SAMSUN MEDICAL JOURNAL
Samsun Tıp Dergisi

Review Article

A SIMULATION STORY

BİR SİMÜLASYON HİKAYESİ

Fethi Sada ZEKEY[1*] **Kübra UYAR ZEKEY**[1]

***Corresponding Author**
f.sada.zekey@bozok.edu.tr
[1]Yozgat Bozok Üniversitesi Aile Hekimliği Anabilim Dalı Yozgat, Türkiye

How to cite: Zekey FS, Uyar Zekey K. A Simulation Story. SMJ 2025; 3(1): 17-26.

Received : 03.10.2024
Accepted : 18.11.2024
Published: 01.05.2025

ABSTRACT

Simulation can be defined as a learning method or technique that recreates experiences without exposing learners to real-life events, under the guidance of instructors. Medical simulation applications play a crucial role in medical education by offering the opportunity to test essential elements without posing risks. These applications create learning opportunities not available in real-life settings, providing a multifaceted, structured, feedback-rich, and safe environment. It prepares students for real patient encounters and supports individualized, patient-centered approaches that nurture the artistic side of medicine. By integrating technology with teaching, it helps train higher-quality physicians. Simulation also offers dynamic, rare, and high-risk scenarios, enhancing understanding of ethics, patient rights, and safety. It supports both vertical and horizontal integration in medical curricula, strengthening connections between disciplines and promoting holistic learning. Simulation-based education is crucial for bridging preclinical and clinical training, exposing learners to rare cases, and addressing key issues like medical errors and accountability. Over time, the integration of medical simulation centers is expected to become a fundamental component of core educational programs.

Keywords: Simulation-based education, Medical education, Patient simulation, Family practice, Clinical skills

ÖZET

Simülasyon, eğitmenlerin rehberliğinde, öğrencileri gerçek yaşam olaylarına maruz bırakmadan deneyimleri yeniden yaratan bir öğrenme yöntemi veya tekniği olarak tanımlanabilir. Tıbbi simülasyon uygulamaları, risk oluşturmadan temel unsurları test etme fırsatı sunarak tıp eğitiminde önemli bir rol oynar. Bu uygulamalar, gerçek yaşam ortamlarında bulunmayan öğrenme fırsatları yaratarak çok yönlü, yapılandırılmış, geri bildirim açısından zengin ve güvenli bir ortam sağlar. Öğrencileri gerçek hasta karşılaşmalarına hazırlar ve tıbbın sanatsal tarafını besleyen bireyselleştirilmiş, hasta merkezli yaklaşımları destekler. Teknolojiyi öğretimle bütünleştirerek daha kaliteli hekimlerin yetiştirilmesine yardımcı olur. Simülasyon ayrıca dinamik, nadir ve yüksek riskli senaryolar sunarak etik, hasta hakları ve güvenlik anlayışını geliştirir. Tıp müfredatında hem dikey hem de yatay entegrasyonu destekler, disiplinler arasındaki bağlantıları güçlendirir ve bütünsel öğrenmeyi teşvik eder. Simülasyon tabanlı eğitim, klinik öncesi ve klinik eğitim arasında köprü kurmak, öğrencileri nadir vakalarla tanıştırmak ve tıbbi hatalar ve hesap verebilirlik gibi temel sorunları ele almak için çok önemlidir. Zamanla, tıbbi simülasyon merkezlerinin entegrasyonunun temel eğitim programlarının ana bileşeni hâline gelmesi bekleniyor.

Anahtar kelimeler: Simülasyona dayalı öğrenme, Tıp eğitimi, Hasta simülasyonu, Aile hekimliği, Klinik beceriler

Introduction

Medical education can be defined as a process in which medical students develop knowledge, skills, and attitudes primarily through direct interaction with real patients (1). Over time, medical education has evolved from the traditional apprenticeship model to one that incorporates practical teaching techniques informed by advancements in educational science. This evolution is now increasingly aligned with competency-based educational models, with a strong emphasis on ensuring the safety of real patients.

Historically, one of the fundamental ethical principles in medicine has been “do no harm.” Despite technological advancements, reports from various organisations have indicated that the annual number of deaths in the United States due to medical errors ranges from 37,000 to 98,000 (2). Public welfare organisations such as the World Health Organization (WHO) and the Organisation for Economic Co-operation and Development (OECD) have identified persistent gaps in healthcare quality and safety on a global scale (3).

Before encountering real patients, medical students must attain a certain level of preparedness. The ability to approach patients with a biopsychosocial perspective and provide personalised solutions is a core aspect of medical practice. This development can be supported through various teaching methods, including the integration of technology, which contributes to the training of highly qualified physicians. One such method is medical simulation.

Simulation can be defined as a method or technique that enables learners to experience scenarios under the guidance of instructors without direct exposure to real-life events (4). While offering opportunities to explore situations not commonly encountered in reality, simulation also provides a multifaceted, instructor-led, and feedback-rich learning environment (5). Simulation applications are widely used across various fields, including aviation, the military, and the health sciences (6).

The healthcare sector has a long-standing history dating back to the earliest civilizations. Certain errors in healthcare can result in fatal outcomes. Evidence indicates that simulation-based learning can help prevent many avoidable medical errors. Notably, simulation-based training has been a standardised component of aviation education for over 150 years—a model that should likewise be adopted as a fundamental standard in medical education (7,8).

Integrating simulation-based learning strategies into medical school curricula is expected to have a positive impact on education. Vertical integration refers to the interaction and exchange of experiences among individuals at different educational levels (e.g., medical students, resident doctors, fellows). Horizontal integration, by contrast, aims to foster collaboration among students at the same level, encouraging the exchange of knowledge and skills across different disciplines. Simulation-based learning supports both vertical and horizontal integration. Vertical integration facilitates mentorship and the transfer of experience between learners at different stages, while horizontal integration promotes collaboration and communication across specialties. This approach enables students to develop not only clinical skills but also an interdisciplinary mindset (9).

The historical roots of simulation in medical education can be traced back to early references. In Aphorisms from Ars longa, vita brevis, Hippocrates emphasised the necessity for physicians to engage in simulated practice before clinical application. Similarly, Aristotle’s Nicomachean Ethics highlights the importance of simulation in skill development (8). From its use in war games (referred to as weich) to the "phantom" birth simulators used in obstetrics, medical simulation has a longstanding history (10,11). Over the past 140 to 200 years, rapid technological advancements have significantly expanded the use of simulation across all disciplines (5).

Evolution of Simulation in Medical Education

1. Mannequins and Baby Models: In the late 19th century, the first medical simulation tools were anatomical models. These models were used to teach students the basic structures of the human body.
2. Simulated Conditions: Some hospitals and educational institutions began using standardised patients to simulate medical conditions. Standardised patient models remain in use today (12).
3. Simulation Laboratories: By the late 1940s, mannequins equipped with mechanical systems were used to teach emergency procedures such as CPR, artificial respiration, and tracheotomy (13).
4. Computer-Assisted Simulations: By the late 1980s, software-based simulation platforms capable of creating realistic patient scenarios and interventions began to emerge.
5. Virtual Reality (VR) and Augmented Reality (AR): In the 1990s, VR and AR technologies were introduced into medical simulations, offering medical students, surgeons, and healthcare professionals the opportunity to practise real-life scenarios in a virtual environment (14).
6. High-Fidelity Simulations: By the early 2000s, simulation systems had evolved to replicate human physiology, biological responses, and various medical conditions. Parameters such as respiration, heart rate, and blood pressure could now be measured during simulations.
7. Simulated Surgical Procedures: Surgical simulations—particularly those for minimally invasive procedures such as laparoscopy—were developed to allow surgeons to practise in a safe environment.

These simulations have significantly contributed to improving the precision of surgical techniques and reducing harm to patients (15).
8. Artificial Intelligence and Machine Learning: By the 2020s, AI and machine learning were integrated into medical simulations, enabling real-time performance analysis and error detection. For example, AI algorithms can evaluate the accuracy of a surgeon's hand movements during heart surgery.
9. Personalized Learning in Simulation: Today, interactive educational programmes featuring virtual patients can be tailored to each individual's learning pace and style.
10. Remote Education and Telemedicine: In the post-pandemic era, the remote accessibility of medical simulations has gained prominence. The ability to use simulators in virtual environments and receive training via the internet has provided significant advantages—particularly for healthcare professionals in remote areas (16,17).

Related Topics

The Role of Simulation in Medical Education

The CanMEDS Physician Competency Framework was developed to align physician competencies with societal needs. Simulation-based learning is regarded as an effective tool for achieving these competencies, influencing knowledge, skills, and attitudes (18). Figure 1 illustrates a simulation centre control room.

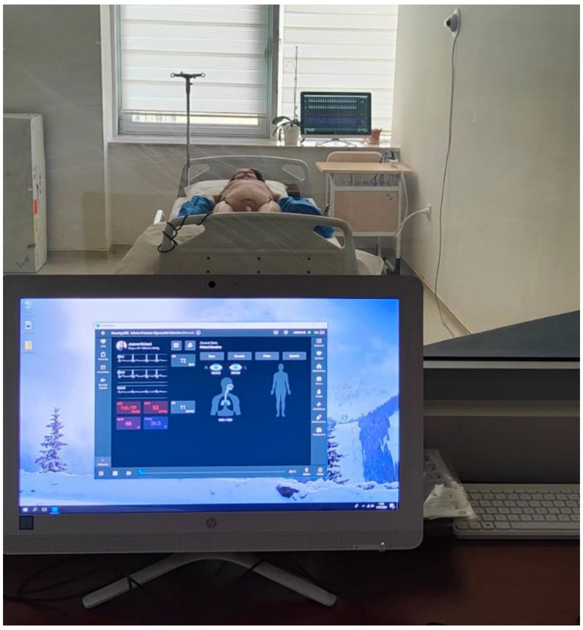

Figure 1: Simulation Center Control Room

Medical Simulation Applications and Their Impact on Education

Medical simulation applications contribute to education by impacting three fundamental domains: cognitive, affective, and psychomotor.

1. Effects of Simulation-Based Learning on the Cognitive Domain

Simulation-based education supports medical students in making clinical decisions based on knowledge.
Active Learning: Simulations enable students not only to memorise information but also to apply it practically. This process allows them to move beyond theoretical understanding and learn how to use acquired knowledge in real-life situations.
Critical Thinking and Decision Making: Simulations enhance the decision-making process. By engaging with various disease scenarios and case studies, students deepen their clinical knowledge and develop critical thinking skills (19).

2. Effects of Simulation-Based Learning on the Affective Domain

Simulation is particularly valuable in helping medical students develop professional attitudes, including patient-centred care and empathy.
Professionalism: Through simulation, students can cultivate attitudes such as respecting patient rights, maintaining confidentiality, and making appropriate medical decisions.
Self-Confidence: Practising in simulated environments helps students feel more prepared to engage with real patients. This increased confidence reinforces their professional attitudes and contributes to a more effective learning experience (20,21).

3. Effects of Simulation-Based Learning on the Psychomotor Domain

The impact of simulation on the development of psychomotor skills is one of its most significant advantages. Medical students can safely learn and practise various clinical procedures and techniques within simulation environments.
Physical Skills: Practical skills—such as surgical techniques, administering injections, and patient monitoring—can be taught in simulated settings, allowing students to develop these competencies in a safe and controlled environment.
Time Management: In emergency scenario simulations, students are trained to find optimal solutions within a specified time frame.
Opportunity for Technical Error: Simulations provide a safe environment in which students can make mistakes and learn from them. This aspect supports experiential learning and is essential for skill development (21,22).
Communication Skills: Simulations also offer opportunities to enhance communication skills with patients' families and members of the healthcare team (23).

Empirical Evidence of the Effectiveness of Simulation-Based Learning

A 2021 study conducted in South Korea evaluated the effects of high-fidelity simulation training on medical students' anxiety and self-confidence. Students participated in two simulation exercises, and their anxiety and confidence levels were measured before and after each session. The results showed that, following the simulations, students exhibited significantly lower anxiety levels and higher confidence compared to their pre-exercise levels. Moreover, students with prior simulation experience reported lower anxiety and greater confidence before the second session than those without such experience (24).

A 2006 study conducted in the United States examined the impact of simulation-based learning in laparoscopic surgery. Residents who received training using laparoscopic simulators demonstrated superior performance in procedural tasks in the operating room compared to those who had not undergone simulator-based training (25).

Similarly, a 2010 study conducted in India found that residents trained with simulators were more likely to adhere to advanced cardiac life support (ACLS) protocols during cardiac arrest cases than those who received standard training (26).

Medical Simulation and Ethics

Medical simulations also offer healthcare professionals the opportunity to develop awareness of their ethical and professional responsibilities (27).

1. Patient Safety and Risk Reduction: Simulation enables healthcare professionals to make and correct mistakes without jeopardising patient safety. This aligns with the ethical principle of minimising harm to patients (27,28).
2. Medical Errors and Accountability: Simulations encourage healthcare professionals to learn from their mistakes. While errors made with real patients can lead to irreversible consequences, mistakes in simulations are typically immediate, visible, and correctable. This fosters a sense of responsibility, promotes learning, and strengthens ethical accountability (27,29).
3. Confidentiality and Privacy: Simulations help reinforce the importance of ethical principles such as confidentiality and privacy. Students learn to handle patient information responsibly and develop an awareness of potential ethical issues related to the improper sharing of medical data or information (27, 28).
4. Medical Ethical Thinking and Decision Making: Simulation exercises present ethical dilemmas and challenges that help healthcare professionals make well-informed decisions. Students are encouraged to assess whether their choices align with ethical principles such as patient rights, equity, justice, and the common good. For example, when determining treatment options, it is essential to consider the patient's values and preferences. Simulations foster critical thinking around these ethical considerations (27,29).
5. Multidisciplinary Ethical Approaches: Collaborative decision-making, teamwork, and shared planning in patient care are essential components of ethical healthcare practice. Medical simulations promote these interdisciplinary values, enhancing the ability of healthcare professionals from different specialties to make ethical decisions collectively (30).

Classification of Medical Simulation Applications

Medical simulation applications can be classified based on their features and levels of realism. These classifications help determine which simulation tools and methods are most appropriate for specific educational objectives, ensuring that simulations are both effective and aligned with learners' needs. Table 1 presents a classification of medical simulation applications.

Table 1: Classification of Medical Simulation Applications

Classification of Medical Simulation Applications
1. Medical Simulation Applications by Features
1.1 Part-Task Trainers
1.1.1 Static Trainers Made of Plastic
1.1.2 Dynamic Trainers Made of Plastic
1.1.3 Low-Fidelity Tactile Feedback Virtual Reality Trainers
1.1.4 High-Fidelity Tactile Feedback Virtual Reality Trainers
1.2 Computer-Assisted Systems
1.2.1 Simulated Patients
1.2.2 Simulated Environments
1.3 Integrated Simulators
1.3.1 Instructor-Controlled Simulators
1.3.2 Model-Based Simulators
2. Medical Simulation Applications by Realism
2.1 Low-Fidelity Simulations
2.2 Medium-Fidelity Simulations
2.3 High-Fidelity Simulations

Based on their features, segment training devices can be grouped into four categories: static trainers made of plastic, dynamic trainers made of plastic, low-realism haptic feedback virtual reality trainers, and highrealism haptic feedback virtual reality trainers (4).

Part-task trainers can be categorised into four types: static trainers made of plastic, dynamic trainers made of plastic, low-fidelity tactile feedback virtual reality trainers, and high-fidelity tactile feedback virtual reality trainers (31–36).

Static trainers made of plastic are simulators that do not move or provide realistic feedback. Due to their simplicity and low cost, they are frequently used for basic skills training (31–36).

Dynamic trainers made of plastic are similar to static trainers but include some movement or interaction, offering a slightly more realistic simulation experience. They may exhibit basic physiological responses (31–36). Figure 2 shows a cardiopulmonary resuscitation manikin.

Figure 2: Cardiopulmonary Resuscitation Manikin

Low-fidelity tactile feedback virtual reality trainers simulate medical scenarios using virtual reality technology with basic tactile feedback. While they provide immersive environments, the realism of physical interaction is limited (31–36).

High-fidelity tactile feedback virtual reality trainers offer highly realistic tactile feedback that closely mimics interactions with real patients. They deliver seamless and authentic simulations for complex clinical situations (31).

Computer-assisted systems involve simulations operated through software that includes simulated patients and environments. These systems are used for interactive learning modules, simulations of medical procedures, and virtual patient consultations (32).

Simulated patients are either actors or mannequins that replicate specific medical conditions, behaviours, or symptoms. They are used for training in communication skills, diagnosis, and patient management (31–36).

Simulated environments enhance realism by replicating real-world medical settings, such as hospital wards, emergency departments, or outpatient clinics (31–36).

Integrated simulators combine multiple technologies or features—such as virtual reality, tactile feedback, and simulated patients—to provide comprehensive training experiences. They can be categorised as instructor-controlled simulators and model-based simulators (31–36).

Instructor-controlled simulators are simulations in which instructors manage scenarios in real time, adapting the training session based on participants' actions and decisions (31–36).

Model-based simulators operate based on predefined models or algorithms, delivering standardised scenarios that simulate physiological responses or disease progression for training purposes (31–36).

Based on levels of realism, simulations can also be classified as low, medium, and high-fidelity simulations (4).

Low-fidelity simulations typically involve the use of simple models or mannequins. For example, low-cost mannequins used in cardiopulmonary resuscitation training, injections, or suturing fall into this category. These simulations are used to teach or practise basic skills and procedures; however, the level of realism is limited (36).

Medium-fidelity simulations mimic real patient care scenarios using more advanced mannequins or technologically equipped simulation tools. Mannequins that more closely resemble human anatomy or those paired with basic patient monitors are examples of this category. Medium-fidelity simulations support the development of skills required to manage complex medical conditions or emergencies by offering a more realistic experience (36).

High-fidelity simulations utilise advanced tools such as high-tech mannequins, virtual reality, simulation software, and real patient monitors. These simulations closely replicate real patient care conditions, offering participants an experience that closely mirrors real-world clinical practice. High-fidelity simulations provide an effective means of developing clinical decision-making, teamwork, and emergency response skills (36).

Figure 3 shows a high-fidelity paediatric simulator,

Figure 3: High-Fidelity Pediatric Simulator

Figure 4 shows a high-fidelity adult simulator, and

Figure 4: High-Fidelity Adult Simulator

Figure 5 illustrates a virtual reality application.

Figure 5: Virtual Reality Application

Studies investigating the conditions necessary for the effective use of simulation applications suggest that repeatable, integrative, and accessible simulation exercises can positively influence learning outcomes. The effectiveness of simulation-based learning depends on the methods and approaches employed, which should be tailored to the target audience, available resources (e.g., financial capacity, human resources, and the educational environment), and specific learning objectives.

Simulation-based education generally consists of three key phases: preparation, execution, and debriefing.

The preparation phase involves creating a highly realistic environment, developing the scenario, defining learning objectives, sharing relevant materials with students, conducting a pre-briefing session, and establishing criteria for assessment and evaluation.

During the execution phase, simulation exercises should be carried out in alignment with the defined objectives and methods. The use of video recordings during this phase can enhance the subsequent debriefing process by helping to identify both effective and ineffective aspects of performance (37).

The debriefing phase brings students and instructors together to review the training session and its outcomes. This phase should encourage discussion and reflection on students' emotions, observations, strengths, weaknesses, and areas for improvement. To maximise the educational impact of simulation experiences, debriefing sessions should be well-structured, comprehensive, and instructor-guided (38). For simulation-based training sessions to achieve their intended outcomes, a supportive learning environment must be established. Learning objectives should be clearly defined, scenarios must be appropriate for students' levels of preparedness, opportunities for repetition should be provided, educator–learner interaction should be encouraged, and the entire process should be open to evaluation by all stakeholders (39).

How to Establish a Simulation Center?

When establishing a simulation centre, it is important to conduct a situational assessment that takes into account a variety of parameters. Key considerations include the level of the target population to be trained, the areas of expertise of the instructional staff, the physical infrastructure of the centre, and the allocated budget. A study conducted in the United States found that the cost of establishing a simulation centre—depending on various factors—is approximately $876,000 (40). Furthermore, when considering that these costs can help prevent harm to patients and reduce future healthcare expenses, simulation centres are not only highly beneficial for medical education but also cost-effective (40).

A simulation centre to be established within a medical faculty should be designed with careful consideration of various dynamics. These include the centre's target population, the expertise and composition of the educators, the physical infrastructure, and—perhaps most critically—the budget allocated for the centre. It is essential that such centres are designed to support not only undergraduate and postgraduate education but also to contribute to continuous professional development. In doing so, they can facilitate multidisciplinary and interdisciplinary working environments.

Considering the target population, educator dynamics, physical infrastructure, and the budget allocated for the centre, a commission should be established to prepare a technical specification that comprehensively addresses each of these aspects. This commission should include, at a minimum, an architect, a civil engineer, a biomedical engineer, a medical educator, and faculty members who will be end users of the centre. Additionally, it would be beneficial to form a separate commission with similar expertise to act as an examination and acceptance committee.Informed by the recommendations of the technical specification commission, the process should include market research, consultations with institutions that have previously established simulation centres, a review of their technical specifications, and an evaluation of current medical devices and communication infrastructure.When preparing the technical specification, it is essential to ensure that devices can be updated in line with evolving medical technologies and practices. Periodic training sessions on device usage should also be planned, and these sessions should be recorded in video format to assist new users and serve as a reference for refreshing procedural knowledge.

A simulation centre can be planned either as a whole or in complementary phases. If the centre is to be established through a bidding process, this process can be structured in one of two ways: either as a phased implementation open to partial bids, or as a single contract covering the entire centre, closed to partial bids. In this task distribution, the role of the commission is to assess the specific needs of the centre, while the decision regarding the preparation and execution of the bidding process—within the framework of applicable laws and regulations—should rest with the relevant authorities and the contracting entity.

Following the completion of the bidding and procurement processes, certain preparations should be made before the arrival of the simulation devices. These include finalising the construction of the centre, ensuring adequate ventilation for optimal device operation, and preventing direct sun exposure—all of which contribute to the long-term functionality of the equipment. Once installation is complete, the centre can begin operations following training sessions delivered to educators by company representatives.

The Role of Simulation Centers in Medical Education and Professional Development

The functionality of a simulation centre relies on the active engagement of faculty members committed to delivering high-quality training, as well as healthcare professionals dedicated to continuous professional development. Simulation-based education is essential for bridging the gap between preclinical and clinical stages, particularly in undergraduate medical training. It also plays a vital role in postgraduate specialty education by providing opportunities to practise rare cases that may be difficult to observe in clinical settings. Furthermore, with the increasing emphasis on malpractice, patient safety, and accountability in healthcare, simulation-based education contributes significantly to training in these critical areas.

Ethical Implications and Contributions of Medical Simulation

Medical simulation applications provide healthcare professionals with valuable opportunities to engage deeply with medical ethics, make informed decisions, learn from mistakes, and deliver ethically sound patient care. These ethical contributions are essential for improving the quality of healthcare services and ensuring that professionals uphold their ethical responsibilities. By simulating real-world scenarios, healthcare providers can practise navigating complex moral dilemmas in a controlled environment, thereby enhancing their ability to make ethically responsible decisions in real clinical settings.

Transformation of Medical Simulation in Healthcare Education

Medical simulation has undergone a significant transformation in the healthcare sector, particularly in the areas of training and skill development. Technological advancements have enabled the creation of more realistic, interactive, and personalised educational experiences. This progression has allowed healthcare professionals to refine their clinical skills and enhance patient safety. Simulation-based education has expanded beyond simple task-based learning to encompass a broad range of clinical scenarios—from routine procedures to high-stakes emergency care.

Looking ahead, medical simulation is expected to evolve further with the integration of genetic and personalised simulations. By leveraging individual genetic data, simulations can be designed to test tailored treatment plans for various diseases. This will be especially beneficial in managing genetic disorders and planning surgical interventions. As biotechnology becomes more deeply integrated into medical practice, simulations may also begin to model human biology at an advanced level—including organs and tissues—thereby improving the safety and effectiveness of surgical procedures (41,42).

The Importance of Simulation in Primary Care and Other Specialties

While physician competencies are essential across all specialties, family physicians—often the first point of contact for patients—must be equipped to manage a broad range of health issues. It is therefore particularly important that these competencies are developed early in their training.

Medical simulation plays a key role in enabling family medicine trainees and other specialists to apply theoretical knowledge in practice before encountering real patients. It allows them to gain experience with emergency situations and complex cases in a controlled, risk-free environment. Additionally, simulation-based training enhances students' communication skills, teamwork, and awareness of patient safety. Through realistic scenarios, physicians learn to make sound decisions, perform procedures accurately, and demonstrate professional behaviour, all while minimising the risk of error.

Such training not only enhances the clinical abilities of family physicians but also strengthens their humanistic skills, enabling them to develop both technical expertise and empathy for their patients. By providing a safe environment for practice and learning, simulation-based education ensures that healthcare professionals—particularly family physicians—are well-prepared to meet the demands of real-world medical practice (43–45).

Enhancing Clinical and Humanistic Skills through Simulation

Medical simulations play a vital role in developing both clinical and humanistic competencies. They enable family physicians and other clinicians to strengthen their ability to make decisions under pressure, manage complex cases, and uphold professional standards. Simulation exercises also support the improvement of communication and teamwork skills—key components of high-quality patient care. By offering opportunities to practise decision-making, technical procedures, and ethical conduct, simulation fosters the development of well-rounded healthcare professionals who are not only clinically proficient but also compassionate and effective in their interactions with patients (46–48).

In summary, the integration of simulation-based education into medical training offers significant benefits in enhancing clinical competence, ethical decision-making, and professional development. This approach is essential for the continuous improvement of healthcare delivery, particularly in fields such as family medicine, where professionals routinely encounter diverse and complex patient needs. Simulation centres—powered by the dedication of committed faculty and healthcare professionals—will continue to play a pivotal role in shaping the future of medical education and patient care.

REFERENCES

1. Scheele F. The art of medical education. Facts Views Vis Obgyn. 2012;4(4):266-9.
2. Institute of Medicine. To err is human: Building a safer health system. [Internet]. 1999 [cited 2015 Oct 11]. Available from: http://www.nationalacademies.org/hmd/~/media/Files/Report%20Files/1999/To-Err-is-Human/To%20Err%20is%20Human%201999%20%20report%20brief.pdf
3. Mossialos E, Wenzl M, Osborn R, et al. International profiles of health care systems 2015. New York: The Commonwealth Fund; 2016. Available from: https://www.commonwealthfund.org/sites/default/files/documents/___media_files_publications_fund_report_2016_jan_1857_mossialos_intl_profiles_2015_v7.pdf
4. So HY, Chen PP, Wong GKC, Chan TTN. Simulation in medical education. J R Coll Physicians Edinb. 2019; 49(1):52-57.
5. Bradley P. The history of simulation in medical education and possible future directions. Med Educ. 2006; 40:254–62.
6. 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; 35:1511-30.
7. Heuer A, Bienstock J, Zhang Y. Simulation-based training within selected allied health professions: an evidence-based systematic review. J Allied Health. 2022; 51(1), 59-71.
8. Owen H. Simulation in Healthcare Education. Cham: Springer International Publishing; 2016.
9. Bienstock J, Heuer A. A review on the evolution of simulation-based training to help build a safer future. Medicine (Baltimore). 2022 Jun 24;101(25): e29503.
10. Yıldırım D, Özer Z, Kocaağalar E, Bölüktaş RP. Eğitimde İnovasyon: Sağlık Eğitiminde Simülasyon Kullanımı. Bilgi Ekonomisi ve Yönetimi Dergisi. 2019;14(1):33-41.
11. Buck GH. Development of simulators in medical education. Gesnerus. 1991;48(1):7-28.
12. Beaubien JM, Baker SR. The role of medical simulation in the training of healthcare professionals. JAMA. 2004;292(9):1173-80.
13. Cook DA, Hatala R. Technology-enhanced simulation for health professions education: A systematic review. JAMA. 2016; 316(1):9-10.
14. Torf R. The role of virtual reality and augmented reality in medical training. Med Educ Online. 2010;15(1):14-25.
15. Kneebone R. Simulating surgery: The future of surgical education. Med Educ. 2003;37(7):550-8.
16. Marasco G, Nardone OM, Maida M, Boskoski I, Pastorelli L, Scaldaferri F. Impact of COVID-19 outbreak on clinical practice and training of young gastroenterologists. Eur Surv Dig Liver Dis. 2020;32(2):75-81.
17. Dharamsi A, Hayman K, Yi S, Chow R, Yee C, Gaylord E. Enhancing departmental preparedness for COVID-19 using rapid cycle in situ simulation. J Hosp Infect. 2020; 105:604–7.

18. Thoma B, Abbott C, Snell L. The future of the CanMEDS physician competency framework. Can Med Educ J. 2023 Mar 21;14(1):1-3.
19. Frank JR, Danoff D. The CanMEDS initiative: implementing an outcomes-based framework of physician competencies. Med Teach. 2007;29(7):642–7.
20. Lateef F. Simulation-based learning: Just like the real thing. J Emerg Trauma Shock. 2010;3(4):348-52.
21. Elendu C, Amaechi DC, Okatta AU, Amaechi EC, Elendu TC, Ezeh CP, Elendu ID. The impact of simulation-based training in medical education: A review. Medicine (Baltimore). 2024 Jul 5;103(27): e38813.
22. Ker J, Bradley P. Simulation in medical education. In: Swanwick T, editor. Understanding Medical Education: Evidence, Theory and Practice. 2nd ed. Oxford, UK: Wiley-Blackwell & ASME; 2010.
23. Okuda Y, Bryson EO, DeMaria S Jr, Jacobson L, Quinones J, Shen B, Levine AI. The utility of simulation in medical education: what is the evidence? Mt Sinai J Med. 2009 Aug;76(4):330-43.
24. Yu JH, Chang HJ, Kim SS, Park JE, Chung WY, Lee SK, Kim M, Lee JH, Jung YJ. Effects of high-fidelity simulation education on medical students' anxiety and confidence. PLoS One. 2021 May 13;16(5): e0251078.
25. Andreatta PB, Woodrum DT, Birkmeyer JD, Yellamanchilli RK, Doherty GM, Gauger PG, Minter RM. Laparoscopic skills are improved with LapMentor training: results of a randomized, double-blinded study. Ann Surg. 2006 Jun;243(6):854-60; discussion 860-3.
26. Sahu S, Lata I. Simulation in resuscitation teaching and training, an evidence-based practice review. J Emerg Trauma Shock. 2010 Oct;3(4):378-84.
27. American Medical Association. Ethical Guidelines for the Use of Simulation in Medical Education. 2017.
28. Ziv A, Ben-David S, Merrill J. Simulation-based medical education: An ethical imperative. Acad Med. 2003;78(8):911-7.
29. Borum M. Ethical challenges in medical simulation: A review of current literature and practices. Simul Healthc. 2018;13(6):380-387.
30. World Health Organization. Simulation-based education in health care: global ethical considerations. Geneva: World Health Organization; 2010.
31. Issenberg S, McGaghie WC, Petrusa E. Features and uses of high-fidelity medical simulations that lead to effective learning: A BEME systemic review. Med Teach. 2005; 27:10–28.
32. Sezer B, Elçin M. Tıp eğitiminde simülasyon. Eğitim Teknolojileri Okumaları. 2017;443-52.
33. Paul B. The history of simulation in medical education and possible future directions. Med Educ. 2006; 40:254–62.
34. Datta R, Upadhyay K, Jaideep C. Simulation and its role in medical education. Med J Armed Forces India. 2012; 68(2):167-72.
35. Vozenilek J, Huff S, Reznek M, Gordon JA. See one, do one, teach one: advanced technology in medical education. Acad Emerg Med. 2004; 11:1149–54.
36. Rubio-Martínez R, Cadena FA, Albornoz R, Vasco M, Ostergaard D. Simulation-based education – how to get started. Update in Anaesthesia. 2022;36:29-34.
37. Jones F, Passos-Neto CE, Braguiroli OFM. Simulation in medical education: Brief history and methodology. Principles and Practice of Clinical Research. 2015;1(2):56-63.
38. Savoldelli GL, Naik VN, Park J, Joo HS, Chow R, Hamstra SJ. Value of debriefing during simulated crisis management: Oral versus video assisted oral feedback. Anesthesiology. 2006; 105:279–85.
39. Alan FM. Human factors and the cardiac surgical team: A role for simulation. J Extra Corpor Technol. 2007;39(4):264-6.
40. McIntosh C, Macario A, Flanagan B, Gaba DM. Simulation: What does it really cost? Simul Healthc. 2006;1(2):109.
41. Nash DB, Joshi M, Ransom ER, Ransom SB. The Healthcare Quality Book: Vision, Strategy, and Tools. Washington, DC; 2019.
42. Elçin M, Odabaşı O. Beceri eğitimi. In: Sayek İ, editor. Tıp eğiticisi el kitabı. Ankara: Güneş Tıp Kitapevleri; 2016. p. 179-93.
43. Cant RP, Cooper SJ. Simulation in healthcare education: a best evidence practical guide. The Clin Teach. 2010;7(3):161-4.
44. Olde Hartman TC, Bazemore A, Etz R, Kassai R, Kidd M, Phillips RL Jr, et al. Developing measures to capture the true value of primary care. BJGP Open. 2021;5(2): BJGPO.2020.0152.

45. Primary Health Care Performance Initiative. The PHCPI conceptual framework. 2018. Available from: https://improvingphc.org/phcpi-conceptual-framework. Accessed 2020 Jun 30.
46. Arya N, Geurguis M, Vereecken-Smith C, Ponka D. Snapshot of family medicine around the world: Introducing the global family medicine website. Can Fam Physician. 2023; 69(5):330-336.
47. Yıldırım B, Eğici MT. Aile Hekimliği Uzmanlık Öğrencilerinin Bakış Açısından Aile Hekimliği Saha Eğitimi ve Eğitim Aile Sağlığı Merkezleri. Ankara Med J. 2018;18(3):300-11.
48. Oluyadi F, Frasca DJ. The impact of self-directed learning on the future of family medicine education. Fam Med. 2022; 54(8):597-598.