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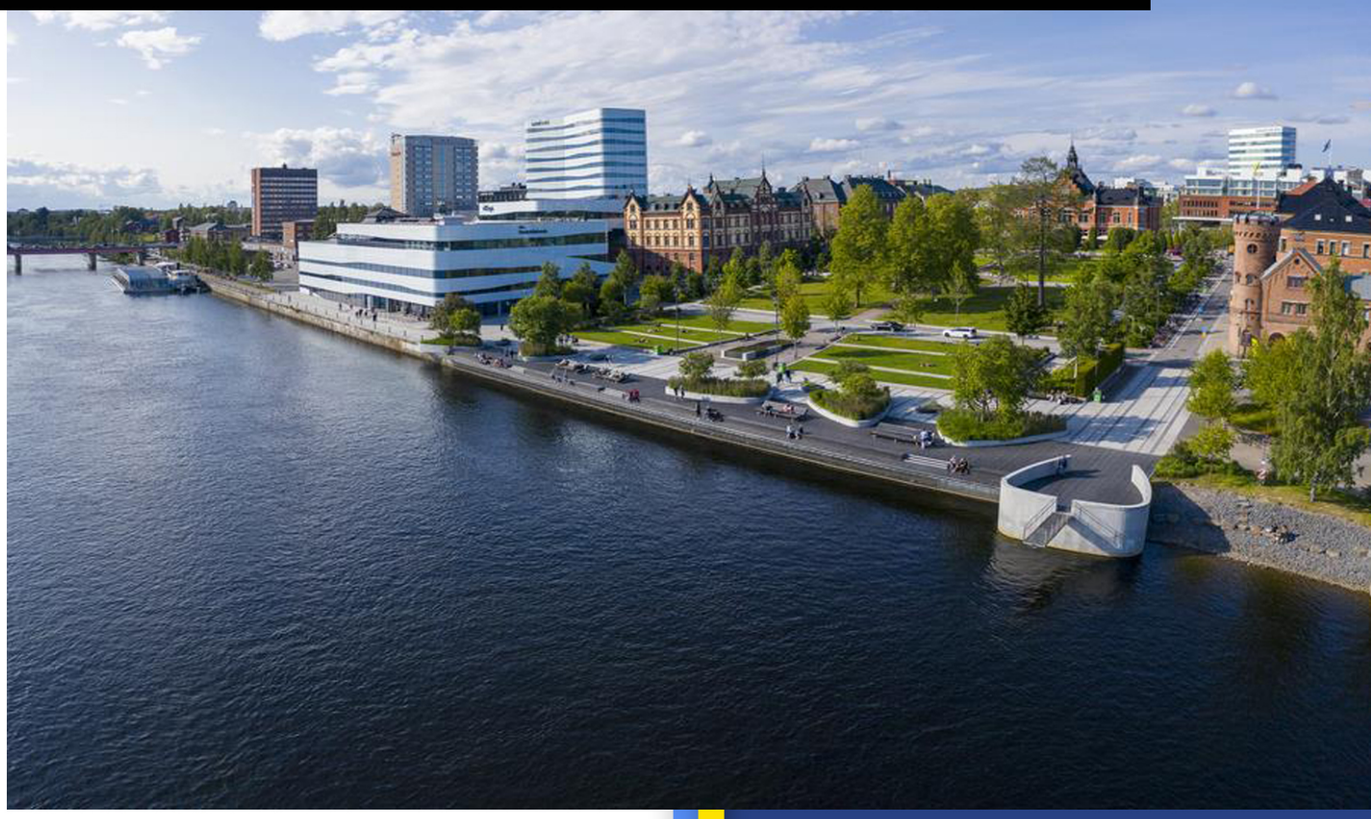

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REVIEW OF SIMULATION MEDICAL TECHNOLOGIES IMPACT ON MODERN EDUCATION

Abstract. *The adoption of simulation-based medical teaching and learning is one of the key phases in curriculum development. Instead of learning through apprenticeship, medical simulation enables the development of clinical skills through purposeful practice. Role-playing games and patient simulations are examples of human simulations. Manikins and computer-based simulations are examples of non-human simulations. At the undergraduate and graduate levels, medical simulation has been shown to improve clinical competence. Additionally, it has been*

discovered to have several benefits that can raise patient safety and lower medical expenses.

Keywords: *simulation, training, medicine, students, education.*

Introduction

A simulation center can recreate actual healthcare situations through clinical simulation in a setting that is secure enough for learning and experimentation [43], [44].

In a wide range of industries, including aerospace and the armed services, simulation has a long and rich history [38]. An area of simulation that is relevant to teaching and training in medical disciplines across numerous businesses is a medical simulation, or healthcare simulation more generally. It is possible to hold simulations in the classroom with the primary goal of teaching medical professionals how to minimize errors during general practice, surgery, prescription, and crisis interventions.

Teaching hospitals and medical schools are institutions that provide training in medicine by simulating medical procedures.

Simulator training gives students the chance to put theory into practice and gain expertise in tasks that would otherwise be challenging without endangering patients, such as managing emergencies and performing CPR.

Both at the undergraduate and graduate levels, medical simulation is a useful educational addition to healthcare training. It makes it possible to gain knowledge, skills, and attitudes in a secure, educationally focused, and effective way [45], [46].

Simulation Technologies in Medical Education

The purpose of simulation in medical education is to instruct medical students and enhance their performance by simulating a complex real-world process artificially and in a simplified way [2]. Immersive learning, student reflection on their performances, and the teacher's in-person feedback all support the learning process [1]. Models with suitable levels of detail can be used for simulation as well as simulated/standardized patients. Depending on the difficulty of the work to be taught and the amount of financial help available, it is necessary to decide on the model's faithfulness [1], [2], [3]. Similar to traditional teaching techniques,

simulation-based education has increased students' knowledge, understanding, and a variety of crucial abilities during undergraduate pharmacy study [31].

Dimensions and Benefits of Simulation

The use of simulation in medical education enables students to develop the organizational skills necessary to respond to real-life situations without endangering the patients' moral or legal rights [2], [4]. Additionally, it contributes significantly to the development of the medical student's attitude and skills (such as communication, problem-solving, and clinical abilities), which lowers the risk of accidents and enhances patient safety [3], [4], [50]. Undergraduate students can receive training in basic and advanced life skill support, the management of crises such as pericardial tamponade and tension pneumothorax, as well as how to deliver terrible news to a simulated patient. Similar to undergraduate students, postgraduate students can receive training for enhancing communication abilities or for particular procedures pertinent to their profession [3].

The usage of simulation ranges in complexity from the straightforward recreation of individual body parts to the sophisticated portrayal of human interactions by simulated patients or high-fidelity human patient simulators that replicate the entire body's appearance and fluctuating physiological data [7].

Healthcare Ethics Education Using Simulation-Based Learning

Millions of individuals die or suffer severe injuries each year as a result of mistakes in medical procedures. Therefore, safe care be made possible, medical errors are reduced in procedures, and changing health situations are dealt with quickly. Simulator-based ethical education has grown in popularity in recent years as a means of educating people with strong professional ethics and competence in their fields. A simulation is a teaching tool that incorporates moral and legal principles. In this context, it is intended for all health sectors to incorporate simulation-based training in areas like self-rule, patient consent, patient defensiveness, empathy, communication skills, and care for particular patient populations [6], [28], [35].

The Implementation of Simulation in a New Medical College

All medical colleges should strive for the gradual inclusion of simulation in

their settings since it has a clear place in the efficient delivery of medical education [3]. The simulation-based instruction can begin with simulated/standardized patients who only need little financial assistance and are utilized to hone the abilities to gather histories, communicate, and perform routine physical examinations [2], [5]. The institutions might gradually spend money on modest simulations (such as lumbar puncture trainers and venepuncture arms) and teach or practice fundamental abilities. As time goes on, further equipment might be used and purchased based on the funding sources [3], [5]. To get the best possible use and output from these simulators, the faculty members must be taught about their use [5].

Issues in Medical simulation

A multidisciplinary and difficult field, medical simulation is. It is a theoretical and applied field that emphasizes several methodologies, paradigms, modeling, and disciplines [8]. The requirement for medical simulators that truly employ multi-modeling to show visual, auditory, haptic, and olfactory representations is one of the major difficulties in medical simulation [9]. And based on that, the difficulty at hand is the correlation of the various displays since there needs to be a proper relationship between how the user receives sensory inputs and how the user interacts [8], [9].

In the modern day, clinical, operational, and management processes produced by medical simulation are apparent and simple to comprehend in terms of their merits and benefits [8]. Medical simulation is still a sophisticated and highly technical instrument that is difficult for non-technical users to understand, even though the fact that the healthcare profession is now more aware of it and prepared for it. Users may become resistant to the challenge, which is viewed as a barrier to successful simulation adoption in the healthcare industry. This barrier is caused by the fact that thorough simulation, like in the case of medical simulation, takes a lot of time and effort [9]. Human-Simulator Interfaces are frequently crucial, as data has also demonstrated. A medical simulator-designed interface should accurately reflect the real world and be simple to use to prevent errors and poor training, and provide a complete solution for various cases in medical simulation (such as performing surgery on a patient or training for healthcare practices) [9]. As a result, every healthcare professional, including doctors, students, and students-at-heart,

should handle devices that have the same appearance and feel as their real-world equivalents [37]. It can be difficult to meet the requirements for these tools, particularly if the simulator is used for open surgery, where there are many more degrees of freedom and instruments than during minimally invasive procedures. The user concludes the prior challenge by healthcare simulation, acceptance is a crucial issue.

Although data gathering is difficult in the context of healthcare simulation, a simulation model can only produce useful and accurate results depending on the input data. Medical simulation tool designers frequently struggle to provide their simulation models with enough input data in the healthcare industry, which results in outcomes that are only loosely accurate. Data collecting is difficult because there are no appropriate formats for historical data, data collection must be done over a lengthy period of time, and meeting with healthcare experts for data collection and verification purposes is challenging because of their busy schedules [8]. Complete, accurate, and true input data are required. As decision support systems, the entered data are very important in determining how well a health professional is doing when making decisions. Simulation models may need to be integrated with the organization's information systems to support daily operations in order to enable appropriate data collection.

An in-depth study has been done on validation and verification in medical simulation. Because it would be unwise, if not disastrous, to base any judgments or forecasts on the model results without performing thorough testing and validation, it is regarded as a true devil. Innovative modeling techniques, particularly for complicated models, and model validation should be employed to overcome this obstacle. Additionally, a technique like the recently developed Collaborative, Participative, Interactive Modelling method, in which models are created jointly with user engagement utilizing medical simulation, can improve model verification [8].

Human factors in medical simulation

Despite the fact that medical simulation offered the best solutions for handling healthcare concerns, there have been fewer successful implementations and

developments than in the industrial sector [16]. High levels of competition are present in both domestic and international markets for modern hospitals and clinics. Patients, doctors, medical students, and trainees are also calling for higher quality health care services to be provided at acceptable costs. Notably, research from [10] suggests that the form of medical simulation models should be such that it maximizes the safety and calibre of healthcare systems [39-41]. On the other side, employing reliable simulation systems may make systems more complex and have a detrimental effect on their effectiveness. Software solutions consequently become available as a result of this.

1. The healthcare systems' complexity and myriad linkages [11].
2. Expensive simulation tool costs [12].
3. Errors in medicine [13].
4. Absence of pertinent data and trustworthy tools [14].
5. Poor usability and a difficult-to-use UI.

The safety of medical simulation technologies is greatly impacted by human error [42]. As was noted, design flaws in the human-machine interface are commonly to blame for human errors. Physicians, operators, and healthcare providers will be put in situations where the demands placed on them are unrealistic from a psychological standpoint if the system and interface design was not done with human capabilities and by considering the limitations of the cognitive, perception, and physical human factors [15]. A mistake will inevitably happen as a result.

By creating interfaces that take into consideration human capabilities and limitations, the field of human factors, often known as ergonomics, addresses the concerns and challenges related to medical simulation that have been identified. Human safety is gravely threatened by the design phase's disregard for human factors. Following design guidelines for medical simulation could reduce human error and improve tool comprehension.

The principles of human factors design that might be used as an example include [15].

1. After every action, the user should receive immediate feedback.

2. Clearly and visibly display the various controls' functionalities.

3. Messages displayed should be simple to comprehend.

4. Reduce as much as you can the demand on the users' memory.

5. Make people more productive by giving them shortcuts.

6. If the medical simulation tool has an interface, provide it with clearly indicated exits for the user to depart the system.

Establishing a simulated training facility

It can be used for competency testing prior to recruitment, residency training, continuing medical or nursing education (practical skills), undergraduate training (such as in the study of anatomy, physiological functions, and familiarization with medical examination techniques), and residency training (mastering procedural skills and techniques) [17], [32], [33]. First, there needs to be a convenient location, which is typically on a hospital or university campus for proximity's sake. The center’s trainers and end users must be consulted when choosing the architecture plan and infrastructure. Among other amenities, it must have enough room for setting up equipment, rooms with one-way mirrors, and enough space for small-group training. Additionally, a place must be set aside for video recording equipment.

1. Human patient simulators: The focal point is typically a life-size patient simulator with realistic breathing, blinking, heart, pulse, and respiratory sounds. This mannequin might have cutting-edge technology. For instance, it might "interact" with students using computer-assisted instruction programs. Vital signs can be shown on attached monitors, which enables a virtual reproduction of practically all-important biological functions [47]. The scenarios that can be used with this simulator range from straightforward physical examination to multidisciplinary catastrophic trauma therapy [52]. Some simulators can even detect injected drugs using a laser bar-code reader and then react by changing vital signs as necessary.

2. Simulated clinical environment: The crash cart and all the necessary supplies are ready in an operating room, emergency room cubicle, or critical care unit. The environment is as accurate as the facility itself. The setup and settings might be

familiarized by the trainees.

3. Virtual procedure stations: According to the focus, many stations can be set up. For procedures including bronchoscopy, colonoscopy, and intubation, these stations will be equipped with all the necessary tools. The trainee can practice using a range of scenarios and diseases presented by the simulators until they have mastered the method [51].

4. Electronic medical records: This could also be a station set up in the center as more medical facilities switch to electronic medical records for patient management and tracking. False patients will be used in the system, complete with histories, notes, and lab results. System integration may also occur, for example, when records are linked to the laboratory and the results of radiology.

Safety and simulation

The safety of the healthcare system can be compared to other high-risk professions including aviation, the military, and nuclear power production. In these fields, safety is dependent on eliminating human error and having redundant components built into the systems. Failures in these environments may result in morbidity and mortality [18-21], [36]. The frequency of medical errors is one of the important performance measures used by hospitals. Patient safety is undoubtedly the most interesting aspect to examine when examining the value of simulation in healthcare [21-23], [49].

The paradigm of learning is a crucial idea in medical safety. The apprenticeship approach has historically been used in medicine. On the first day of their internship, trainees and residents start providing care for patients under the supervision of more seasoned professionals, who act as a safety net in case mistakes are made. Even if they learn about medical care before taking care of their first patient, there must be a first time for high-risk surgeries, resuscitation, and the application of crucial decision-making abilities on actual patients. In addition to standard medical education, simulation offers a different learning approach. Even though these simulation exposures are simply imagined circumstances, they can guarantee that the inhabitants are exposed to these emergencies. For the execution of procedures, prior to performing these treatments on people, simulations do enable for the

development of experience [17, 21-24].

In patient care settings, high-fidelity simulations are an educationally successful adjunct to conventional instruction [48]. The simulation characteristics that best support learning include [21].

– Feedbacks

– Consistent practice

– Curriculum integration

– The capacity to vary the degree of difficulty

Department of Simulation Medical Technologies in Odesa National Medical University

The cycle "Simulation and virtual technologies in medicine" was upgraded in 2021, and the cycle "Medical ethics, deontology, and professional communication" was formed, both with the assistance of top experts from clinical departments at the Odessa National Medical University. Their invention has contributed to the development of practical abilities and raised students' capacity to deliver emergency treatment. To enhance student learning algorithms, multidisciplinary collaboration with top clinical departments is taking place during these cycles.

Medical ethics, deontology, and professional communication are covered in the training directions for the cycles "Simulation and virtual technologies in medicine" and "Medical ethics, deontology, and professional communication." These directions include both practical stations (where practical skills from top disciplines are developed in accordance with contemporary emergency care protocols, using high-quality mannequins with feedback) and full practice of simulation scenarios for emergencies. Acute coronary syndrome, pulmonary edema, severe bronchial asthma attacks, anaphylactic shock in adults and children, hypo/hyperglycaemia in adults and children, and all scenarios according to BLS, ACLS, PBLS, and PALS are all performed in addition to the aforementioned most common emergency conditions [26].

Students can practice the following practical skills from the emergency situations throughout cycles: needle decompression during tension pneumothorax, cricothyroidotomy, pericardium puncture, and figuring out the algorithm first person

on a scene during a Trauma scenario.

Execution of a typical scenario includes:

1. The briefing (brief explanation of goals and objectives, dummy capabilities, and expected results)

2. Scenario (a group of students (interns) of 5-6 people on their own without the presence of a teacher, cope with a clinical task on high-fidelity mannequins)

3. Debriefing (analysis of the scenario based on video recording, conclusions) [25], [27], [29], [30].

Another consideration is the scenario's broadcast for professors and other students, who may monitor the situation as it develops in real-time [34].

Students in the last courses (6th year of study) within the training cycle, as well as interns from all disciplines, pass all situations. Separately, it is crucial that interns with interests in Emergency Medicine, Traumatology and Orthopaedics, Anaesthesiology and Reanimatology, Cardiology, and General Practice - Family Medicine must complete emergency scenario exams.

The implementation of such scenarios and the development of practical skills, according to the review's authors, are important key points in acquiring competencies for the future. Another point is the issue of practicing doctors regularly attending trainings in order to advance their credentials and continuously update pertinent modern knowledge and skills at a competent level.

Conclusion

A new avenue for medical education has been made possible by simulation-based training. Protocols and algorithms can be used to put evidence-based practices into action, and simulated scenarios can be used to test them out. Integration of simulation training into regular educational programs is essential for its success. A program of this nature must involve the clinical faculty from the beginning of its creation. Early adopters and champions will recognize the potential of VR learning and put in time and effort to assist in curriculum development. The larger medical community can then be involved with their assistance. In addition to the benefits of standard didactic instruction, teamwork training that is carried out in a virtual setting may also improve performance and perhaps even cut down on mistakes. Examining

the enhancement of clinical competence and its effects on patient safety can help determine the cost-effectiveness of potentially expensive simulation-based medical education and training.

Perhaps with the acceptance of simulation as a requirement for training and certification, the public will perceive health care systems as more responsible and moral. Many skills, including professionalism, communication, self-evaluation, time management, and teamwork, are acquired by students through simulation-based learning. Simulator technology has undergone tremendous advancements as a result of the revolution in surgical training that was sparked by time constraints and patient safety concerns. The training for surgeons has undergone some fresh alterations as a result, though. The need for educators to be meticulous in confirming that standard training is beneficial and that simulation can genuinely enhance trainees' capacity to provide patient care has arisen from the need for surgical training to be held accountable for its efficacy. It's unclear whether surgical simulation actually makes skill learning more effective; more accurate ways to gauge skill acquisition will be needed for this procedure. The question of how often and in what circumstances to employ simulations in clinical training will now present a challenge for educators. We'll likely find a means to maximize skill acquisition for medical students and residents as simulator technology advances and methods for measuring skill acquisition advance. Future physician quality should rise while training costs should ideally go down as a result.

Declaration of conflicting interests

The authors declare that there is no conflict of interest.

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