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A COMPREHENSIVE REVIEW OF SIMULATION-BASED MEDICAL EDUCATION: CURRENT PRACTICES AND FUTURE PERSPECTIVE

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ABSTRACT

Simulation is a method or technique that is employed to produce an experience without going through the real event and is defined as "the imitative representation of the functioning of one system or process employing the functioning of another". The degree to which a simulation resembles reality is termed fidelity. Simulation-Based Medical Education (SBME) can improve a resident's self-confidence, medical knowledge, clinical skills, communication, critical thinking, team building, and leadership qualities. With this, educators can provide a minimum number of simulated experiences during training to ensure exposure, while also preparing residents to fully participate in rare clinical experiences when they occur. The primary goal of SBME is to reduce mistakes to enhance patient safety and improve medical care. An additional objective of SBME is to train professionals in error management and accountability. In the medical field, the first notable simulator, Resusci-Annie, was developed in the early 1960s for resuscitation training. Since then, medical simulation has seen significant growth. Incorporation of SBME as a teaching strategy in undergraduate and postgraduate medical education curricula requires a stepwise approach where the first step is the assembly of human capital. The benefits of SBME are comparable between resource-poor and resource-abundant settings. It's crucial to universally incorporate SBME into both undergraduate and postgraduate medical education. Therefore, the strategic and integrated use of simulation emerges as the progressive path forward in global healthcare education.

KEYWORDS: Simulation, Curricula, Undergraduate, Postgraduate.

INTRODUCTION

Simulation is a method or technique that is employed to produce an experience without going through the real event.[1] Simulation opens up opportunities that are not available in real-event learning, such as apprenticeships, and at the same time provides a multifaceted safety zone for learning. Simulation can provide a safe environment to reflect on and learn from mistakes without threat to professional identity.[2] Simulation is defined as "**the imitative representation of the functioning of one system or process employing the functioning of another**".[3] The degree to which a simulation resembles reality is termed fidelity.[4] While healthcare simulation can substitute real patient encounters or other clinical situations for learning purposes, it is important to understand that it is not the only method available and it may be combined with other learning methods to achieve the education goal.

Simulation-Based Medical Education (SBME) can improve a resident's self-confidence,[5] medical knowledge, clinical skills, communication,[6-8] critical thinking,[9] team building, and leadership qualities. With simulation, educators can provide a minimum number of simulated experiences during training to ensure exposure, while also preparing residents to fully participate in rare clinical experiences when they occur. SBME has been shown to improve learner's performance in both simulated and clinical settings.[10–15] Performance improvements are commonly noted in the areas of technical skill development, trauma management, crisis resource management, and resuscitation skills training[10,13,16] all essential to the EM provider. Simulation-based training has also been shown to be superior to problem-based learning when teaching critical assessment and management skills.

The **primary goal** of SBME is to reduce mistakes to enhance patient safety and improve medical care. It creates a safe environment for students and professionals to make mistakes without harming patients. Through practice and constructive feedback, they learn to prevent the repetition of these errors in real-life patient care. An **additional objective** of SBME is to train professionals in error management and accountability.

The combination of technology and the faculty time required for many experiential learning opportunities makes simulation-based learning one of the more resource-intensive educational methods available to educators.[17] Facilitation of simulation-based activities requires faculty training in debriefing and simulator logistics. This can pose a significant barrier when developing simulation-based educational content to accompany a residency curriculum for the first time.

Evolution of Simulation-Based Medical Education, initially pioneered by the aviation, aerospace, and nuclear industries during the latter half of the 20th century. It has since become a standard practice for improving skills and teamwork while reducing errors,[18] particularly in industries where mistakes can have life-threatening consequences, such as commercial aviation and nuclear technology.[19]

In the medical field, the first notable simulator, **Resusci-Annie**, was developed in the early 1960s for resuscitation training.[20] Since then, medical simulation has seen significant growth. Simulation-based medical education (SBME) gained prominence in anaesthesiology in the 1980s and later in emergency medicine in the late 1990s. The importance of SBME in Pediatric and neonatal intensive care settings is due to its dynamic and high-stress nature, where medical errors can have serious consequences.

Medical errors encompass various incidents that result from the failure of planned actions intended to enhance a patient's well-being. These errors can lead to adverse consequences such as surgical injuries, wrong diagnoses, and avoidable deaths. High error rates are more likely in critical care settings due to the complexity of patient care and the demand for high-quality teamwork. Complete prevention of mistakes is unattainable in medicine because it is conducted by fallible human beings. SBME can be seen as an educational approach that recognizes the inevitability of errors and uses them as valuable learning experiences.

Error management involves multiple skills that contribute to minimizing mistakes in the medical system, involving all participants in the healthcare process. These skills encompass individual awareness of the potential for errors, recognition of one's competencies and limitations, the ability to seek help when necessary, and strategies for recovering from mistakes while minimizing harm to patients. Professionals must also analyze mistakes in real-time for immediate recovery and in retrospect for optimal learning. In cases of crisis resulting from mistakes, the team leader must inform the patient and family, report the error to superiors and risk-management officers, and take responsibility for the error. Thus, team training using simulation is recommended to improve teamwork and enhance patient safety in these critical healthcare settings.

These skills are best taught and implemented within the framework of an error-management program that includes several stages:

1. Identification and acknowledgment: mistakes performed by individuals or teams;
2. Analysis of errors: an attempt to discover the root causes and course of events that led to their occurrence (at individual, team and system levels);
3. Determination: changes and corrections to be implemented;
4. Internalization and implementation: lessons learned.

The Advantages and Disadvantages of simulation as an educational tool:

Simulation can provide programs with great flexibility in meeting educational objectives. While not a replacement for experiences gained when providing care to real patients, simulators can create any patient problem, in any context, at any time of day or night to target the required knowledge, skills, or attitudes that may be lacking in a trainee's experiences to date. In this way, programs can ensure that trainees receive at least a minimal level of exposure to core objectives, regardless of the patient population and resources to which they have access.[21]

Learning about simulated patients does not constitute a patient care activity and is thus a realistic way for trainees to hone their skills in off-duty hours should they wish to do so.

With further limitations to work hours likely to be instituted very shortly[22] the use of simulation in postgraduate medical education may become even more prevalent. Yet it is not just the practical aspects of simulation that have led to its widespread adoption within medicine; there are also several features inherent within the process of simulation that align with educational ‘‘best practice.’’

According to Malcolm Knowles, the father of Andragogy, adults learn best when they see the information being taught as relevant, when they are actively engaged in determining what they learn and how they will be evaluated, and when the session content builds upon their previous experiences.[23] With a small amount of advanced planning, a simulation session can easily be designed to meet each of these goals.

Other advantages of simulation from an educational theory perspective are that simulation provides the opportunity for deliberate practice, context-dependent learning, and experiential learning. Based on the work of Ericsson, individuals must undertake ‘‘deliberate practice’’ to become experts[24]. Rather than relying on chance opportunities in the clinical environment over the years, simulators can provide repeated exposures over a short period, and when combined with constructive and timely feedback, simulators have the potential to accelerate the learning curve for skills acquisition.

Although unacceptable when learning with actual patients, trainees who are erroneously managing a simulated patient may even be allowed to carry out their mistakes without intervention. Following the scenario, debriefing provides the opportunity to discuss what happened in a supportive and constructive manner, with the session then being repeated until the trainee and the facilitator are satisfied with the performance. In addition, context-dependent learning, or learning in an environment that is similar to that in which they will later be using that information, and experiential learning, or learning by doing, have both been shown to be effective methods of improving learning in adults.[25-28]

While there are numerous positive aspects to simulation-based medical education, it is equally important to comment on **potential drawbacks**. For example, the setup costs of a simulation laboratory, including construction, simulator, procedural equipment, and computer technology, have been estimated at over $1 million.[29] Maintenance of the equipment and laboratory, procurement of new equipment, and salary support for involved individuals all contribute to significant ongoing costs.

In addition, despite impressive technological advances and elaborate staging, simulations used in medical education are still not perfect at replicating reality. For example, a physician trained on the simulator may have difficulty locating similar anatomical landmarks on a real patient to perform a central line insertion or intubation. Also, some participants may not be able to immerse themselves in the simulated environment in an appropriate fashion, and as a result, may become more reckless or hypervigilant than if they were managing a real patient.[30,31]

Such deviations from normal behavior make it more challenging to identify a learner's true gaps in knowledge, skills, or attitudes and represent lost educational opportunities. While a significant amount of learning can occur with simulation, caution must also be exercised in automatically equating this with the acquisition of clinical expertise. For example, studies have yet to explore whether training on a simulator provides adequate preparation to deal with complex procedures, abnormal anatomy, or complications arising from a procedure, all of which would be considered part of the skill set of an expert.

In addition, some authors have gone so far as to express concerns that students may be learning how to ‘‘act’’ in a simulated environment rather than how to function effectively in the true healthcare environment.[32] At this point, additional investigations are needed to help shed further light on these issues and explore potential solutions.

SBME in Medical Education

Medical education is intensive and extensive.[33] Medical professionals are expected to be proficient and effective.[33] With a rapidly changing pattern of healthcare delivery, medical students and residents face an added challenge to keep up to date with the most recent standards of care.[34,35] Calls to reduce the duration of professional training and time constraints throughout the education process have the adverse effect of limiting exposure of students and residents to adequate quality and quantity of clinical exposure.[36,37] This is where simulation may flourish. It can provide all learners with an acceptable variety and number of clinical scenarios. Furthermore, exposing all participants to the same scenarios and uncommon clinical cases might allow a more standard approach to clinical curricula.[4] This might also be useful downstream in potentially confronting the inadequacy and lack of preparedness felt by medical students and novice physicians in recent years.[38-43]

Incorporation of SBME as a teaching strategy in undergraduate and postgraduate medical education curricula requires a stepwise approach.[44,45] The first step is the assembly of human capital.[46] Simulation, as a teaching method, requires properly trained facilitators.[46] Improperly executed simulation can lead to unaccomplished objectives, poor to no learning, and disengaged or even psychologically impacted participants.[47-49] It is extremely important for medical institutions to recognize this and provide their faculty with adequate training in the operation of healthcare simulators before planning for induction and implementation of simulation as an education strategy. Adherence to best practices during the pre-brief, the simulation itself, and the debrief (including skill sign-off) is essential for the long-term success of a simulation program.[50] The next step is an integration of simulation into the standard curriculum of a teaching program.[44] This can be done via the amalgamation of this modality into an existing curriculum or through the development of new curricula.[44] The process is carried out by a collaboration of the program director, content expert, and simulation expert in four phases: planning, implementation, evaluation, and revision.[44] Curricular integration has the advantage of using simulators to achieve learning objectives instead of ad hoc use that only adds to the course load, without achieving palpable benefit.[44] Once part of the curriculum, there should be provisions for deliberate practice.[44] Coined by Ericsson in 2004, deliberate practice is the repetition of psychomotor or cognitive skills to achieve defined goals in a controlled setting.[44] It is designed to provide feedback for error correction in subsequent practice until the participant displays competence and advances to the next skill.[51] Deliberate practice is a more powerful predictor of superior expert performance than clinical aptitude.[52] It is also particularly useful in training for rarely performed procedures.[51] Simulation is versatile in the ability to not only expand on psychomotor skills but also assist in refining trainee confidence and self-sufficiency.[53-58] Deliberate practice is crucial in mastery learning.[44] The objective of mastery learning is to achieve performance on a level higher than basic competence.[44] Residents take different times to achieve mastery as they have dissimilar strengths and weaknesses.[44] Each participant must meet a set standard to progress through educational units of increasing difficulty.[44] Once mastery is achieved for a skill, the range of difficulty and clinical variation in simulation training is increased in the case mix.[44] Both need to be adjusted according to the needs of the training program.[44] True learning occurs when participants are given time to achieve goals at a pace that is complementary to their learning capability. Desired outcomes can be accomplished by integrating simulation into curricula with the support of trained facilitators.

Challenges for developing countries

SBME has already become the gold standard for medical education in a vast majority of the developed world.[59] The benefits of SBME are comparable between resource-poor and resource-abundant settings.[60] However, the need for these benefits is far more pronounced in developing countries due to inadequate access to care.[60]

Using SBME to train entry-level providers, educate community workers, and bridge the gaps of understanding between healthcare providers and local populations who mistrust modern medicine may enhance the overall impact of SBME.[60] It may also lower the rate of preventable adverse events that are already underreported in developing countries.[61]

A recent literature review done by Martinerie et al showed that most studies investigating SMBE in Low- to Middle-Income Countries (LMICs) were conducted in collaboration with international organizations.[59] Indeed, most quality improvement projects launched in LMICs are reliant on external funding.[61]

Unit cost and operator expertise remain notable areas of concern regarding SBME implementation in resource-poor settings.[59] This is worsened by inadequate cost reporting in SBME research.[62] Nevertheless, the availability of modern low-cost simulators could promote self-reliance in developing countries.[59] This is important as it will prevent unnecessary disruptions in the continuity of SBME due to bureaucratic tribulations.[63]

Simulation may also be conducted online or virtually where the use of the internet or computer programs can help eliminate costs related to purchasing expensive equipment for on-site training.[64-66] However, there are limitations to these initiatives such as the availability of technology, a stable internet connection, and digital literacy and confidence of users.[65,66]

Another challenge is the adaptability of SBME.[63] SBME is only effective if the simulations mimic realistic and relevant scenarios that account for resource limitations and disease distribution in the target setting.[63] If the simulation involves rare scenarios or clinical management that are not in common practice, the overall impact of the educational activity is lost.[63] Additionally, vital learner feedback during the process may be hindered by the hierarchy in training structures, social and cultural norms, gender implications, or language barriers.[63]

Since each developing country faces different challenges, dedicated time from experts and educators is required to define clear learning objectives, establish effective delivery of feedback, and evaluate the type of SBME modality to use.[63] Also the collaboration of local experts, institutions, and manufacturers to develop and implement SBME can prove to be helpful.[63]

A recent study by Gheza et al has shown that the overall cost of expensive medical equipment can be effectively controlled using locally sourced materials and readily available devices while yielding comparable outcomes to patented products.[67] These efforts not only improve accessibility but also help increase market share for the products.[68]

CONCLUSION

It's crucial to universally incorporate SBME into both undergraduate and postgraduate medical education. Despite overwhelming evidence supporting its effectiveness in adult learning, its utilization varies widely and is often opportunistic. To ensure the production of skilled and confident future doctors, students, and residents must be given ample opportunities to practice and refine their abilities before engaging with real patients. The focus of future research should center on the sustainability of simulation in Developing countries like ours, with an emphasis on comprehensive and informative cost reporting. Rather than investing foreign funds in limited, short-term simulation projects in developing nations, collaboration with local experts should redirect resources toward more achievable and enduring initiatives. Therefore, the strategic and integrated use of simulation emerges as the progressive path forward in global healthcare education.

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