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Review Article

The Role of Simulation-Assisted Teaching in Rehabilitation Sciences

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Abstract

Rehabilitation education is increasingly challenged by limitations in traditional apprenticeship-based clinical training, including concerns regarding patient safety, restricted opportunities for early procedural practice, shortages of clinical placements, and variability in clinical exposure among students. These constraints have prompted growing interest in simulation-assisted teaching as an innovative strategy to enhance clinical education in disciplines such as physiotherapy, occupational therapy, and speech-language pathology. This review synthesizes current evidence on the role of simulation-based education in rehabilitation sciences, with particular emphasis on its pedagogical foundations, major modalities, learning outcomes, and implementation challenges. Simulation-assisted teaching encompasses a broad spectrum of approaches ranging from low-fidelity task trainers to high-fidelity computerized mannequins, standardized patients, and emerging technologies including virtual and augmented reality. These methods provide structured, controlled environments that enable learners to practice psychomotor skills, clinical reasoning, and patient communication without risk to real patients. Evidence from systematic and scoping reviews indicates that simulation-based interventions are at least equivalent to traditional instructional approaches for technical skill acquisition and are frequently associated with improvements in learner confidence, engagement, and preparedness for clinical practice. However, barriers including high implementation costs, faculty training requirements, and limited longitudinal evidence regarding long-term transfer of skills to clinical practice remain significant considerations. Overall, simulation-assisted teaching represents an increasingly integral component of contemporary rehabilitation education, offering a safe and standardized framework for developing professional competencies while addressing systemic challenges in clinical training.

Keywords: Rehabilitation education, Simulation-based learning, Physical therapy, Occupational therapy, Virtual reality

1. Introduction

Contemporary rehabilitation education faces several structural and pedagogical challenges that undermine the sustainability of the traditional apprenticeship-based clinical training model (Rassie 2017). A major challenge is balancing the obligation to uphold patient safety with the necessity of exposing trainees to complex, high-risk clinical scenarios. Besides this ethical standards and regulatory oversight have limited opportunities for students and learners to perform invasive or sensitive procedures on patients during the early phases of skill acquisition (Wilson et al. 2013). Besides this the availability of clinical training sites has become limited due to increase in student enrolment and lesser number of qualified clinical supervisors (Wilson et al. 2013). This imbalance restricts access to supervised practice and places additional strain on existing healthcare institutions and educators. Moreover, student's learning experience are largely dependent upon the case mix encountered during assigned rotations. Such variability contributes to uneven exposure to core competencies and may result in heterogeneity in skill attainment within the same graduating cohort (Wilson et al. 2013).

Simulation-assisted teaching is an established pedagogical methodology that creates a structured learning environment where students can refine psychomotor and clinical reasoning skills within a realistic, controlled, and safe framework (Zhang 2017). While the integration of simulated assisted teaching into medical and surgical training dates to the late 19th century, its adoption in rehabilitation sciences including physiotherapy, occupational therapy, and speech-language pathology has accelerated significantly in recent decades (Greenwood and Ewell 2018). Faculty now utilizes a sophisticated spectrum of media, ranging from low-fidelity anatomical task trainers to high-fidelity computerized mannequins and standardized patient actors, to create authentic clinical experiences that allow for measurable skill acquisition (Greenwood and Ewell 2018).

Simulation-assisted teaching represents a diverse array of pedagogical techniques rather than a singular technology, encompassing a spectrum of modalities categorized by their fidelity or degree of realism. At the foundational level, low-fidelity simulators include static mannequins and compiler-driven task trainers such as anatomical arms for IV insertion or even organic models like oranges for biopsies. Medium-to-high-fidelity approaches integrate sophisticated computerized mannequins with physiological programming that respond automatically to interventions, or scenarios involving standardized patients who are trained to simulate complex clinical encounters and history taking. Modern advancements have further expanded this field into virtual reality (VR), augmented reality (AR), and virtual patients, where computer-based graphical simulators and programs replicate entire clinical environments (Elendu et al. 2024).

The efficacy of SBE in rehabilitation is emphasized by robust educational theories. Experiential Learning Theory (Kolb) and Deliberate Practice (Ericsson) emphasize the importance of the debriefing phase, where faculty guide students through a reflection on their actions to solidify new learning (Kolb 2014; Ericsson 2008)). Furthermore, Situated Learning Theory suggests that learning is most effective when it occurs in context-rich, authentic environments. Immersive simulations provide this authenticity, increasing learner motivation and engagement, which facilitates the transfer of knowledge from the classroom to real-world practice (Battista 2020).

The transition toward simulation-based learning and curricula requires faculty to expand their roles, developing expertise in creating educational objectives and facilitating complex examinations. As the field evolves, there is a need to synthesize the evidence regarding its implementation. This review aims to evaluate the effectiveness of simulation-assisted teaching in rehabilitation sciences, identify the barriers to widespread implementation, and discuss future directions for integrating emerging technologies into standard pedagogical practice.

2. Types of Simulation Used in Rehabilitation Sciences

The selection of a simulation modality in rehabilitation is fundamentally guided by the concept of fidelity which refers to the degree to which the educational activity replicates reality as perceived by the learner (Figure 1). This comprises of three distinct layers including physical fidelity, degree to which the equipment, patient, and physical environment replicate the tangible world, psychological fidelity, the extent to which the simulation captures the phenomenal aspects of practice, and conceptual fidelity which is the internal logic of the scenario, ensuring that clinical signs, patient histories, and responses to interventions make clinical sense to the practitioner (Mori et al. 2015). Ultimately, the effectiveness of these types of simulation hinges on perceived realism

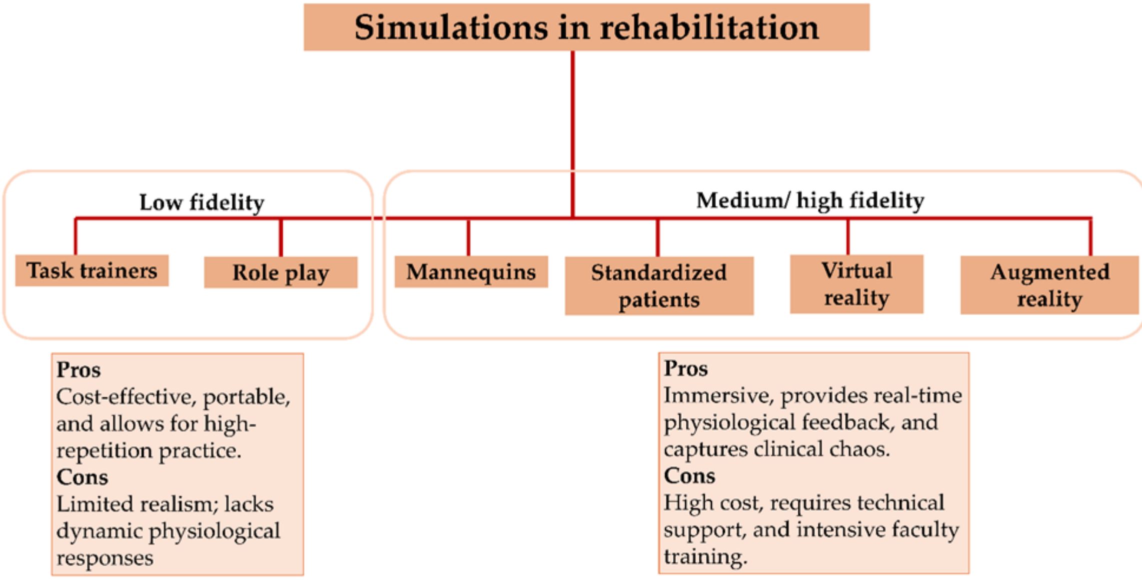

Figure 1: Classification of Simulation Modalities in Rehabilitation Education

For a rehabilitation student, the tactile resistance of a weighted mannequin may be more real and educationally valuable than a high-definition screen-based simulator. The following subsections categorize these modalities based on their technological interface and instructional intent.

2.1. Low-fidelity simulations

Low-fidelity simulations are important in rehabilitation education as these focus on the isolation of specific psychomotor skills and play an important role in the development of interpersonal competencies through active learning (Garg and McLelland 2025). Part-task trainers consist of 3-D representations of body parts or functional anatomy designed for teaching and evaluating specific technical skills (Scalese et al. 2008). In rehabilitation, these devices allow for the breakdown of physical tasks into simple, discrete action steps. Unlike more advanced simulators, the user interface is largely passive, where the device is examined or manipulated with only rudimentary responses. Their primary value lies in deliberate practice, allowing for the repeated execution of procedures to build expertise and confidence.

From an ethical perspective, task trainers are indispensable as they allow instructors to validate a skill before them interact with a human life, thereby maximizing patient safety (Singh and Restivo 2023). Role play is an active, experiential learning method that serves as a bridge to clinical practice. Within the context of physiotherapy and occupational therapy, it is a primary vehicle for training students in complex patient interactions and the professional skills of the discipline. This method provides a safe environment for students to practice effective communication, develop the ability to explain medical conditions, and deliver patient education regarding self-care and prevention. Role play also promotes the development of empathy and therapeutic connection (Manuaba et al. 2026). Role play allows students to engage in realistic clinical scenarios without the fear of causing psychological or physical harm to actual patients. By integrating role play into the curriculum, educators facilitate the practical application of theoretical knowledge, ensuring that students are prepared for the multifaceted responsibilities of a registered therapist (Smith and Crocker 2017).

2.2. Medium/High-Fidelity Simulation

Medium- and high-fidelity simulations represent a technologically advanced category of rehabilitation education (Bragard et al. 2019). These utilize sophisticated mannequins and standardized patients to replicate complex physiological and clinical conditions. High-fidelity mannequins can simulate a wide array of human processes including autonomous breathing, heart rhythms, palpable pulses, changing pupil size, and blinking. These simulators are driven by advanced software that allows instructors to control and monitor parameters in real time, creating dynamic scenarios that range from routine assessments to high-stakes medical emergencies like respiratory failure or cardiac arrest. High-fidelity simulators in rehabilitation are particularly vital in acute care and cardiorespiratory training, as these mannequins can simulate respiratory distress, change heart sounds in response to manual techniques, or exhibit altered vital signs during early mobilization (Elendu et al. 2024).

2.3. Standardized Patients

Complementing these technological tools is the use of standardized patients (SPs), which involve trained actors who role-play specific clinical histories and physical symptoms. The integration of SPs is particularly effective for teaching and assessing non-technical skills, such as communication, empathy, and professionalism. Many educators report that sessions with SPs provide a broader and more organized teaching process, as they allow for a selected range of clinical scenarios that require students to synthesize technical knowledge with human interaction. It has been reported that scenarios involving SPs feel more realistic, which in turn increases their confidence and perceived self-efficacy in providing high-quality care (Nestel and Bearman 2014).

2.4. Virtual Reality and Augmented Reality

Technology-enhanced learning represents a modern frontier in rehabilitation education, offering interactive, flexible, and immersive 3D environments that cater to the evolving needs of the students. Virtual Reality (VR), Augmented Reality (AR), and web-based simulations bridge the gap between theoretical knowledge and clinical operation by allowing students to model complex concepts in a quasi-realistic setting. These methods are known to achieve learning outcomes and student satisfaction comparable to traditional methods, their true value lies in their ability to foster metacognition. These tools encourage students to reflect on their own learning processes, serving as effective predictive tools for future clinical performance (Elendu et al. 2024).

A significant advantage of VR simulations is the provision of a consistent, standardized training experience. Unlike real-life clinical rotations, where patient variability and differences in instructor methodology can lead to inconsistent learning, VR offers uniform scenarios that ensure every student meets the same competency benchmarks. This standardization is particularly beneficial for the objective assessment and comparison of learner performance. Furthermore, these platforms offer unparalleled flexibility; scenarios can be easily modified to suit different skill levels or specialties, such as practicing robotic surgery or navigating complex neurological rehabilitation protocols without risk to a physical patient (Dhar et al. 2023). Beyond individual skill acquisition, VR is increasingly utilized for interprofessional education.

These simulations bring together physiotherapy, nursing, and pharmacy students in a shared virtual space to practice teamwork, communication, and collaborative decision-making.Such immersive, interprofessional training is crucial for promoting the high-level collaboration required in modern healthcare systems to improve patient outcomes (Al-Elq 2010). AR supplements clinical education by superimposing virtual objects onto real-world environments, allowing students to visualize

Table 1: Summary of Key Evidence on Simulation-Assisted Learning in Rehabilitation Education

Author (Year)	Purpose	Key Findings	Implications
Brown et al. (2021)	Evaluate effect of high-fidelity simulation (HFS) using computerized mannequins on clinical performance and preparedness in acute cardiorespiratory physiotherapy	Small, non-significant improvement in short-term clinical performance; improved self-efficacy and confidence; qualitative benefits in familiarity with clinical settings and patient safety	Use validated outcome measures; simulation may enhance preparedness, but optimal timing, dosage, and content require clarification
Roberts and Cooper (2019)	Compare effectiveness of high- vs low-fidelity simulation for clinical skill development	Only six heterogeneous studies; no definitive conclusions regarding superiority of fidelity level	Evidence limited; need for standardized designs and comparable outcome measures
Macauley et al. (2017)	Assess impact of simulation-based learning on clinical decision-making (CDM), clinical reasoning (CR), and critical thinking (CT)	Several studies showed improvements in CDM, CR, and CT compared with traditional teaching; measurable changes detected using standardized tools	Simulation can enhance higher-order cognitive skills; standardized assessment tools recommended
Pritchard et al. (2016)	Examine impact of standardized patient (SP) interaction in entry-level PT education	No significant difference when up to 25% of placement replaced by SPs; SPs perceived as more realistic and valuable than peer role-play; improved post-test scores in pre–post studies	SPs are educationally valuable; optimal proportion of substitution unclear; cost considerations noted
Ryall et al. (2016)	Evaluate simulation as an assessment tool for technical skills	High-fidelity simulators showed good reliability and validity; reliability improved with increased scenarios; simulation and written exams assess different constructs	Combine simulation with written assessments; avoid sole reliance on SP-based evaluation
Wang et al. (2016)	Investigate serious games for healthcare education	79% of serious games identified as valid teaching tools; applicable to multiple health disciplines	Serious games represent a valid adjunct teaching modality
Mori et al. (2015)	Examine impact of simulation-based learning experiences in entry-level PT curricula	Improved skill development, ICU clinical reasoning, reduced anxiety; potential to replace up to 25% of clinical internship without impairing learning	Simulation can partially substitute clinical hours; further rigorous trials required
Rezayi et al. (2022)	Evaluate effectiveness of computerized simulation tools in physiotherapy education	Statistically significant improvements in knowledge, professional behavior, confidence, and stress reduction; small sample sizes common	Computerized simulation is effective; larger samples and longer follow-up needed
Stockert et al. (2022)	Map literature on simulation-based education in PT	Rapid growth in publications; limited funding; inconsistent reporting of standardized outcomes	Need for higher methodological rigor, longitudinal impact evaluation, and cost-effectiveness studies

computer-generated graphics as if they were physically present. In rehabilitation, this technology bridges the gap between abstract anatomy and functional activities (Modlin and Kuo 2025). Educational applications range from head-mounted displays that provide X-ray vision of skeletal structures on a body, to screen-based mirrors that track real-time movement to display internal organs, and projection-based systems which project muscles or bones directly onto a patient to enhance clinician-patient communication. While these tools significantly improve spatial visualization and student engagement through gamified identification tasks, their implementation must carefully consider hands-on nature of rehabilitation, ensuring that hardware does not act as a physical barrier between the therapist and the patient (Kelly et al. 2018).

2.5. Hybrid / Multimodal Approaches

Hybrid simulations represent the most integrated tier of modern clinical training, merging distinct simulation modalities to create a comprehensive learning experience. By combining different tools such as standardized patient interacting alongside a high-fidelity mannequin or a part-task trainer, educators can bridge the gap between isolated skill acquisition and complex clinical practice (Zackoff et al. 2021). This multimodal approach is specifically designed to target the dual requirements of professional competence, including technical skills, which involve the clinical adequacy of medical interventions, and non-technical skills, which encompass the decision-making, teamwork, and communication processes essential during crisis management (Sivrikaya and Gonenli 2024).

3. Targeted Learning Domains & Outcomes

Simulation-assisted teaching in rehabilitation sciences is a dynamic, cyclical process that moves beyond rote memorization to provide professional competency. The integration the three core phases of simulation including pre-briefing (establishing goals and a safe psychological environment), the briefing (the active simulation encounter), and the debriefing (reflective dialogue) can help the educators to target specific learning domains essential for clinical preparedness (Levett-Jones and Lapkin 2012; Mariani et al. 2013).

In the psychomotor domain, simulation provides a controlled environment for the acquisition of knowledge and the enhancement of manual skill. By using various modalities like part-task trainers or video-based cases, students can refine technical interventions without the risk of incurring potential errors with real users. This repetitive practice is vital for building the muscle memory required for safe patient handling and complex physical assessments (Mariani et al. 2013).

Clinical reasoning (CR) is a foundational, complex process that integrates cognitive, psychomotor, and affective skills. In rehabilitation, CR is a collaborative approach to patient management that considers the context of the situation and the perspectives of both the therapist and the client. Simulation allows educators to intentionally grade the complexity of cases to support the transition from theory to practice. This intentional scaffolding helps students navigate uncertainty and make high-stakes decisions in a safe space, preparing them for the challenges of clinical fieldwork (Murphy and Radloff 2019).

Simulation-based learning is significantly impacted by affective domains that encompass empathy and professional identity. Following clinical simulations, students frequently report greater satisfaction and self-confidence (Mori et al. 2015). The debriefing phase is particularly critical as it is the stage that most effectively allows for the transfer of learning into routine practice. By investigating their own actions and thoughts during a dialogue with instructors, students develop the self-efficacy necessary for effective patient-centered care. Finally, by utilizing case-based learning across a curriculum, rehabilitation programs ensure that foundational knowledge is not only acquired but retained. Whether through immersive VR or standardized patients, these context-rich scenarios provide the cognitive anchors needed to link academic theory to real-world clinical operations (Mori et al. 2015).

4. Evidence of Effectiveness

The effectiveness of simulation-assisted learning in rehabilitation education has been explored across multiple modalities, including high-fidelity simulation, standardized patients, virtual reality, serious games, and computerized platforms. Although methodological heterogeneity and limited longitudinal data persist, the cumulative literature suggests that simulation-based educational interventions are at least equivalent to traditional teaching approaches for skill acquisition and frequently superior with respect to learner confidence, satisfaction, and preparedness (Table 1).

A mixed-methods systematic review by (Brown et al. 2021) examining high-fidelity simulation using computerized mannequins in acute cardiorespiratory physiotherapy found a small, statistically non-significant effect on short-term clinical performance (4–6 weeks post-intervention). However, improvements in self-efficacy and learner confidence were reported, alongside qualitative evidence indicating enhanced familiarity with clinical environments and patient safety practices.

In relation to SPs, (Pritchard et al. 2016) reported no significant difference in pooled learning outcomes when up to 25% of clinical placement time was replaced with SP interaction. Nevertheless, learners perceived SP encounters as more authentic and educationally valuable than peer role-play, and improvements were seen in post-intervention scores in pre–post study designs. While cost considerations were noted as a potential barrier, SP-based activities were considered pedagogically meaningful. Besides this comparative evidence between high- and low-fidelity simulation remains limited. In a systematic review conducted by (Roberts and Cooper 2019), only six heterogeneous studies were found, and it was concluded that variability in design and outcomes precluded definitive conclusions regarding superiority of fidelity level for clinical skill development.

With regards to transfer of learning from simulated environments to real-world clinical performance, (Mori et al. 2015) reported that simulation learning experiences in physiotherapy education enhanced clinical reasoning, skill development in intensive care contexts, and reduced anxiety related to internships. In another study by (Ryall et al. 2016) it was demonstrated that high-fidelity human patient simulators can provide reliable and valid assessment of technical competencies, particularly when multiple scenarios are used. They also recommend combining simulation with written examinations to capture both knowledge and psychomotor skills.

While studying the effectiveness of digital and computer-based simulations, (Rezayi et al. 2022) reported statistically significant improvements in knowledge, professional behaviors, self-confidence, and stress reduction among physiotherapy students. Similarly, (Wang et al. 2016) reviewed serious games for health professions education and concluded that approximately four-fifths of evaluated games constituted valid teaching interventions. While many applications targeted medical and nursing learners, certain programs were directly applicable to rehabilitation contexts, including anatomy and pathology training relevant to physiotherapy.

A scoping review by (Stockert et al. 2022) documented a marked increase in simulation-related publications in physical therapy education over the past decade, particularly following the publication of international simulation standards. Despite this growth, funding for simulation research remains limited, and reporting of standardized outcome measures is inconsistent. One of the most critical findings in recent rehabilitation research is the potential for simulation to replace traditional clinical placement hours. Both (Mori et al. 2015) and (Pritchard et al. 2016) provided evidence that SBE could replace up to 25% of a clinical internship without impairing student learning or competency.

These studies suggest that while methodological limitations restrict definitive conclusions, the cumulative findings support simulation as a pedagogically sound and increasingly integral component of contemporary rehabilitation education.

5. Implementation Considerations & Challenges

Despite their transformative potential for rehabilitation sciences, the widespread adoption of simulation-assisted teaching is governed by significant logistical, financial, and pedagogical challenges. The transition from a traditional apprenticeship model to a simulation-enhanced curriculum not only requires technological acquisition but it demands a fundamental shift in institutional resources and faculty expertise (Elendu et al. 2024). One of the most prominent challenges is the high cost of simulation equipment. Establishing and maintaining high-fidelity programs requires substantial financial investment as a single high-fidelity mannequin can cost upwards of $50,000, excluding additional expenses for software, specialized facilities, and ongoing technical maintenance (Elendu et al. 2024). VR systems, while increasingly portable, still demand significant investment in hardware and specialized IT support. These financial burdens can be prohibitive for institutions with limited budgets, particularly in resource-limited settings, potentially creating a divide in the quality of education available to students (Murphy and Radloff 2019).

The efficacy of simulation hinges less on the technology itself and more on the skills of the instructors. Faculty must be adapted not only to operating complex equipment but also in the facilitating students through structured debriefing. However, providing this level of instruction requires comprehensive, time-consuming training for faculty to ensure they can create a psychologically safe environment while still challenging student reasoning. Institutions must prioritize continuous professional development to prevent a disconnection between the available technology and the quality of the learning experience (Higham et al. 2020).

A recurring debate in simulation literature is the effectiveness of fidelity in comparison to the educational value. While high-fidelity mannequins and VR provide total immersion, they cannot fully replicate the unpredictability and emotional stress of real clinical practice, such as the variability of patient responses or the chaotic nature of a live healthcare team. There is a concern that the controlled nature of simulation may not fully prepare learners for the dynamic environments of actual patient care. This gap underscores the need for longitudinal research to determine if skills learned in a simulated lab translate to sustained behavioral changes and improved patient outcomes in real-world settings (Datta et al. 2012).

6. Discussion

The review of current evidence suggests that simulation-assisted teaching is no longer a theoretical concept, but a core pedagogical pillar in rehabilitation sciences. Simulations ranging from low-fidelity task trainers to immersive VR are effective in enhancing student confidence, clinical reasoning, and psychomotor proficiency. In alignment with broader health professions literature, rehabilitation-specific literature demonstrates that simulated environments can replace significant portions of traditional clinical hours without compromising learner competency. This parallels trends in nursing and medicine, where simulation has long been validated as a primary tool for ensuring patient safety and procedural mastery.

A notable strength of the current literature is the increase in studies recently providing a diverse array of modalities tailored to rehabilitation, such as specialized AR systems for gait and anatomy visualization. However, the evidence base is not without significant limitations. Much of the current research relies on small sample sizes and exhibits high heterogeneity in simulation design. Furthermore, while short-term gains in student satisfaction and knowledge acquisition are well-documented, there are no longitudinal studies exploring the long-term transfer of these skills to authentic clinical practice.

6.1. Future Research Directions

To achieve meaningful educational transformation, future research must move beyond measuring immediate learner satisfaction and focus on systemic and long-term impacts. Among this there is a critical need for rigorous experimental designs utilizing validated outcome measures, such as the Assessment of Physiotherapy Practice (APP), to provide more generalizable data on simulation-assisted learning efficacy (Dalton et al. 2012). Research must be conducted on mapping the developmental trajectory of competencies, especially patient education skills across different career stages to determine if simulation leads to sustained improvements in patient outcomes. As high-fidelity systems are highly expensive, efforts should be made to explore cost-benefit analyses and scalable solutions for resource-limited settings. Initiatives must focus on adapting simulation to diverse cultural and linguistic contexts to ensure equitable access. One of the major advancements in recent times is artificial intelligence (AI) which has the potential to revolutionize simulation-assisted learning by offering personalized, adaptive training programs. AI-driven simulations can analyze performance data in real time to tailor scenarios to a learner's specific needs, while advancements in VR/AR will continue to enhance the situational awareness and immersion of these experiences (Komasawa and Yokohira 2023).

7. Conclusion

Simulation-assisted teaching has transitioned from an experimental novelty to an important component of modern rehabilitation education. By integrating a spectrum of modalities from low-fidelity task trainers and role play to high-fidelity mannequins and immersive AR/VR environments, rehabilitation programs can provide a safe, structured, and ethically sound bridge between theoretical classroom learning and authentic clinical practice. The evidence suggests that when implemented through a rigorous cycle of pre-briefing, active simulation, and reflective debriefing, these methods not only enhance psychomotor proficiency and clinical reasoning but also foster the self-efficacy and empathy essential for patient-centred care. Evidence from literature over the past decade highlights the potential of simulation to improve the global shortage of clinical placements, with evidence supporting the substitution of up to 25% of traditional internship hours. The integration of AI and adaptive learning technologies promises to personalize the educational trajectory for every student. Ultimately, the goal of simulation in rehabilitation is to ensure that every graduate enters the workforce not just with knowledge, but with the clinical wisdom and technical fluency required to maximize patient safety and functional recovery in a complex healthcare landscape.

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Emaan Malik contributed to the conceptualization and initial drafting of this review article, Aneeza Zara contributed to critical revision and refinement of the manuscript. Both authors approved the final version.

Data Availability
All the data relevant to this study is with the authors.

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References
Al-Elq, Abdulmohsen H. 2010. "Simulation-Based Medical Teaching and Learning." Journal of Family and Community Medicine 17 (1): 35–40.

Battista, Alexis. 2020. "Situated Learning Theory in Health Professions Education Research: A Scoping Review." Advances in Health Sciences Education 25 (2): 483–509.

Bragard, Isabelle, Nesrine Farhat, Marie-Christine Seghaye, et al. 2019. "Effectiveness of a High-Fidelity Simulation-Based Training Program in Managing Cardiac Arrhythmias in Children: A Randomized Pilot Study." Pediatric Emergency Care 35 (6): 412–418.

Brown, L., E. Ilhan, V. Pacey, et al. 2021. "The Effect of High-Fidelity Simulation–Based Learning in Acute Cardiorespiratory Physical Therapy—A Mixed-Methods Systematic Review." Journal of Physical Therapy Education 35 (2): 146–158.

Dalton, Megan, Megan Davidson, and Jennifer L. Keating. 2012. "The Assessment of Physiotherapy Practice (APP) Is a Reliable Measure of Professional Competence of Physiotherapy Students: A Reliability Study." Journal of Physiotherapy 58 (1): 49–56

Datta, Rashmi, K. K. Upadhyay, and C. N. Jaideep. 2012. "Simulation and Its Role in Medical Education." Medical Journal Armed Forces India 68 (2): 167–172.

Dhar, Eshita, Umashankar Upadhyay, Yaoru Huang, et al. 2023. "A Scoping Review to Assess the Effects of Virtual Reality in Medical Education and Clinical Care." Digital Health 9: 20552076231158022.

Elendu, Chukwuka, Dependable C. Amaechi, Alexander U. Okatta, et al. 2024. "The Impact of Simulation-Based Training in Medical Education: A Review." Medicine 103 (27): e38813.

Ericsson, K. Anders. 2008. "Deliberate Practice and Acquisition of Expert Performance: A General Overview." Academic Emergency Medicine 15 (11): 988–994.

Garg, Joshua, and Thomas McLelland. 2025. "Introducing Low-Fidelity Simulation Teaching in the Early Years of Undergraduate Medical Training." Cureus 17 (8): e89521.

Greenwood, Kristin Curry, and Sara B. Ewell. 2018. "Faculty Development Through Simulation-Based Education in Physical

Therapist Education." Advances in Simulation 3 (1): 1.

Higham, Helen. 2020. "Simulation Past, Present and Future—A Decade of Progress in Simulation-Based Education in the UK." BMJ Simulation & Technology Enhanced Learning 7 (5): 404.

Kelly, David, Thuong N. Hoang, Martin Reinoso, et al. 2018. "Augmented Reality Learning Environment for Physiotherapy Education." Physical Therapy Reviews 23 (1): 21–28.

Kolb, David A. 2014. Experiential Learning: Experience as the Source of Learning and Development. FT Press.

Komasawa, Nobuyasu, and Masanao Yokohira. 2023. "Simulation-Based Education in the Artificial Intelligence Era." Cureus 15 (6): e40304.

Levett-Jones, Tracy, and Samuel Lapkin. 2012. "The Effectiveness of Debriefing in Simulation-Based Learning for Health Professionals: A Systematic Review." JBI Evidence Synthesis 10 (51): 3295–3337.

Manuaba, Ida Bagus Amertha Putra, Made Violin Weda Yani, Anak Agung Bagus Putra Indrakusuma, et al. 2026. "Integrating Simulation, Role-Play, and Technology in Physiotherapy Education: A Narrative Review on Teaching Methods for Patient Education." Physical Therapy Journal of Indonesia 7 (1): 25–34.

Mariani, Bette, Mary Ann Cantrell, Colleen Meakim, et al. 2013. "Structured Debriefing and Students' Clinical Judgment Abilities in Simulation." Clinical Simulation in Nursing 9 (5): e147–e155.

Modlin, Deiadra, and Yu-Tung Kuo. 2025. "The Effects of Using Augmented Reality in Rehabilitation and Recovery Exercise on Patients' Outcomes and Experiences: A Systematic Review." Frontiers in Virtual Reality 6: 1641316.

Mori, Brenda, Heather Carnahan, and Jodi Herold. 2015. "Use of Simulation Learning Experiences in Physical Therapy Entry-to-Practice Curricula: A Systematic Review." Physiotherapy Canada 67 (2): 194–202.

Murphy, Lynne F., and Jennifer C. Radloff. 2019. "Using Case-Based Learning to Facilitate Clinical Reasoning Across Practice Courses in an Occupational Therapy Curriculum." Journal of Occupational Therapy Education 3 (4): 3.

Murphy, Lynne F., and Jennifer C. Radloff. 2019. "Using Case-Based Learning to Facilitate Clinical Reasoning Across Practice Courses in an Occupational Therapy Curriculum." Journal of Occupational Therapy Education 3 (4): 3.

Nestel, Debra, and Margaret Bearman. 2014. Simulated Patient Methodology: Theory, Evidence and Practice. John Wiley & Sons.

Pritchard, Shane A., Felicity C. Blackstock, Debra Nestel, et al. 2016. "Simulated Patients in Physical Therapy Education: Systematic Review and Meta-Analysis." Physical Therapy 96 (9): 1342–1353

Rassie, Kate. 2017. "The Apprenticeship Model of Clinical Medical Education: Time for Structural Change." The New Zealand Medical Journal 130 (1461): 66.

Roberts, Fiona, and Kay Cooper. 2019. "Effectiveness of High Fidelity Simulation Versus Low Fidelity Simulation on Practical/Clinical Skill Development in Pre-registration

Physiotherapy Students: A Systematic Review." JBI Evidence Synthesis 17 (6): 1229–1255.

Ryall, Tayne, Belinda K. Judd, and Christopher J. Gordon. 2016. "Simulation-Based Assessments in Health Professional Education: A Systematic Review." Journal of Multidisciplinary Healthcare 9: 69–82.

Scalese, Ross J., Vivian T. Obeso, and S. Barry Issenberg. 2008. "Simulation Technology for Skills Training and Competency Assessment in Medical Education." Journal of General Internal Medicine 23 (Suppl 1): 46–49.

Singh, Maninder, and Andrew Restivo. 2023. "Task Trainers in Procedural Skills Acquisition in Medical Simulation." In StatPearls [Internet]. StatPearls Publishing.

Sivrikaya, G. Ulufer, and M. Gokhan Gonenli. 2024. "Medical Simulation: The Vision of Learning in Healthcare." Medical Research Archives 12: 10–18103.

Smith, Susan N., and Amy F. Crocker. 2017. "Experiential Learning in Physical Therapy Education." Advances in Medical Education and Practice 8: 427–433.

Stockert, Brad, Nicki Silberman, Jason Rucker, et al. 2022. "Simulation-Based Education in Physical Therapist Professional Education: A Scoping Review." Physical Therapy 102 (12): pzac133.

Wilson, Ian, Leanne S. Cowin, Maree Johnson, et al. 2013. "Professional Identity in Medical Students: Pedagogical Challenges to Medical Education." Teaching and Learning in Medicine 25 (4): 369–373.

Zackoff, Matthew W., Daniel Young, Rashmi D. Sahay, et al. 2021. "Establishing Objective Measures of Clinical Competence in Undergraduate Medical Education Through Immersive Virtual Reality." Academic Pediatrics 21 (3): 575–579.

Zhang, Jun. 2017. "Perceptions of Simulation-Assisted Teaching Among Baccalaureate Nursing Students in Chinese Context: Benefits, Process and Barriers." Journal of Professional Nursing 33 (4): 305–310.management." *American family physician* no. 94 (12):993-999.

Zaralieva, A., G. P. Georgiev, V. Karabinov, A. Iliev, and A. Aleksiev. 2020. "Physical Therapy and Rehabilitation Approaches in Patients with Carpal Tunnel Syndrome." *Cureus* no. 12 (3):e7171. doi: 10.7759/cureus.7171.

Zubair, Muhammad, Perviz Khan, Uzair Ahmad, Syed Zain Ul Abidin, Saeed Ullah Shah, and Abeer Kazmi. 2022. "Frequency of Carpal Tunnel Syndrome Among Dentists Working in Tertiary Care Hospitals of Peshawar, Pakistan." *Ann Jinnah Sindh Med Uni* no. 8 (1).