Simulation-based Medical Education: Time for a Pedagogical Shift

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The purpose of medical education at all levels is to prepare physicians with the knowledge and comprehensive skills, required to deliver safe and effective patient care. The traditional 'apprentice' learning model in medical education is undergoing a pedagogical shift to a 'simulation-based' learning model. Experiential learning, deliberate practice and the ability to provide immediate feedback are the primary advantages of simulation-based medical education. It is an effective way to develop new skills, identify knowledge gaps, reduce medical errors, and maintain infrequently used clinical skills even among experienced clinical teams, with the overall goal of improving patient care. Although simulation cannot replace clinical exposure as a form of experiential learning, it promotes learning without compromising patient safety. This new paradigm shift is revolutionizing medical education in the Western world. It is time that the developing countries embrace this new pedagogical shift.

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"I hear and I forget. I see and I remember. I do and I understand." - Confucius [551 BC-479 BC]

In Medical education, the traditional training model - 'See one, do one, teach one' has been the accepted teaching standard for centuries. Didactic teaching and observation of more experienced colleagues at the bedside was followed by independent performance of clinical procedures on real human patients [1]. During the training period, each trainee's exposure varies and it is next to impossible to ensure that all important learning opportunities will be available to them in the clinical environment. The assumption underlying this traditional model – that placing a trainee in a supervised clinical environment for a set period of time, will allow the trainee to acquire adequate skills and experience to practice independently and safely does not always prove to be true [2].

'First, do no harm': Patient safety has become a major focus of individual hospitals, academic institutions, and health care regions/countries over the last 15 years. This was due in part to a report published by the Institute of Medicine (IOM) in 1999. The IOM report, To Err is Human, estimated that approximately 98,000 Americans die each year from preventable medical errors [3]. Recent estimates are even higher - between 210,000 and 440,000 deaths per year [4], equivalent to 1-2 Jumbo jets crashing every day! Trained health care professionals require some exposure to patients in order to improve skills and gain experience. Institutions, governments and patients are becoming increasingly concerned that safety is being compromised as health care workers gain this experience. Similar to the airline industry, the integration of simulation into medical education – Simulation-based medical education (SBME) – may address some of these concerns. The traditional 'apprentice' learning model in medical education is undergoing a pedagogical shift to a simulation-based learning model – 'see one, do one, teach one' now becomes 'see one, practice many, do one' [5].

EVOLUTION OF SIMULATION

Simulation-based training was pioneered by the aviation, aerospace and nuclear industries in the latter half of the 20th century. It has become the standard for both skill acquisition and improved team performance while reducing errors in industries such as commercial aviation and nuclear industry, where the costs of mistakes may be high because they pose direct threat to human life [6]. Simulation has the potential to reduce the chances of error if or when similar crisis occur in real life [7]. In medicine, the first simulator (Resusci-Annie) was developed in the early 1960s for resuscitation training [8]. Since then, medical simulation has experienced an exponential growth over the past few decades. The use of SBME has led the way in the field of anesthesia since 1980s and in emergency medicine since late 1990s. One might question the necessity of SBME when the apprenticeship model of training under experienced clinicians has served us well for so many years. We must remember, not everything that is taught is necessarily learned, programs that best facilitate skill acquisition are those that focus on learning, rather than on teaching [2].

The pediatric and neonatal intensive care settings are highly dynamic and stressful workplaces where medical errors have significant consequences. In general, the ethical imperative for SBME may be stronger in pediatrics, since children are not capable of providing informed consent on their own, unlike other fields of health care [9]. Every healthcare provider is human, therefore prone to make mistakes; the question is when and why? High error rates with serious consequences are most likely to occur in intensive care units, operating rooms and emergency departments, reflecting the complexity of patient care in these clinical environments as well as the challenging demand for high-quality teamwork. It is well recognized that communication can be a major problem in these environments. In 2004, a review and root cause analysis of over a 100 perinatal cases resulting in infant death or severe disability identified that two-thirds of such 'sentinel events' were linked to communication failures rather than deficiencies in knowledge. Recommendations included the need for team training using simulation to improve teamwork and enhance patient safety [10].

SBME creates a safe learning environment where mistakes made are not harmful or dangerous to patients but, rather a powerful learning experience for students and professionals. Health care workers are allowed to practice and commit mistakes in a controlled environment that provides them an opportunity to learn from the mistakes made and with constructive feedback. Evidence is now emerging that simulation-based education is improving the delivery of care in pediatric cardiac arrest, both in technical skills and team performance [11].

EDUCATIONAL METHODOLOGIES

Several learning theories help guide the importance of simulation-based learning and its effectiveness. According to the Adult learning theory, adults are internally motivated, self-directed and need to know why they are learning [12,13]. In simulation, relevance is ensured since the learning environment matches the real-life clinical situation, which helps the learner to effectively transfer the skills learnt to daily clinical practice [14]. The concept of 'learning by doing', or Experiential learning is a model explained by David Kolb, which emphasizes a process of learning building on concrete experiences [15]. The simulation experience affords an excellent opportunity to expand on this learning model. Simulation sessions should be spread across the training period to take advantage of the 'spacing effect', a phenomenon in educational psychology showing, Distributed practice yields better learning results than Massed practice learning model for a given amount of study time [16,17]. Deliberate practice using simulation with immediate feedback not only leads to effective learning but also improves overall performance; repetition of this deliberate practice over a period of time helps learners sharpen their skills [18]. It is essential for health care professionals to progress from a stage of 'incompetence' to 'competence' as quickly as possible, in order to maximize patient safety. Simulation-based training allows learners to accelerate their learning curve by deliberate practice [6].

ROLE OF STRESS IN SIMULATION

The error rate in a stressful clinical environment is significantly higher than in a relaxed clinical environment [19]. Although the term 'stress' has a negative connotation, it does not necessarily have a negative effect. Performance is enhanced when the learning and clinical emotional states are similar. The learner's emotional state during the learning experience influences retention and activation of knowledge. Studies underline an important principle regarding stress and memory. Increases in stress hormone levels, particularly corticosteroids, within the context (and around the time) of the learning situation helps to remember that particular event, by inducing focused attention and improving memory of relevant over irrelevant information [20]. This may help to explain the role of experiential learning and the effectiveness of simulation as an educational methodology.

SKILLS TRAINING

Worldwide, SBME has been widely accepted in many neonatal, pediatric and adult life-support courses, like neonatal resuscitation program (NRP), Acute care of at-risk newborn (ACoRN), STABLE program, and Pediatric advanced life support (PALS) courses. These courses have focused on recommended resuscitative protocols, procedural (technical) skills and management guidelines so far, but have now recognized the need for teamwork (non-technical) skills and the importance of team dynamics. A team of healthcare experts need not necessarily constitute an 'expert team'. As healthcare professionals, we are predominantly educated as individuals or trained in 'silos' within our disciplines, while in reality we often work as a team. While working in a multidisciplinary, inter-professional team, it is difficult for team members to anticipate each other's roles, skills, knowledge, strengths and habits. This could affect the consistency of care and patient safety in any intensive care unit [11,21]. SBME is being increasingly used to help healthcare professionals become effective team members, by educating them on various team behavioral skills.

FIDELITY IN SIMULATION

A potential element that influences the effect of simulation is the level of authenticity of the simulation, known as 'fidelity'. There are 3 types of fidelity in simulation – environmental, equipment, and psychological [22]. Environmental fidelity refers to the realism of the physical space in which the training occurs, where effort is made to mimic clinical environment. Equipment fidelity includes the mannequins, standardized patients and the persons acting as confederates during the simulation scenario. Finally, psychological fidelity is the degree to which the trainee perceives the simulation to be authentic or real by 'suspension of disbelief'. Literature states that psychological fidelity is considered to be the most essential requirement than physical fidelity when conducting team training [23,24].

There are a range of simulation equipments available. A part-task trainer replicates specific portion of the patient or task and it helps learners to acquire the basic skills or finer details to learn a particular task and skill. The term 'low-fidelity' simulator refers to mannequins that do not provide cues or prompts to the trainee. These mannequins are relatively inexpensive; the degree of realism is low and is often used during resuscitation courses. Prompts during the scenario are provided by the facilitator. The term 'high-fidelity' simulator describes mannequins that are sophisticated interactive patient models which can produce breath sounds, heart sounds, visible chest rise, and palpable pulses, generate sounds (e.g. cough and cry), demonstrate cyanosis, and mimic seizure activity. They can be intubated and often have facilities for the insertion of lines. Vital signs, cardiac and respiratory status, pulse oximeter readings and blood pressure could be adjusted in real time *via* a remote computer in response to learner actions with a monitor display, adding realism during simulation sessions [5, 25, 26]. There is a debate that continues in the healthcare simulation community as to how much fidelity is necessary and the fidelity requirements vary according to the learning context.

STAGES OF SIMULATION

It is the methodology, not the technology that determines the success of any simulation-based training session. Every effort should be made to ensure that the scenarios are realistic in detail and relevant to the clinical practice. Pre-briefing is an introduction that orients the learner to the simulation environment and discusses the features of the mannequin before starting the scenario. Effective simulation is not dependent on the use of highly complex and expensive patient simulators; instead it is dependent on carefully designed scenarios that align closely with the needs of the learners and skillfully-led debriefings [2]. The best learning phase of the simulation session is the debriefing. No one would like to be judged in their learning environment and it is, therefore, essential for the facilitator to create a safe learning environment. The instructor must be trained to debrief effectively and provide constructive feedback to the learner using any debriefing strategies and models. Simulated clinical scenarios can be video recorded and played back during debriefing sessions, so that learners and instructors can review together to enhance the team's performance. In critical care settings, immediate debriefing after real resuscitations almost never occurs, as the team dissipates to care for other patients once the resuscitation is over. The ability to provide immediate feedback is the primary advantage of SBME, which fosters integration of cognitive, technical, and behavioral skills; and facilitates multidisciplinary team training.

CENTER-BASED *VS IN SITU*

Simulation sessions can be conducted at a dedicated simulation center or at the actual clinical environment. Center-based simulation takes place in a separate location and is often used for undergraduate training (such as basic sciences and familiarization with medical examination techniques), for postgraduate/residency training (like learning and refining clinical procedural skills), for conducting life-support/resuscitation courses, for continuing medical education of the inter-professional team (practicing both procedural skills and communication skills), and for assessment or competency testing [13]. It allows practice without interruption. *In situ* simulation is a form of simulation-based training that occurs within the actual clinical environment and whose participants are on-duty clinical providers during their actual workday [27]. It can be used to improve the efficiency of healthcare teams, where it can be challenging for acute care staff to leave their work environment and find protected time for education in a dedicated simulation center. There is a major concern about retention of the skills learnt in resuscitation / life-support courses. Healthcare professionals should practice the skills they have learnt by routine participation in 'mock' codes using simulation and in real-life events for better retention. It offers opportunities for clinical teams to rehearse infrequent and/or high-risk clinical scenarios and learn about the best practices without having to leave their location [21]. Designing simulations that take place in real clinical settings can help identify both obvious and hidden errors in the system, known as 'active' and 'latent' errors respectively, that cannot be identified in a simulation center [28].

COMPETENCY ASSESSMENT

The pedagogical shift of medical education from a time-based model to a competency-based model is promising [5]. Simulation has been used as an evaluation tool to assess knowledge *e.g.*, OSCE stations of medical licensing exams. Thus simulation is continuously evolving to help scale trainees on the Miller's pyramid, a framework to assess clinical competence in medical education [29]. It is used to typically appraise the competence (*e.g*., in cognitive knowledge, technical skills and interpersonal skills) of the individuals or the teams involved.

SIMULATION FACILITY

Simulation facilities often require audio-visual aids, specialty mannequins, and the appropriate clinical tools and equipment to create a realistic patient-care environment. An enclosed observation room and a debriefing room are important in the simulation facility. Simulation suites are often designed to accurately replicate actual hospital set-up and the use of high-fidelity simulators may provide a more realistic model for training [25]. To achieve suspension of disbelief, students must fully engage and immerse in their learning, and instructors should stay as hands-off as possible during the simulated scenario [30]. Financial challenges of setting up simulation centers are universal. One could consider resource-sharing agreements, where the equipments and costs are shared among multiple departments or training programs [31]. For example, task trainers for teaching procedural skills are significantly less costly than high-fidelity simulation mannequins.

LIMITATIONS

Identifying opportunities and barriers are the initial steps to implement SBME and efforts to overcome these challenges will yield a rich return. It is a well known fact that the development of a dedicated simulation centre is expensive to establish, run and maintain. It is both time and labor intensive to setup a simulated session. The main limitation in simulation-based learning is that it is learner-dependent and requires full participation and engagement by the individual. The challenge is to embed a simulation-based training program into the existing medical curriculum. More research is needed to determine the required exposure time in simulation and create guidelines for SBME to make it educationally beneficial for students. There is need for trained faculty familiar with debriefing skills and assessment tools like checklists and global rating scales. There are ongoing studies to evaluate the transfer of skills from the simulation room to the real clinical environment [1].

In conclusion, simulation-based training is becoming an increasingly used instructional methodology internationally. Many pediatric and neonatal units are beginning to incorporate simulation-based training into their educational programs. Although SBME cannot replace clinical exposure, it does provide an opportunity for repetitive practice in a low-risk environment. The immersive, hands-on nature of simulation-based training is able to overcome limitations of the traditional training model. With its potential to improve human performance, enhance professional confidence, and reduce inherent patient risks, this new paradigm is revolutionizing medical education in the Western world. It is time to explore and embrace this educational methodology in the Indian sub-continent.

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Erratum

In the November 2014 issue of Indian Pediatrics, on page number 876 of article entitled "Effect of Inclusion of Hepatitis B Vaccine in Childhood Immunization Program in India: A Retrospective Cohort Study", the following errors were noted in Table I.

1. The first row labelled as 'Anti-HBc' should have been 'Anti-HBs'.
2. The second row labelled as 'HBsAg' should have been 'Anti-HBc'.
3. The third row labelled as 'Anti-HBs' should have been 'HBsAg'.

The corrected table is as follows:

Serological marker	*Boys*		*Girls*		*All children*		*P value*
	Immunized (n=1357)	*Unimmunized (n=1236)*	*Immunized (n=1317)*	*Unimmunized (n=1114)*	*Immunized (n=2674)*	*Unimmunized (n=2350)*	
Anti-HBs	735 (54%)	233 (19%)	680 (52%)	184 (17%)	1415 (52.9%)	417 (17.7%)	<0.001
Anti-HBc	13 (1.0%)	28 (2.3%)	15 (1.1%)	14 (1.3%)	28 (1.05%)	42 (1.79%)	0.026
HBsAg	3 (0.2%)	4 (0.3%)	1 (0.1%)	0 (0%)	4 (0.15%)	4 (0.17%)	0.855

P values relate to comparison of total immunized versus total unimmunized children.