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Simulation Practices in Telemedicine Education: A Systematic Review

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Abstract **Original Research Article**

Telemedicine has significantly expanded access to care, particularly in underserved and remote regions. This transformation requires that medical education be adapted to prepare providers for the effective use of telemedicine. Simulation-based education, by replicating realistic clinical scenarios in a controlled environment, offers a pedagogically sound method for developing both technical and decision-making competencies without compromising patient safety. Accordingly, this systematic review aims to examine the existing literature on simulation in telemedicine training, with the objective of identifying best practices and effective pedagogical strategies to enhance the preparedness of healthcare professionals. This study presents a systematic review conducted in accordance with PRISMA 2020 guidelines. A comprehensive search was carried out in PubMed and SCOPUS for original articles published between 2018 and 2023. The review focused on studies describing simulation-based training in telemedicine, aiming to identify effective pedagogical strategies, challenges, and outcomes. Data were extracted on study objectives, target populations, instructional content, simulation settings, and assessment methods. Given the heterogeneity of findings, a qualitative synthesis was performed. From an initial pool of 762 records, 22 studies were included in this review, primarily conducted in the United States and involving medical residents, students, and nursing trainees. These studies explored diverse applications of simulation in telemedicine education, including emergency response, chronic disease management, interprofessional collaboration, and technical troubleshooting. Simulations were typically preceded by didactic sessions and followed structured scenarios with briefing, execution, and debriefing phases. Assessments—mostly pre- and post-simulation—revealed significant improvements in participants' confidence, communication, remote examination skills, and interdisciplinary collaboration. The findings underscore the effectiveness of simulation-based training in enhancing telemedicine competencies across a range of clinical and technical domains.

Keywords: Systematic review, Telemedicine, Simulation-based education, Medical education.

INTRODUCTION

Telemedicine, which refers to the use of information and communication technologies to provide healthcare services at a distance [1], has greatly transformed access to medical care. By enabling healthcare professionals to diagnose, treat and monitor patients without geographical constraints, telemedicine offers a promising solution to challenges such as disparities in access to care, overcrowding in healthcare establishments and the needs of isolated populations or those with reduced mobility. Consequently, training in telemedicine has become essential to prepare future healthcare providers to effectively integrate these technologies into their clinical practice, thereby guaranteeing better quality care and an appropriate response to technological and societal advances [3].

Moreover, telemedicine contributes to alleviating healthcare system burdens by reducing unnecessary patient travel. Providing remote access to medical consultations allows for rapid diagnosis and medical advice without physical visits, decreasing wait times and increasing consultation efficiency. Additionally, telemedicine facilitates coordination among multidisciplinary healthcare teams through the secure and rapid exchange of medical information,

promoting comprehensive and coherent patient management [4]. It also offers advantages for long-term patient follow-up; regular remote consultations support improved treatment adherence and ongoing management, which may enhance clinical outcomes [5]. Furthermore, telemedicine's capacity to collect and analyze health data remotely opens new avenues for medical research and the development of personalized care protocols tailored to individual patient needs.

Simulation-based education is an innovative and effective pedagogical approach, enabling students to translate theoretical knowledge into practical skills. By recreating realistic and immersive scenarios, learners are encouraged to make decisions, solve problems, and actively engage with their environment. This method fosters the development of practical competencies and critical thinking abilities while simultaneously boosting learners' confidence and motivation [6]. Additionally, simulation provides educators with valuable opportunities to assess student performance, observe skills in action, and deliver personalized, constructive feedback. Through experimentation with diverse scenarios in a controlled and safe environment, students can learn from their errors and take risks without risking patient safety. As a result, simulation enhances experiential learning and is a vital tool for training future professionals across various domains, including medicine, engineering, and business [7].

In medical education, simulation represents a significant advancement in pedagogical strategies. By recreating realistic clinical scenarios within a controlled environment, simulation allows learners to hone practical skills, make critical clinical decisions, and reflect on their practice without endangering patients [8, 9]. Its strength lies in its ability to integrate theoretical knowledge with practical application, thereby fostering better retention and understanding. In the context of telemedicine, simulation-based training is particularly promising for maximizing educational effectiveness, preparing healthcare providers to master remote care delivery [7, 10, 11].

The integration of telemedicine into healthcare systems is accelerating markedly, driven by the imperative to improve access to care, especially in remote regions [12]. This shift towards a more connected healthcare model necessitates rapid adaptation in medical education to meet emerging needs. Simulation emerges as a key pedagogical tool, offering an innovative approach aligned with the goals of healthcare modernization and innovation [13]. However, for this approach to be effective, it is crucial to ensure that telemedicine training programs are relevant and tailored to the specific needs of the target audience [14].

The primary aim of this systematic review is to analyze existing literature on the use of simulation in telemedicine training, with the goal of identifying best practices, effective programs, and optimal pedagogical strategies.

MATERIALS AND METHODS

Our study involved conducting a comprehensive systematic review in accordance with the PRISMA 2020 guidelines [15]. The literature search was performed using the following search equation: (("Teaching"[Mesh] OR "Education"[Mesh] OR "education"[Subheading] OR "Learning"[Mesh]) AND ("Computer Simulation"[Mesh] OR "Patient Simulation"[Mesh] OR "High Fidelity Simulation Training"[Mesh] OR "Simulation Training"[Mesh]) AND ("Telemedicine"[Mesh])). The analysis focused on original articles published between 2018 and 2023 retrieved from PubMed and SCOPUS databases. We targeted publications that detailed the application and outcomes of simulation-based training in telemedicine education, with the aim of identifying effective pedagogical practices, encountered challenges, and learning outcomes. Data extracted primarily included study objectives, target audience, instructional materials, scenarios implemented, simulation settings, as well as assessment methods and results. Due to the heterogeneity of the data, a qualitative synthesis of the extracted information was performed.

RESULTS

Following this systematic review, a total of 22 articles were selected from an initial pool of 762 identified and analyzed sources, comprising 536 articles retrieved from PubMed and 226 from Scopus (**Figure 1**).

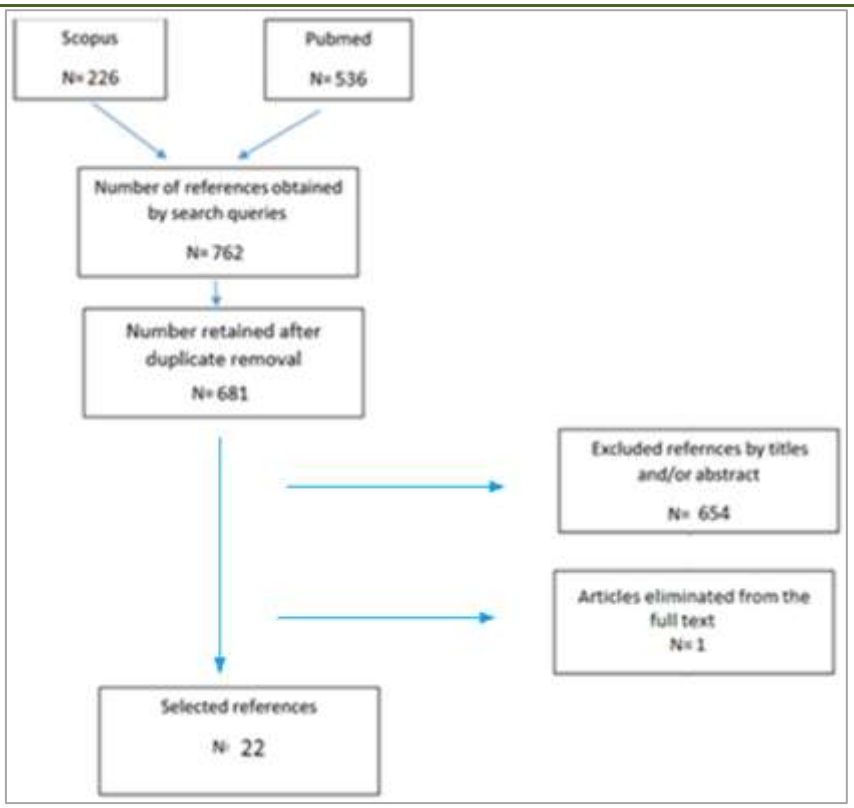

Figure 1: Systematic literature search flowchart based on

The objectives reported across these studies explore the diverse applications of simulation in telemedicine education, encompassing domains ranging from initiating students into telehealth practices [16] to managing medical emergencies such as acute ischemic stroke [17]. These aims also include assessing the usability of telehealth technologies for intra-professional communication and expanding telehealth competencies in primary care settings [18]. Furthermore, the studies address interprofessional simulation-based training, the development of specialty-specific skills, and the enhancement of remote clinical reasoning.

The target populations in these studies primarily consisted of medical residents and students, each representing 33% of the sample, with nursing students comprising 22% (Figure 2).

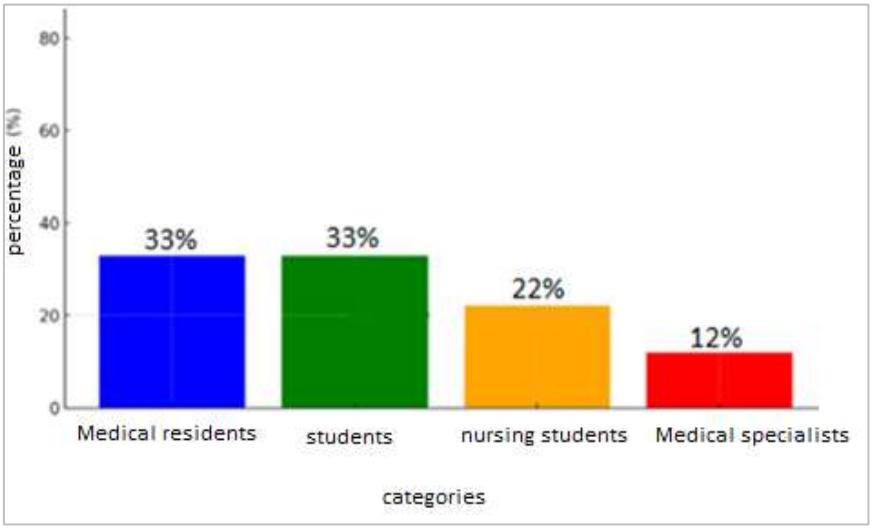

Figure 2: Distribution of the public targeted by telemedicine training

Geographically, the majority of the research was conducted in the United States, accounting for 63.60%, while the remaining 37.40% was distributed among France, Australia, and Colombia.

In 60% of the examined studies, the training process initiated with a preliminary didactic session scheduled 3 to 4 weeks prior to the simulation exercises (Figure 3). This preparatory phase was followed by practical simulation application, structured around an initial briefing, execution of various scenarios, and a concluding debriefing. To evaluate skill acquisition, all studies incorporated an assessment phase, with 72% performing both pre- and post-simulation evaluations. The simulated scenarios encompassed a wide range of situations, from managing specific pathologies to troubleshooting technical issues and systemic malfunctions within the simulation environment.

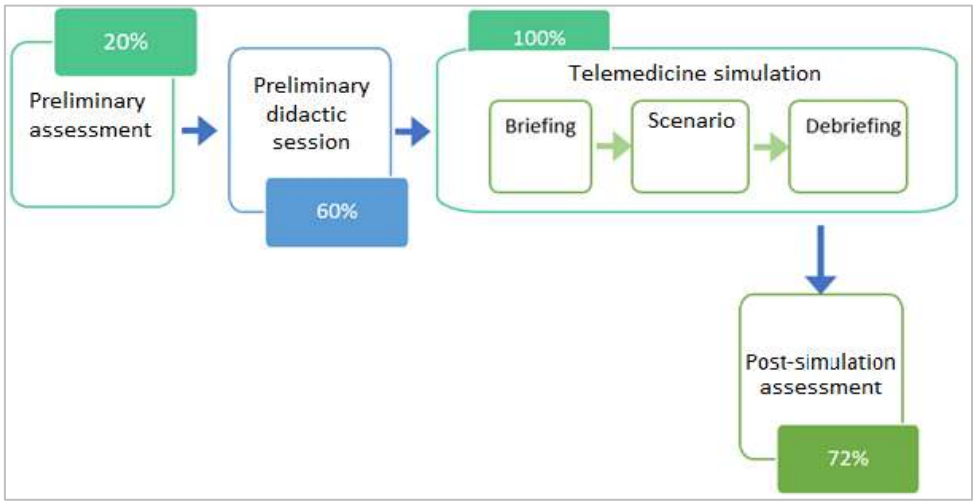

Figure 3: The training programme

The materials and equipment utilized across these telemedicine simulation training studies include video and audio transmission systems, secure telehealth software platforms, high-fidelity mannequins, telepresence robots with bidirectional video conferencing capabilities, and communication platforms such as Zoom. These are complemented by standardized patients, simulation rooms equipped for observation and debriefing, and computer-assisted collaborative learning environments. Collectively, these tools facilitate immersive and interactive engagement within realistic clinical scenarios.

The simulated scenarios span a broad spectrum of clinical and technical situations specific to telemedicine, which can be categorized into several thematic groups. The "Chronic Conditions and Physical Pathologies Management" category includes cases such as chronic disease management, standard orthopedic cases [19], hypertension treatment [20], and dermatological diagnosis [21]. The "Emergency Management" category covers simulated injury scenarios [22], musculoskeletal pain management, and the "Mental Health" category features scenarios such as managing severe depression: simulation of patient care for severe depression [23], highlighting the importance of psychological support and appropriate pharmacological management. The final category, "Technical and Interpersonal Skills," emphasizes developing proficiency in managing connection issues during teleconsultations, effective use of telehealth platforms, and improving patient communication, including therapeutic counseling.

Pre- and post-simulation assessments demonstrated a significant increase in learners' confidence in delivering telemedicine care and notable improvements in managing interdisciplinary care. Residents reported increased confidence levels, with evaluation scores rising from 18-33% pre-simulation to 85-98% post-simulation. Additionally, a substantial proportion of participants recognized that telemedicine enhanced team collaboration (89.3%) and decision-making by healthcare leaders (77.2%). Participants showed significant progress in essential telemedicine skills; notably, 98% improved their communication abilities with patients, 85% developed physical examination skills remotely, and 82% enhanced their capacity to explain treatments to patients.

DISCUSSION

The findings of the systematic review demonstrate widespread adoption of simulation-based training for teaching various aspects of telemedicine, revealing significant improvements in learners' confidence and skills following simulation sessions. These sessions encompassed a broad spectrum of clinical and technical scenarios, ranging from the management of chronic conditions to troubleshooting technical issues, thereby illustrating the effectiveness of simulation in enhancing diagnostic, interpersonal, and technical competencies among healthcare trainees.

The interdisciplinary approach, involving resident physicians, medical students, nursing students, and specialist physicians, underscores the vital role of simulation in the education of diverse healthcare

professionals. Such training not only broadens telehealth competencies but also enhances interprofessional communication and the management of multidisciplinary care, which are critical in the current healthcare landscape [23].

Notably, there was a substantial increase in learners' confidence, from 18-33% pre-simulation to 85-98% post-simulation, alongside marked improvements in their capacity to deliver telemedicine services. These outcomes indicate the efficacy of simulation-based training in preparing healthcare professionals for telemedicine practice [24]. Furthermore, a majority of participants acknowledged that telemedicine improves team collaboration and decision-making, highlighting the positive impact of this educational approach on healthcare delivery processes.

The materials and equipment employed—including video and audio transmission systems, secure telemedicine software, and high-fidelity mannequins—played a crucial role in creating a realistic and interactive learning environment. The integration of advanced technologies such as telepresence robots and telemedicine platforms like Zoom facilitated immersive experiences in simulation scenarios, allowing for rich and engaging learning experiences [25, 26].

In conclusion, these results suggest that simulation constitutes a valuable pedagogical method for telemedicine education, offering tangible benefits in enhancing clinical skills and boosting learner confidence. It is recommended to further integrate simulation into medical curricula and to explore new scenarios and technological innovations to enrich this learning experience.

CONCLUSION

In summary, the research conducted on the utilization of simulation-based training in telemedicine education has definitively demonstrated its effectiveness as a pedagogical tool. The incorporation of diverse scenarios and a practical, hands-on approach during simulation sessions have led to significant and measurable improvements in participants' clinical and technical skills. Ultimately, this study reaffirms the strategic importance of telemedicine in the evolution of healthcare delivery and advocates for the intentional and thoughtful integration of telemedicine education through simulation into the curricula of future healthcare professionals. Such an approach is essential to ensure that the medical sector remains at the forefront of healthcare innovations, equipped to address future challenges with competence and confidence.

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