THE EUROPEAN SOCIETY OF MEDICINE
Medical Research Archives, Volume 12 Issue 12

RESEARCH ARTICLE

MEDICAL SIMULATION: The Vision of Learning in Healthcare

Dr. G. Ulufer Sivrikaya[1], **Dr. M. Gokhan Gonenli** [2]

[1] Academy of Interventional Medicine, Education and Simulation (RMK AIMES) Istanbul, Türkiye
[2] Koç University School of Medicine, Internal Medicine Department Istanbul, Türkiye

OPEN ACCESS

PUBLISHED
31 December 2024

CITATION
Sivrikaya, GU., and Gonenli, MG., 2024. MEDICAL SIMULATION: The Vision of Learning in Healthcare. Medical Research Archives, [online] 12(12). https://doi.org/10.18103/mra.v12i12.6122

DOI
https://doi.org/10.18103/mra.v12i12.6122

ISSN
2375-1924

ABSTRACT

Simulation-based education, is a relatively new approach, for practice and learning to develop healthcare professionals' knowledge, skills, and attitudes, with different simulation modalities. This educational strategy is used to achieve adequate command in learning on preselected, programmed real-life or near-real-life clinical scenarios, avoiding undesirable features encountered or confronted in learning with real patients and undue stress to real patients within a safe learning environment. This editorial aimed to give a general overview of simulation in healthcare education. A brief history, the healthcare simulation concept and challanges of this training modality mentioned in the highlights of relevant references. Simulation based education has emerged as a transformative approach, significantly enhancing healthcare professionals' learning experience and clinical competency. The various types of simulations offer a safe and controlled environment for participants to practice and hone technical and non-technical skills, ultimately improving patient safety and clinical outcomes. The integration of simulation with other training modalities and its adoption in diverse global contexts highlight its potential to revolutionize medical education worldwide.

Introduction

Simulation based education (SBE) is a useful teaching and learning strategy as an example of evolving technologies. It has emerged as an increasingly necessary tool improving technical and non-technical skills of healthcare personnel to have better patient safety outcomes.

The purpose of this editorial paper is to collate, synthesize, and analyze the literature focusing on the use of simulation as an educational strategy.

Medical simulation

Simulation is defined as "A technique that creates a situation or environment to allow persons to experience a representation of a real event for the purpose of practice, learning, evaluation, testing or to gain an understanding of systems or human actions".[1] *Healthcare Simulation* is defined as "The application of a simulation activity to training, assessment, research, or systems integration toward patient safety".[1] The concept of healthcare simulation stems from *"Never the first time on the patient"* principle. It provides a safe and controlled environment for learners to practice and refine their skills, improving clinical proficiency, decision-making, and teamwork. It plays a crucial role in medical education, enhancing patient safety and healthcare quality by allowing professionals to gain experience before working with real patients.

Medical simulation is often defined as, "a technique (not a technology) to replace and amplify real life experiences with guided ones, often "immersive" in nature, that evoke or replicate substantial aspects of the real world in a fully interactive fashion".[2] Indeed, it is a tool for quality improvement, and safety of care by providing the opportunity to repeat clinical situations or therapeutic procedures in a secure (safe) environment.

High-reliability industries such as aviation, military, nuclear, and oil industries have long emphasized the importance of human factors in understanding safety measures and made simulation-based training a prerequisite.[3] Efforts have taken underway to translate lessons learned in these environments to the healthcare industry and the education of future healthcare professionals. Simulation originates from its application in the military and aviation. Edward Link introduced simulation into aviation with his "Blue box" flight trainer.[4] Medical simulation was not immediately accepted as a useful training technique, both because of technological limitations and because of the limited availability of medical expertise at the time. Later in 1990s, at the beginning of 2000s aviation simulation training concepts, begun to be gradually introduced into anaesthesia and other areas of medicine like critical care, obstetrics, emergency medicine, internal medicine and paediatrics.

History

Simulation use has been described in medical education for a long time; since ancient times. About 800 B.C. Sushruta Samhita, an Indian surgeon recommended his students to train in the following areas incision, ligation and suturing using pieces of leather, tissue or lotus leaves. In China around the year 1027, the emperor's physician has manufactured adult-sized statuses for teaching anatomy and train young doctors in the art of acupuncture. In an 18th century scientific culture, which was predominantly patriarchal, the French royal midwife Angelique Marguerite Le Boursier du Coudray excelled in this field. In 1778, she used a life-sized women's pelvis covered with fabric and leather and a doll of the size of a newborn to teach the art of childbirth. Using "La Machine", one of the first obstetric phantoms, she taught thousands of midwives and even physicians. In the 19th and early 20th centuries, obstetric simulators were widely used in medical schools to teach patient assessment skills and to allow students to learn and practice management of a wide range of conditions. The very well known "the Budin-Pinard phantom", was specifically identified and recommended by J. Whitridge Williams of Johns Hopkins University. The era of modern medical simulation has been inaugurated by the work of Peter Safar. This resuscitator of the Baltimore City Hospital has been deeply marked by the death of his daughter at the age of 11 years from an asthma attack, will dedicate his life to the development and improvement of resuscitation techniques and cardio-respiratory maneuvers. In the early 1960s, this doctor teamed up with a Norwegian toy manufacturer, Asmund Laerdal, to develop the first cardiopulmonary resuscitation dummy. This is the world-famous dummy Resusci-Anne®. In 1967, Abrahamson and Denson presented the first computer-guided dummy, the "Sim One" intended for anesthesiologists in training. These two researchers from the University of Southern California have marked a decisive turning point in the history of simulators by inventing the current ancestor of high-fidelity mannequin. At the same time, Michael Gordon also put the name (on behalf of his mentor, Dr. Harvey), a dummy dedicated to cardiology which allows to simulate several cardiac pathologies, in particular valvulopathies. In parallel with the development of simulators, an American neurologist, Dr. Howard Barrows, will be introducing the concept of the standardized patient (an actor simulating a patient). The first "patient" will simulate a case of sclerosis in plates and this technique will be quickly adopted by North American medical schools.

A milestone in the history of simulation was the publication, in 1999 in the United States of a medical report by the Institute of Medicine entitled "to Err is Human" (*"Errare est humanum"*) which was originally an awareness in the world of health of the weight of the human factor in medical errors. This document reported that annually in the United States, that between 44,000 and 98,000 patients die because of an error that could have been avoided.[5] It is recommended to position medical simulation as one of the most important essential educational tools to reduce the frequency and the consequences of these errors by integrating it into the medical training.

Historically, medical education relied heavily on the apprenticeship model, where students learned through direct patient care under the supervision of experienced clinicians. This model has inherent limitations, including the variability of clinical experiences and the potential risk to patient safety.[6] Medical education has undergone different transformations from its inception and is being influenced by many factors, the most important being

patient safety. It has widened its horizons to inculcate simulation-based training of both technical and non-technical skills that have direct impact on patient outcome. With the advent of simulation education, there is a new wave in education: first achieving competency using simulation training, and assuming patient care duties only after competency is assured.[7] Simulation as a training tool also has been validated and incorporated into healthcare professionals training to train and to objectively assess the competency-based skills and translate them into real clinical areas.

Simulation-based healthcare education

Healthcare Simulation is based on the *adult learning theory*. Adults consider past experiences to decide whether something is worth learning. To teach adults effectively, instructors must be able to feed into what learners already know. Important to consider, is that if adults do not find a relevance, they will lose interest. Simulation-based learning is explained as experiential learning, usually dealing with adult learners in healthcare professions.[8]

Bioscience, sociocultural, and learning theories have been used to design frameworks that are core to healthcare simulation education strategies.[9] Kolb's learning cycle is the most prominent among these theories and has been commonly used as a conceptual framework for simulation programs involving team training.[10] Kolb emphasizes that transformation of experience is essential in creation of knowledge. His theory consists of four parts: concrete experience, reflective observation, abstract conceptualization, and active experimentation. Participants undergo concrete experience as they complete the simulation scenario. This is followed by debriefing where they reflect upon the experience and draw generalizations and conclusions from their observations to form abstract concepts. These concepts are then actively used to influence actions in repeat simulations.[11] Active experimentation is an important but neglected step in the simulator learning process in most programs. This is partly due to time and resource constraints.[12]

Additionally, within any of the domains of competence, we can assess learners at 4 different levels, according to the pyramid model conceptualized by Miller.[13] These levels are: a) *knows* (knowledge)—recall of basic facts, principles, and theories; b) *knows how* (applied knowledge)—ability to solve problems, make decisions, and describe procedures; c) *shows how* (performance)—demonstration of skills in a controlled setting; and d) *does* (action)—behavior in real practice. Simulation can help a learner ascend from novice to expert in Miller's pyramid.

In healthcare, the principle of simulation-based training applies to the acquisition of any procedural, clinical, or attitude-related skills in environments that range from low-fidelity to high-fidelity. It enables healthcare professionals to acquire knowledge and skills in an educationally oriented, safe, low-stress environment. With simulation-based learning, trainees can acquire and retain clinical skills with repetitive practice.[14] One of the most significant advantages is the opportunity for deliberate practice, where learners can repeatedly perform tasks and refine their skills. This repetition is crucial for developing proficiency and ensuring that skills are retained over time.[15] Studies have reported that simulation-based medical education with deliberate practice can be, at times, more effective than traditional clinical medical education in achieving some of the clinical education skills.[16, 17] Skills acquired through simulation-based activities can be cross-pollinated into clinical practice, resulting in improved patient outcomes. Evidence suggests improved performances in clinical settings after the use of simulation.[18, 19]

The benefits of this training extend beyond skill acquisition. Additionally, simulation provides a safe environment for learners to make and learn from mistakes, essential for effective learning. Immediate feedback and structured debriefing are key components of simulation based training. After each simulation session, learners participate in debriefing sessions, receiving feedback on their performance, reflecting on their actions, and discussing ways to improve.[20] Debriefing can help to understand how learners make medical decisions by evaluating medical knowledge and interpersonal and communication skills by asking open-ended questions.[1]

There have been various forms of simulators with an increase in the availability and diversity over the years; standardized/simulated patients, part-task trainers, manikins, computer-based simulations, high fidelity models, virtual reality, and augmented reality simulators. Today, these simulation modalities and simulator types can be used either alone or combined during hybrid simulation to target different learning objectives.[21]

Standardized patients, individuals trained to portray real patients consistently and accurately, are a valuable component of healthcare simulation. They allow learners to practice history taking, physical examination, and communication skills in a realistic, patient-centered context. Standardized patients have been shown to improve learners' diagnostic accuracy, communication skills, and overall clinical competence.[20] Furthermore, this allows for assessing learners in a controlled, standardized manner, providing valuable feedback, and identifying areas for improvement.

Part-task trainers comprise a representation of only a component of the human body. These are frequented by subspecialties that recognize the benefit of deliberate practice to obtain mastery in technical, procedural, or psychomotor skills.[22] Advanced part-task trainers with haptic feedback (ie, creating an experience of touch by applying force, vibration or movement in response to user operation) are being increasingly accepted in interventional and surgical training specialties such as general surgery, urology, gynecology, orthopedics and etc.[22]

High fidelity simulators are sophisticated, lifelike mannequins capable of mimicking various physiological responses and medical conditions. These simulators allow learners to practice procedures such as intubation, chest tube insertion, and advanced cardiac life support in a realistic setting. Studies have shown that high fidelity simulation improves skill acquisition and retention

compared to traditional training methods.[23, 24] Moreover, it enhances learners' confidence and reduces anxiety, critical for effective performance in high-stakes clinical environments.[20]

Virtual reality and augmented reality technologies are also gaining traction in medical education. These tools create immersive, interactive environments where learners can practice surgical techniques, navigate complex anatomical structures, and manage critical care scenarios without the constraints of physical simulators.[25, 26]

Hybrid simulations combine various simulation modalities to create comprehensive, realistic training scenarios.

Technical skills are defined as the "adequacy of the actions taken from a medical and technical perspective," while non-technical skills are defined as the "decision-making and team interaction processes used during the team's management of a situation".[27] Healthcare simulation can be used effectively for individuals or teams to learn, practice, or assess technical and non-technical skills in a safe and controlled environment.[28, 29] Simulation-based team training methodology utilizes simulated scenarios that closely mirror real-life clinical situations, providing healthcare professionals with a controlled environment to practice and enhance their teamwork and communication skills.[30, 31] It allows healthcare professionals to practice critical skills, such as effective communication, shared decision-making, and situational awareness, which are essential for delivering safe and coordinated care.

Integrating simulation with other training modalities, such as interdisciplinary, interprofessional training programs, can create a more holistic and comprehensive educational experience.[32] Interprofessional collaboration in simulation-based training is essential for preparing healthcare professionals to work effectively in multidisciplinary teams, improving patient outcomes and safety. This collaborative approach involves professionals from various healthcare disciplines, such as physicians, nurses, pharmacists, and allied health professionals, working to address patient care needs in simulated environments. Interprofessional simulation trainings focuses on developing communication, teamwork, and leadership skills among participants, ultimately enhancing the quality and coordination of patient care. One of the key benefits of interprofessional simulation training is improved communication among healthcare team members. Effective communication ensures seamless care coordination, prevents medical errors, and promotes patient safety.[20, 33]

Simulation in healthcare offers a dynamic and interactive approach to continuing education, allowing practitioners to refine existing skills, learn new techniques, and stay abreast of advances in medical practice. One of the primary benefits of continuing education through simulation is the opportunity for hands-on practice in a safe and controlled environment. Healthcare professionals can engage in simulated scenarios that mirror real-world clinical situations, allowing them to apply their knowledge and skills in a risk-free setting. This hands-on experience enables practitioners to gain confidence, improve clinical competency, and enhance patient care outcomes.[20, 34]

Along with these, it should be known that simulation-based learning is not a substitute for learning with real patients in real clinical contexts, but it is an accepted technique for educating and training health-care professionals in both technical and non-technical skills prior to working with real patients.[35]

Simulation also can be a powerful tool in assessment. While it 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.[36]

Challenges

The implementation of simulation in healthcare is challenging. It requires substantial financial investment, specialized equipment, and trained faculty. One of the primary barriers is the high cost associated with establishment of a simulation facility, purchasing and maintaining simulation equipment and the need for specialized facilities and trained personnel. Another major challenge revolves around developing an educational curriculum incorporating a simulation based educational model, understanding the value of this new technology, the overall cost factor, and the lack of adequate infrastructure.[1] Furthermore, there is technical difficulty in imitating real case scenarios. The realism of simulations still cannot fully replicate the complexities and unpredictability of real-life clinical situations and simulators and task trainers cannot replace real-life experience.[20] Additionally, there are concerns about the transferability of skills to real-world clinical settings.

Conclusion

A worldwide paradigm shift has emphasised the 'experiential approach' in medical education incorporating cognitive, psychomotor, and affective learning.

Simulation based education ensures the effective use of adult learning principles and enables healthcare professionals to acquire knowledge and skills in a safe and educationally oriented environment and can be a valuable tool for improving clinical practice and patient outcomes. Simulation technology holds great promise to improve healthcare professionals' training and, thereby, to impact patient safety and healthcare outcomes in a positive and significant way.

Healthcare simulation is a robust educational instrument and will continue to play an integral role in the modern world of medical education.

Conflicts of Interest Statement: None

Funding Statement: None

Acknowledgements: None

References

1. Lioce L. (Ed.), Lopreiato J. (Founding Ed.), Downing D., Chang T.P., et al. Healthcare Simulation Dictionary – Second Edition. Rockville, MD: Agency for Healthcare Research and Quality; September 2020. AHRQ Publication No. 20-0019.
2. Lateef F. Simulation-based learning: Just like the real thing. J Emerg Trauma Shock. 2010 Oct; 3(4): 348-52. Doi:10.4103/0974-2700.70743
3. Aggarwal R, Darzi A. Technical-skills training in the 21st century. N Engl J Med. 2006 Dec 21; 355(25): 2695-6. Doi:10.1056/NEJMe068179
4. Ayaz O, Ismail FW. Healthcare Simulation: A Key to the Future of Medical Education - A Review. Adv Med Educ Pract. 2022 Apr 5; 13: 301-8. Doi:10.2147/AMEP.S353777
5. To Err is Human: Building a Safer Health System. In: Kohn LT, Corrigan JM, Donaldson MS, eds. Washington, DC: National Academies Press; 2000.
6. Bradley P. The history of simulation in medical education and possible future directions. Med Educ. 2006 Mar; 40(3): 254-62. Doi:10.1111/j.1365-2929.2006.02394.x
7. Khan MR, Begum S. Apprenticeship to simulation - The metamorphosis of surgical training. J Pak Med Assoc. 2021 Jan ;71(Suppl 1)(1) :S72-S76.
8. Piryani RM, Piryani S, Shrestha U, Acharya A, et al. Simulation-based education workshop: perceptions of participants. Adv Med Educ Pract. 2019; 10: 547-54. Doi:10.2147/AMEP.S204816
9. Hodges BD, Kuper A. Theory and practice in the design and conduct of graduate medical education. Acad Med. 2012 Jan ;87(1): 25-33. Doi:10.1097/ACM.0b013e318238e069
10. Yardley S, Teunissen PW, Dornan T. Experiential learning: AMEE guide no. 63. *Med Teach.* 2012; 34(2): e102–15.
11. Kolb DA. *Experiential Learning: Experience as the Source of Learning and Development*. 2nd ed. Upper Saddle River (NJ): Pearson Education; 2015.
12. Stocker M, Burmester M, Allen M. Optimisation of simulated team training through the application of learning theories: a debate for a conceptual framework. BMC Med Educ. 2014 Apr 3; 14: 69. Doi:10.1186/1472-6920-14-69
13. Miller GE. The assessment of clinical skills/competence/performance. Acad Med. 1990 Sep; 65(9 Suppl): S63-7.
14. Leiphrakpam PD, Armijo PR, Are C. Incorporation of Simulation in Graduate Medical Education: Historical Perspectives, Current Status, and Future Directions. J Med Educ Curric Dev. 2024 May 26; 11. Doi:10.1177/23821205241257329
15. Hood RJ, Maltby S, Keynes A, Kluge MG, et al. Development and Pilot Implementation of TACTICS VR: A Virtual Reality-Based Stroke Management Workflow Training Application and Training Framework. Front Neurol. 2021 Nov 11; 12: 665808. Doi:10.3389/fneur.2021.665808
16. Miyoshi T, Ino H, Kataoka H, Otsuka F. Effects on postgraduate-year-I residents of simulation-based learning compared to traditional lecture-style education led by postgraduate-year-II residents: a pilot study. BMC Med Educ. 2019 Mar 20; 19(1): 87. Doi:10.1186/s12909-019-1509-y
17. Higgins M, Madan C, Patel R. Development and decay of procedural skills in surgery: A systematic review of the effectiveness of simulation-based medical education interventions. Surgeon. 2021 Aug; 19(4): e67-e77. Doi:10.1016/j.surge.2020.07.013
18. Ali KQ, Soofi SB, Hussain AS, Ansari U, et al. Simulator-based ultrasound training for identification of endotracheal tube placement in a neonatal intensive care unit using point of care ultrasound. BMC Med Educ. 2020 Nov 7; 20(1): 409. Doi:10.1186/s12909-020-02338-4
19. Ali AA, Chang WW, Tabatabai A, Pergakis MB, et al. Simulation-based assessment of trainee's performance in post-cardiac arrest resuscitation. Resusc Plus. 2022 Apr 28; 10: 100233. Doi:10.1016/j.resplu.2022.100233
20. Elendu C, Amaechi DC, Okatta AU, Amaechi EC, et al. The impact of simulation-based training in medical education: A review. Medicine (Baltimore). 2024; 103(27): e38813. Doi:10.1097/MD.0000000000038813
21. Savoldelli GL, Burlacu CL, Lazarovici M, Matos FM, Østergaard D; Utstein Simulation Study Group. Integration of simulation-based education in anaesthesiology specialist training: Synthesis of results from an Utstein Meeting. Eur J Anaesthesiol. 2024 Jan 1; 41(1): 43-54. Doi:10.1097/EJA.0000000000001913
22. Schaff, J., Russell, C. (2020). Mannequin-Based Simulators and Part-Task Trainers. In: Mahoney, B., Minehart, R., Pian-Smith, M. (eds) Comprehensive Healthcare Simulation: Anesthesiology . Comprehensive Healthcare Simulation. Springer, Cham. https://doi.org/10.1007/978-3-030-26849-7_11.
23. Scalese RJ, Obeso VT, Issenberg SB. Simulation technology for skills training and competency assessment in medical education. J Gen Intern Med. 2008 Jan; 23 Suppl 1(Suppl 1): 46-9. Doi:10.1007/s11606-007-0283-4
24. Tonapa SI, Mulyadi M, Ho KHM, Efendi F. Effectiveness of using high-fidelity simulation on learning outcomes in undergraduate nursing education: systematic review and meta-analysis. Eur Rev Med Pharmacol Sci. 2023 Jan; 27(2): 444-58. Doi:10.26355/eurrev_202301_31040
25. Cipresso P, Giglioli IAC, Raya MA, Riva G. The Past, Present, and Future of Virtual and Augmented Reality Research: A Network and Cluster Analysis of the Literature. Front Psychol. 2018 Nov 6; 9: 2086. Doi:10.3389/fpsyg.2018.02086
26. Zackoff MW, Young D, Sahay RD, Fei L, et al. Establishing Objective Measures of Clinical Competence in Undergraduate Medical Education Through Immersive Virtual Reality. Acad Pediatr. 2021 Apr; 21(3): 575-9. Doi:10.1016/j.acap.2020.10.010
27. Weile J, Nebsbjerg MA, Ovesen SH, Paltved C, Ingeman ML. Simulation-based team training in time-critical clinical presentations in emergency medicine and critical care: a review of the literature. Adv Simul (Lond). 2021 Jan 20; 6(1): 3. Doi:10.1186/s41077-021-00154-4

28. Higham H, Baxendale B. To err is human: use of simulation to enhance training and patient safety in anaesthesia. Br J Anaesth. 2017 Dec 1; 119(suppl_1): i106-i114. Doi:10.1093/bja/aex302
29. Savoldelli GL, Brindley PG, Jaffrelot M, Cardinal P. Chapter 25 – Crisis resource management and nontechnical skills: from individuals to teams, from danger to safety. In: Chiniara G, editor. Clinical simulation. 2nd ed: Academic Press; 2019. p. 347–72.
30. Motola I, Devine LA, Chung HS, Sullivan JE, Issenberg SB. Simulation in healthcare education: a best evidence practical guide. AMEE Guide No. 82. Med Teach. 2013 Oct; 35(10): e1511-30. Doi:10.3109/0142159X.2013.818632
31. Schram A, Bonne NL, Henriksen TB, Paltved C, et al. Simulation-based team training for healthcare professionals in pediatric departments: study protocol for a nonrandomized controlled trial. BMC Med Educ. 2024 Jun 1; 24(1): 607. Doi:10.1186/s12909-024-05602-z
32. Cook DA, Hatala R, Brydges R, Zendejas B, et al. Technology-enhanced simulation for health professions education: a systematic review and meta-analysis. JAMA. 2011 Sep 7; 306(9): 978-88. Doi:10.1001/jama.2011.1234
33. Velásquez ST, Ferguson D, Lemke KC, Bland L, et al. Interprofessional communication in medical simulation: findings from a scoping review and implications for academic medicine. BMC Med Educ. 2022 Mar 26; 22(1): 204. Doi:10.1186/s12909-022-03226-9.
34. Nagarajappa A, Kaur S. Simulation in contemporary medical education: Current practices and the way forward. Indian J Anaesth. 2024 Jan;68(1):17-23. Epub 2024 Jan 18. Doi:10.4103/ija.ija_1203_23
35. Lawson S, Reid J, Morrow M, Gardiner K. Simulation-based Education and Human Factors Training in Postgraduate Medical Education: A Northern Ireland Perspective. Ulster Med J. 2018 Oct; 87(3): 163-167.
36. Scalese RJ, Obeso VT, Issenberg SB. Simulation technology for skills training and competency assessment in medical education. J Gen Intern Med. 2008 Jan; 23 Suppl 1(Suppl 1): 46-9. Doi:10.1007/s11606-007-0283-4

