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Pros and cons of simulation in medical education: A review

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Abstract
Simulation is the artificial representation of a real-world process with sufficient fidelity in order to facilitate learning through immersion, reflection, feedback and practice without the risks inherent in a similar real-life experience. Simulation in medical education has come a long way from the basic task trainers used for the rehearsal of basic skills to the high fidelity human patient simulators. Both advantages and disadvantages have been identified for simulation based medical education. This article based on literature search reiews the pros and cons of simulation in medical education. Before we incorporate simulation further in medical curriculum, more evidence on its utility is needed in the form of studies that assess the impact of simulation training on patient outcome.

Keywords: patient outcome, pros and cons, simulation in medical education

Introduction

Simulation is derived from the Latin word ‘simulare’ which means ‘to copy’ [1]. Simulation has been defined as a situation in which a particular set of conditions is created artificially in order to study or experience something that is possible in real life; or a term that refers to the artificial representation of a real world process to achieve educational goals via experimental learning [2].

Simulators have been an instrumental part of medical training and education for nearly 400 years since birthing mannequins were first developed in the 17th century [3]. Once limited to basic task trainers for the rehearsal of basic skills, simulation now aims to increase task proficiency and patient safety, reduce medical errors and enhance professional communication and team management skills. Simulation can be adapted to accommodate the need of preclinical, paraclinical and clinical subjects of the medical curriculum. Simulators have been developed for training procedures ranging from drawing blood to laparoscopic surgery and trauma care.

Literature search on simulation based medical education revealed both advantages and disadvantages of simulation when included in the medical curriculum. This article based on literature search reviews the ‘pros’ and ‘cons’ of simulation in medical education.

History of medical simulation

The use of simulation in medicine dates back to 9th Century when Madame du Coudray, a French midwife created anatomically correct, life-size mannequin pelvis and mannequin babies and used those to train midwives in childbirth and management of childbirth-related complications. There have been reports of simulation in some form or the other being used in various places at different times. The first mannequin for commercial use is reported to have been marketed in 1911. Anaesthesia was the first speciality to have created a simulated training environment for anaesthesia administration. Simulation has come a long way with the introduction of versatile human patient simulators in the late 1990s & early 2000s [4].

Reasons leading to incorporation of Simulation in Medical Education [5-7]

Patient safety: Patients are to be protected from all avoidable harm. They are not commodities to be used for training. Simulation based medical education aims to provide correct attitude and skills among medical students to cope with critical situations in a planned manner, while avoiding harm to actual patients due to procedures done by inexperienced trainees.

Ethical sensitivities about patients: A patient’s consent for participation in teaching programmes becomes invalid if prompted by a compromise in care following refusal. Any payment to the patient for participating in teaching programmes may constitute an inducement. Also, confidentiality about a patient is lost if the clinical and non-clinical staff has access to the data information of the patients used for teaching purpose. These ethical issues too hint towards alternatives to real patients for medical teaching.

Depleted resources: Patients on whom accepted medical concepts can be demonstrated may not always be available or willing to become a part of teaching programmes. Another example is regarding the non-availability of experimental animals for teaching students due to ethical and legal constraints.

Changing medico-legal milieu: This has impacted training practices by limiting skills training in real patients.

Reduction in teaching time coupled with rapid explosion of knowledge: Busy schedules of physicians leave them with less time for teaching medical students.

Classification of simulation used in medical education

Simulators available for medical education are vast and varied. Classification of present day medical simulators as per type is given in Table 1 [8, 9]. The simulators are classified as low to high fidelity, according to how closely they imitate the circumstances under which the skill is typically performed. Classification of simulation as per fidelity is given in Table 2 [8, 9].

Pros of medical simulation

Immersive learning: The simulated scenarios are realistic enough to engage the students emotionally, thus providing a unique learning experience. Eg: the *high fidelity simulator "patient'* actually talks, breathes, blinks, and moves like a real patient [10].

Experimental learning: It has been said that learning is always better if it can be practical. Simulation gives the students a chance to practice the skills and also apply the knowledge that they have acquired.

Better understanding of abstract concepts: Simulation at the very beginning of the undergraduate medical curriculum can improve understanding of basic concepts of medical science, such as Pharmacology and Physiology because these simulated experiences help students to understand abstract concepts of basic science that are difficult to perceive with regular discourse. Eg: Effect of drugs on the blood pressure would be difficult to understand through static images or by demonstrations using traditional methods but can be better understood through simulation (Ex Pharm) [11].

Skill acquisition and maintenance: Acquisition of clinical skills is better when students are trained using simulations than didactic lectures alone. In a study conducted by Langhan *et al*, 19 residents were educated about critical resuscitation procedures by using simulators. The evaluation process consisted of 2 stages, after 8 hours of simulation, and the other after 3 months. The residents showed improvement immediately and continued to demonstrate the skills after the 3-month washout period. In a randomized crossover study, McCoy *et al* evaluated 28 medical students in the management of myocardial infarction after training with a human patient simulator or a PowerPoint lecture. Significant percentage of students demonstrated better assessment and management skills after simulation training than after power-point lecture [12, 13].

Student satisfaction and confidence: Simulation training prior to the actual performance of a procedure boosts the students' confidence. In one of the studies, simulation was incorporated into a training session of medical students to manage resuscitation during severe shock. The students reported that it gave a boost to their confidence level to handle similar cases in the future. A study conducted by Ten Eyck *et al* also showed similar results in the student satisfaction scores [14, 15].

Rare event training: Simulation is used when the real system cannot be engaged, because it may not be accessible, or it may be dangerous or unacceptable to engage. Simulation provides educators with the ability to deliver controlled training environments under a variety of circumstances including uncommon or high-risk scenarios [2].

Classroom based training: Simulation-Based Medical Education is one form that allows students to learn for educational purposes in a classroom. This can help them understand the concepts better than learning in crowded hospital settings.

Patient safety: Medical students cannot experiment on the human subjects without prior practice of procedures. Training by simulation provides a safe environment for training that does not expose patients to risk by procedures performed by inexperienced trainees. A study conducted by Graber *et al* surveyed patients in an Emergency department on whether they would agree to be a student's first procedure after that student had mastered the skill on simulator training for the procedures. The results were compared with those of a prior study regarding patients' willingness to be a student's first procedure without simulation training. Comparison of the 2 surveys showed a higher percentage of patients reporting that they would agree to be a student's first procedure if the student had mastered the procedure in simulation [16].

Planning of training: Simulator based clinical training can be planned with predesigned clinical encounters rather than relying on random case availability [17].

Standardised training: Simulation based training can provide a standardised training for all students.

Training and retraining: Simulation based training allows students to repeat procedures as often as necessary in order to correct mistakes and fine tune their skills. It also allows for feedback and comparison of the performance of individuals at the same level [4].

Assessing performance: Simulators have been also proposed as an ideal tool for assessment of students for clinical skills. Such a simulator meets the goals of an objective and standardized examination for clinical competence. This system permits the quantitative measurement of competence, as well as reproduces the same objective findings [4].

Analysis of training: The training provided can be analysed by trainees and trainers. A simulation can be frozen to allow discussion, and then repeated or alternative techniques demonstrated. Video and audio recordings of simulation scenarios provide the facilitators with unique opportunities to review the training [18].

Team training: Multidisciplinary team training and specific behavioural and communication skills can be taught using simulated environments as it also provides educators with opportunities to observe participants. In a study by Small *et al*, high-fidelity simulation was used to introduce emergency medicine residents to multiple patient scenarios. This type of simulation was shown to improve team coordination and leadership [17, 19].

Cons of medical simulation

Incomplete mimicking of human systems: Human systems are very complex and diverse. Lots of information is gained from humans, not instruments. Models and instruments can never match humans completely.

Defective learning: Poorly designed simulation can promote negative learning. Eg: if physical signs are missing in the simulation, students may neglect to check for these. Simulation based learning may also encourage shortcuts, such as omitting patient consent and safety procedures, and may foster artificial rather than genuine communication skills [20].

Attitude of learners: Participants will always approach a simulator differently to real life. Two common changes in attitude can occur: (a) hypervigilance which causes excessive concern because one knows an event is about to occur (b) cavalier behaviour which occurs because it is clear no human life is at stake [21].

Cost factor: Simulators especially the high fidelity ones are available at considerable costs; both in terms of initial purchase prices as well as maintenance charges. Hence, they are not affordable to many teaching hospitals.

Time factor: Incorporating time-slot for simulation in already burdened medical curriculum is difficult.

Infrastructure: Dedicated and exclusive resource personals are not always available. An instructor to learner ratio of 1:3–4 is ideal which is not feasible in the current medical curriculum where each session consists of a batch of 10–15 medical students.

Technical difficulties: Some physical findings like skin colour cannot be taught in simulators.

Programming difficulties: The simulation models have to be manipulated by facilitators and simulation engineers in such a way as to replicate a physiological response that may be desired under specific circumstances. Manipulating these systems in accordance with desired simulation goals is often cumbersome.

Learner specific teaching not possible: Instructors may wish to present optimally circumstances according to the abilities of different learners (advanced tasks for proficient students while basic tasks to new or slow learners). This individualized approach is not possible in simulation based teaching.
Supporting evidence insufficient: There is only limited amount of good quality evidence on the effect and validity of simulation based training.

Discussion

Simulation-based education is a rapidly developing discipline that can provide safe and effective learning environment for students. Clinical situations for teaching and learning purposes are created using mannequins, part-task trainers, simulated patients or computer-generated simulations. As can be seen there are many advantages that simulation will bring into the medical field. However, the limitations of simulation have to be recognised as well, the most important being the lack of valid and experimental evidence on the utility of medical simulators.
Most of the evidence that is available is in the form of observational studies, assessing student and patient satisfaction and the educational efficacy of simulation with that of didactic lecture. Most of these studies show the superiority of simulation over other teaching methods for the parameters assessed. Only two papers were found, that reported negative or equivocal findings for the use of simulators in medical education [22, 23]. However, the available evidence on utility of simulation in medical education is still weak as most of the studies are low powered studies and the parameters assessed in most studies are subjective based on personal reports of the participants. Hence the validity of most of these studies is questionable.
Added to the above, there are some questions regarding simulation that remain unanswered in the literature: Can simulation teach students how to diagnose and decide the right treatment? Can simulation change the attitudes of the student? Are there effects on how knowledge and skills are acquired and retained? Does simulation training improve patient outcome? What aspects of competence can be assessed by a simulator? It is not known if good performance in a simulation is reflected in real clinical situations, and if simulation can be accepted by our profession as a method of assessment.
Based on the literature evidence that is available, we can presume that simulation provides a better teaching modality for certain tasks, such as acquisition of clinical skills, whereas didactic or problem-based learning teaches patient assessment, diagnosis and treatment algorithms more effectively. Hence, future studies should be stratified based on the task the simulator is intended to teach or assess. This will help in elucidating the value of simulation for medical education. Also, it will provide information to future simulation designs. Besides this, long term studies are required which analyse the effects of simulation teaching on patient outcome rather than just assessing short term goals like acquisition of knowledge, skill and student satisfaction.

Conclusion

Simulation based medical education has both pros and cons. Before we embrace simulation based medical education as a valuable tool for training and assessing medical students, we need more valid evidence on the utility of simulation training for medical students. Also future studies should concentrate on the effect of simulation training in improving patient outcome, which is the ultimate goal of medical profession. Only after sufficient analysis of the impact of simulation on patient outcome, can we fully advocate its further incorporation into medical curriculum. As of now, simulation should be complementing traditional clinically based training.

Table 1: Types of Simulation

Type	Description	Examples
Compiler driven	Specific task trainers replicating a particular part of the anatomy.	Intravenous-insertion arms, urinary catheter trainers, airway management heads, central line placement torsos.
Event driven Standardised patients	Actors trained to role-play patients for training and assessment of history taking and physical procedures.	Simulated clinical situations
Hybrid simulation	Combination of standardised patients and part-task trainers	
Computer-based	Uses mouse and keyboard navigation for multiple pharmaco-physiological models	

Table 2: Classification of simulation as per fidelity

Low fidelity Screen based text simulators	Create scenarios with user selecting one of the several responses. E.g. in a scenario involving a patient with severe headache, the user may be offered options such as prescribing an analgesic or getting a CT scan of the head. Simple to construct and are less expensive but they focus on single skills and there is poor immersion
Static mannequins	Used for hands-on practice. E.g. intubation, laparoscopic training or cardio pulmonary resuscitation ('Ressusi' dolls)
Medium fidelity Screen-based graphical simulators	Suited to demonstrate physiological, pharmacological processes. Provide a more realistic representation, are portable, and relatively less costly. These help one to understand the basic concepts but do not confer actual practical skills. E.g. Computer simulation of changes in Blood pressure in response to drug administration(Ex pharm)
Mannequins with mechanical movement	Includes a mannequin and software. Computer-based pictures help confer practical skills Includes 'range of normal variation' E.g. Cardio-pulmonary resuscitation (AMBU Man)
High fidelity simulators	Combine part or whole body mannequins to carry the intervention with computers that drive them to produce physical signs. They are usually designed to resemble the reality. They can talk, breathe, blink, and respond either automatically or manually to physical and pharmacological interventions
Non-physiologic programming	Manually set parameters dependent on operator programming. Parameters need to be reset after intervention
Physiologic programming	Automatic generation of appropriate physiological responses to treatment-interventions in the mannequin allowed. E.g. human patient simulator.

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