge of simulation.

Current practices in simulation

SBME is an upcoming technique in contemporary medical education, opening avenues for upscaling practical knowledge.[11] Simulation can help a learner ascend from novice to expert in Miller's pyramid.[12] Based on how closely the simulation mimics the real-time scenario, the simulation modalities have been classified as low, medium, and high fidelity [Table 2].[13] Low-fidelity simulation refers to acquiring basic psychomotor skills that are not interactive and lack computer programming. The advantage is that it is easy to construct and less expensive, but it has a disadvantage in terms of a limited number of skills for assessment. Medium-fidelity simulation offers more realism than low-fidelity simulation and is preferred for basic physiological and pharmacological processes. The objective is for the participant to resolve problems, perform a skill, and practise decision-making during a clinical scenario. High-fidelity simulation integrates multiple physiological variables with various healthcare scenarios to create a natural learning environment.[12] The environment determines the level of fidelity, tools and resources, and psychological factors like the participants' emotions, beliefs, and self-awareness.[14]

Current scenario

The recent National Medical Commission (NMC) guidelines have integrated SBT into the curriculum as early as the first year of undergraduate medical school.[15] This has paved the way for setting up centralised simulation training facilities at the institutional or departmental levels.[16] Thus, according to guidelines, it is mandatory to have a skill laboratory in a medical college to foster learning and practice in a safe and non-threatening environment. This involves at least four rooms for examining patients/ standardised patients, a debriefing area, a faculty coordinator, trainers, mannequins, and facilities for video recording and review.

SBME and undergraduate medical education

SBME is an impactful training approach for undergraduate students to enhance their understanding of clinical skills, critical thinking abilities, and overall preparedness for real-world settings. Undergraduate medical education is an impressionable time wherein strategic exposure to simulation-based scenarios can transform academic and professional trajectories. Weller J incorporated a medium-fidelity simulator for the resuscitation module and documented that students had a better learning experience and felt they could integrate theoretical knowledge into practical applications.[17] In emergency medicine, Ander D *et al*.[18] recommended that to make SBT sustainable, tailor-made education programmes can be made keeping in mind the objectives, assessment needs, and available resources. Effective communication is a must-know skill for an undergraduate student, especially concerning sensitive topics like breaking bad news, intimate partner violence, etc. A recent study by Manuel B *et al*.[19] concluded that simulation activities are a good method to develop clinical skills and can complement the existing curriculum. Contrarily, Mohiaddin *et al*.[20] reported that first-year medical undergraduate students perceive better enhancement of communication skills with actual patients compared to simulated patients based on focus group discussions. In a quasi-experimental study, Murugavadigal *et al*.[21] investigated the effect of the simulation environment on perceived stress in undergraduate and final-year medical school undergraduate students. They found that as the students were exposed to more and more simulation sessions, the scores of stressor elements decreased. A recently published study used simulation for six imperative clinical skills in paediatrics and compared the students' performances vis-à-vis the traditional teaching method. They found that the students scored higher in the simulation group than in the pre-intervention group. Furthermore, the students highlighted that simulation provides a safe learning environment and practice sessions and facilitates their skills.[22] Shenoy R *et al*.[23] recently published a simulated form of pre-clinical task-based learning (TskBL) and compared it to conventional tutorials in first-year undergraduate medical school in physiology. They found that the students performed better [assessment scores in multiple-choice questions (MCQs) and Objective Structured Clinical Examination (OSCE)] in a simulation-based group compared to the control group. They concluded that TskBL could be an innovative approach that could be incorporated into the curriculum. McCoy *et al*.[24] evaluated the effectiveness of high-fidelity simulation versus standard mannequin training for cardiopulmonary resuscitation and reported the superiority of high-fidelity simulation for chest compression depth and compression fraction.

Compared to no intervention, technology-based simulation has shown consistent results concerning the knowledge, attitude, and skills gained by the student, improving patient-related outcomes.[25] There is a plethora of data on using simulation-based studies in anaesthesia research and education. Lorello *et al*.[26] have succinctly highlighted the key sub-areas involved (general anaesthesia, regional anaesthesia, peri-operative medicine, rare events, and crisis management.) Surprisingly, a good proportion of research has been carried out on medical students during the undergraduate period. Consistent with previous studies, the authors concluded that the learning experience was significantly better with simulation compared to no intervention at all. Exposure to undergraduate students, especially during their semester posting in anaesthesia, can shorten their learning curve, delivering a better understanding of the clinical scenarios in the future. In their study, Baribeau *et al*.[27] utilised motion analysis technology to evaluate anaesthesiology interns' skill acquisition learning curve when practising central venous catheter placement in a simulation setting. Their findings suggest that motion metrics can effectively describe the learning curves of novice trainees and provide valuable insights into skill acquisition, which can inform deliberate practice techniques. Thus, the faculty may undertake a structured approach during pre- and paraclinical periods to collaborate with anaesthesiology educators, especially about simulation-based teaching.

SBME and Postgraduate medical education

Similar to undergraduate training, NMC has proposed a competency-based training programme for postgraduate programmes, one of the components being the integration of simulation into the curriculum for training and assessment. There is a great need for newer interactive teaching–learning techniques to promote a higher level of thinking and facilitate problem-solving and decision-making. Pavithran *et al*.[28] did a web-based needs assessment survey among anaesthesiology postgraduate students of Kerala to learn about their current clinical learning environment and to identify lacunae in the training programme. With a 64% overall response rate, most respondents were optimistic about the clinical learning environment. However, they identified a need for more research training and training in simulation labs. These activities should be planned to address three domains of competencies, cognitive, psychomotor, and affective, which have been well explained by Kundra *et al*.[5]

SBT is instrumental in training students in situations of significant consequences, such as increased morbidity or mortality and events with rare incidences. Under everyday clinical situations, a postgraduate resident must get adequate opportunities to train for various critical events. Moreover, real-life critical clinical scenarios demand a lot from the trainer, whose primary concern will be patient safety. With so much at stake, teaching takes backstage. After the event, the team usually requires debriefing with psychological closure. Retracing events may help identify learning objectives for further improvement. SBT provides a safe learning environment that can be repeated a reasonable number of times, whether through initiation, practices, or even assessments, without risk to patient safety.

Technical skills such as chest compression, airway management, vascular cannulation, fascial plane blocks, central neuraxial blocks, and so on are currently being utilised in SBT. Cardiopulmonary resuscitation training programmes like Basic Cardiopulmonary Life Support (BCLS), Advanced Cardiovascular Life Support (ACLS), and Comprehensive Cardiopulmonary Life Support (CCLS) have successfully incorporated simulation in their core. Patil *et al*.[29] used SBT to train postgraduate students in ACLS and found that simulation training significantly improved knowledge, skills, and confidence in managing cardiac arrest. Students also reported that the training enhanced their clinical decision-making. Blanchard *et al*.[30] studied the rapid cycle deliberate practice technique of SBME, which includes frequent feedback and opportunities to practise specific skills such as improving teamwork and communication, role designation, defibrillator operation, leadership, and clinical treatment of cardiac emergencies. However, in another study, Blanchard and Riesenberg *et al*.[31] compared traditional, immersive simulation, and rapid cycle deliberate practice in anaesthesiology postgraduate second-year residents and found no difference between the three groups regarding emergency cardiovascular care skills or perceived value of interventions. On the contrary, residents in the group receiving traditional training expressed greater contentment and self-assurance in various domains.

Torrano *et al*.[32] studied SBT in erector spinae blocks to teach first-year postgraduate residents. They found that a 4-hour hands-on simulation training enhanced the proficiency. Failor *et al*.[33] used a high-fidelity AirSim Bronchi airway simulator to train students in managing lung isolation with double-lumen endotracheal tubes and bronchial blockers. They found the programme is practical and feasible for such techniques. Besides its use in technical skills training and assessment, SBT is also helpful for non-technical skills such as leadership, teamwork, communication, and self-awareness. SBT has also been used for distance education in conjunction with Telemedicine. Watt *et al*.[34] incorporated Telemedicine with simulation to train second-year anaesthesiology residents to conduct remote pre-operative assessments. They used didactic teaching sessions and a simulated virtual pre-operative evaluation with a standardised patient. Residents felt the exercise was demanding yet practical and helpful learning due to realistic simulation exercises and valuable immediate debriefing sessions.

Simulation is necessary for the initial training of skills and the regular honing of techniques for better patient outcomes. Yau *et al*.[35] compared differences in intubation performance in success rate, time for intubation, force applied on incisor and tongue, and Cormac Lehane grades between medical students, residents, and junior and senior physicians on a high-fidelity simulator. They found that attending physicians were faster than medical students on intubation attempts. However, some junior physicians applied more force on the incisors in rigid neck scenarios, indicating the need for regular practice sessions. They recommended creating a tool for training junior physicians, emphasising efficiency and practice and providing quick, clear feedback for performance improvement. This kind of instruction offers and enhances conventional instruction. Simulation-based mobile applications are available for training specific skills or acting as adjuncts for simulation scenarios such as Airway Ex, Simman, QCPR, and Simpl. These applications may be considered for training in limited resource settings per the needs and learning objectives.

Many postgraduate medical boards have already integrated simulation into postgraduate anaesthesia training programmes.[36,37]

Advantages of SBME

SBME is an approach that can be applied to various disciplines and trainees to develop the student's knowledge, skills, and attitudes while mitigating ethical tensions and practical risks.

While simulation offers numerous benefits in skill enhancement, substantial evidence has come up recently regarding its role in assessing learners' performance and feedback. It has been widely used in formative assessment, enhancing competency and potentially shortening the student's learning curve. Ryall *et al*.[38] conducted a systematic review of simulation-based assessments in health profession education and concluded that it is a robust assessment tool when used with other assessment modalities. Sando *et al*.[39] formulated guidelines and documented that simulation can be easily used for formative, summative, and high-stakes evaluation, encompassing the cognitive (knowledge), affective (attitude), and psychomotor (skills) domains. Furthermore, Buléon *et al*.[40] highlighted that simulation-based summative assessment holds great potential as we advance if conducted meticulously and well-supervised. Hwang *et al*.[41] described their experience using simulated patients and crisis management scenarios to conduct a virtual summative assessment in anaesthesiology in an objective structured clinical examination format during the COVID-19 pandemic. Though they modified the examination format to suit the teleconferencing platform due to the pandemic, it is an excellent platform for formative and summative assessment of students' cognitive, behavioural, and psychomotor performances. It is possible to test higher levels of understanding using appropriate simulation exercises.

Thus, to sum up, the key benefits of SBME are:[42]

- It gives opportunity to the students to practice, and feedback is provided for their improvement
- It exposes them to rare cases/unusual events
- The scenarios are reproducible and can be adjusted as per the difficulty level
- Minimal risks to the patients
- Formative and summative assessments can be undertaken.

Challenges of SBME

SBME has inherent challenges, which must be considered for a balanced view. Simulation models used for skill training are expensive, and costs incurred for acquiring and developing simulations are substantial, especially if the centre is resource-limited. To overcome this challenge, many researchers are working to find inexpensive alternatives. Liu *et al*.[43] used an affordable and ingenious central venous catheter (CVC) simulator model. The model was built using a piece of pork and two latex catheters filled with red and blue ink to provide immediate visual feedback. After the training workshop, they found that the model used for simulation is feasible, inexpensive, and very effective in improving residents' skills. Irfanullah *et al*.[44] conducted a hands-on training-of-trainers workshop for local teachers. They collaborated with and created various low-cost,

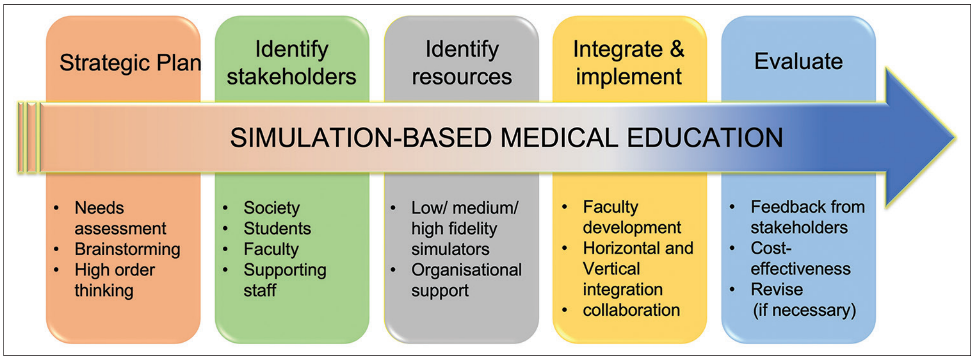

Figure 1: Pipeline for integration of simulation-based teaching in medical education

moderate-fidelity simulation models on the pericardial synthesis and thoracic cavity training models. They were later used to train postgraduate anaesthesiology trainees in other educational workshops. The authors concluded that collaboration with local leaders and innovators is critical for developing low-cost hybrid fidelity simulation models and is the need of the hour. Another challenge is that simulation mimics the natural environment but does not. Thus, translating to real-time clinical learning still needs to be determined. This can be catered to by carrying out research not only limited to students' perceptions but also correlated to their academic performance.

CONCLUSIONS

Simulation in medical education needs to be planned and coordinated strategically with the learning objectives to maximise its impact rather than an isolated/disconnected event. Based on the current review, we propose the following pipeline to integrate simulation for undergraduate and postgraduate medical education [Figure 1].

Despite these, technological advancements have promising opportunities to enhance the effectiveness of simulation-based education in medical training at both undergraduate and postgraduate levels. With that being said, there are inherent challenges of cost and accessibility. Local collaboration with various stakeholders may address the problem of expensive simulation models to create, design, or invent cost-effective alternatives.

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