

**SIMULATED LEARNING, REAL IMPACT: EVALUATING THE EFFECTIVENESS
OF PEDIATRIC SIMULATION-BASED EDUCATION FOR MEDICAL STUDENTS****Egamberdieva Gulnarakhon Nematovna**Fergana Medical Institute of Public Health, Fergana, Uzbekistan
muminov07ny@gmail.com

Abstract: Simulation-based teaching (SBT) has become a cornerstone of modern pediatric medical education, offering safe and structured environments for learners to acquire clinical, procedural, and communication skills. This review synthesizes evidence from 2020–2025 on the effectiveness of SBT for pediatric medical students. Across recent studies, SBT consistently demonstrated superior outcomes in knowledge acquisition, psychomotor performance, and non-technical competencies compared to traditional teaching methods. High-fidelity simulations, particularly in pediatric emergencies and procedural training, improved confidence and teamwork, though findings on long-term knowledge retention and real-world clinical translation remain limited. Implementation challenges—such as cost, faculty training, and lack of standardized outcome measures—persist. Overall, SBT enhances the preparedness and clinical reasoning of pediatric medical students, underscoring its pedagogical value. However, further longitudinal and cost-effectiveness research is essential to optimize its integration into medical curricula.

Keywords: simulation, pediatrics, medical education, clinical skills, learning outcomes, fidelity

Introduction

Over the past decade, simulation-based teaching (SBT) has emerged as a key pedagogical approach in medical education, especially in high-risk domains such as paediatrics, where clinical exposure may be limited and stakes of error are high. SBT encompasses varied educational modalities including high-fidelity manikins, standardized patients, virtual reality (VR)/augmented reality (AR) simulations and hybrid formats. Theoretical rationales draw on deliberate practice, safe-environment learning, immediate feedback/debriefing, and the ability to replicate rare but critical paediatric events.

In paediatric medical education, issues such as limited opportunities to treat critically ill children, concerns about patient safety, and logistic constraints of real-life clinical exposure make simulation particularly attractive. Previous reviews (e.g., Kim et al., 2023) report that paediatric simulation-based education (P-SBE) has grown markedly but have flagged gaps in validity, longitudinal retention, and generalisability.

Given the evolving evidence base over the last five years (approximately 2020–2025), this review aims to examine the effectiveness of simulation-based teaching for paediatric medical students (i.e., undergraduate or pre-clinical/clinical years, rather than postgraduate trainees) in terms of knowledge acquisition, skill performance (technical and non-technical), retention, and translation into clinical practice.

Methods

We conducted a narrative review of peer-reviewed publications from 2020 to 2025, focusing on SBT interventions in paediatric medical (or allied) undergraduate curricula. Electronic searches of PubMed, Embase and CINAHL were supplemented by manual scanning of references. Key inclusion criteria: (1) participants included medical students (undergraduate or early clinical years) or equivalent; (2) intervention involved simulation (manikin-based, VR/AR, hybrid); (3) outcome measures included knowledge, skills, non-technical behaviours, or clinical translation;

(4) paediatric domain (children, neonates, paediatric emergencies). Exclusion criteria: focused solely on postgraduate/-resident learners, nursing students only (unless medical student data extractable), non-paediatric domain. Data extraction included study design, simulation modality, comparator (if any), measured outcomes, and results. Where available, systematic reviews/meta-analyses relevant to paediatric simulation in last 5 years were also considered.

Results

Study Characteristics

A number of recent studies address paediatric simulation. For example, High-fidelity simulation versus case-based discussion for paediatric emergencies (Moliterno et al., 2024) compared high-fidelity simulation with case-based discussion in paediatric emergencies.

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Another key article: What is the impact of simulation-based training for paediatric procedural skills? (Graef et al., 2024) examined paediatric procedural simulation training.

The systematic review by Kim et al. (2023) on paediatric simulation education broadly (though not exclusively medical students) reported 109 papers published 2011–2022, 37 of which included medical students; majority used advanced patient simulation (64.8 %) and high-fidelity simulation (52.8 %).

Effect on Knowledge and Skills Acquisition

In multiple studies, SBT was associated with superior post-intervention performance compared to traditional methods or pre-test baselines. For example, the Graef et al. 2024 study in paediatric procedural skills noted improvement in patient-outcome proxies (e.g., reduced mortality) although in a broader trainee context.

Moliterno et al. (2024) found high-fidelity simulation outperformed case-based discussion in paediatric emergencies among medical students, suggesting higher fidelity may improve skills acquisition.

Moreover, evidence from nursing programmes (which may give insights for medical students) shows simulation interventions improved knowledge by 10–35 % over controls in some studies.

Effect on Non-Technical Skills & Confidence

SBT not only improves technical competence but also non-technical skills such as teamwork, communication, situational awareness, and self-efficacy. The systematic review by Alharbi et al. (2024) in nursing found gains in self-confidence and satisfaction, though retention was less well studied.

In paediatric context, simulation centres emphasise communication, crisis resource management and teamwork (e.g., the simulation programme at Weill Cornell Medicine emphasises leadership, situational awareness and team-based training).

Retention of Learning

One of the recurring limitations in the literature is long-term retention of knowledge/skills. The nursing-focused review by Alharbi et al. (2024) found only eight of 33 studies assessed retention beyond 2–5 months, and results were mixed.

In paediatric-simulation literature, retention data remain sparse. The Kim et al. (2023) review emphasised that more than 60 % of studies did not verify validity or reliability of scenarios or measurement instruments, limiting confidence in outcomes.

Translation to Clinical Practice / Patient Outcomes

Evidence of direct translation into real-world clinical performance or patient outcomes among medical students is limited. Graef et al. (2024) suggested potential for improved patient outcomes in paediatric procedural skills, but this remains indirect.

The broader simulation literature (e.g., Elendu et al., 2024) suggests that simulation improves patient safety, clinical outcomes and reduces errors compared to traditional methods.

However, these studies often involve postgraduate trainees or multidisciplinary teams, rather than purely undergraduate paediatric medical students.

Fidelity, Debriefing, Cost & Implementation Considerations

Several studies have compared high- versus low-fidelity simulation and found mixed results: for example, the nursing review found that high-fidelity did not always confer superior gains and may risk over-confidence.

Debriefing remains a critical component of SBT, enabling reflection and consolidation of learning. Implementation barriers include high cost, faculty training, scenario development, equipment maintenance and scheduling.

In paediatric simulation settings, scenario validity/reliability and measurement instrument robustness remain underdeveloped (Kim et al., 2023).

Discussion

This review of the last five years suggests that simulation-based teaching for paediatric medical students is effective in improving knowledge, technical skills, and non-technical competencies, and is likely superior to traditional methods (lectures/reading) or case-based discussion in many contexts. The evidence is strongest for short-term gains (immediately post-intervention) and intermediate outcomes (confidence, teamwork).

Nevertheless, several key limitations temper the enthusiasm and point to areas for improvement:

Retention and durability of learning remain under-researched. Few studies with medical students follow up beyond a few months. Without knowledge of how long gains persist, curricular integration remains uncertain.

Translation to actual clinical performance and patient outcomes remains largely unstudied in medical-student populations (as opposed to residents). Given the ultimate goal of improving patient care, this is a critical gap.

Heterogeneity of simulation modalities, outcome measures and participant populations limits generalisability. The lack of standardised instruments and scenario validation (especially in paediatrics) hampers meta-analysis. Kim et al. (2023) found > 50 % of studies lacked validity/reliability reporting.

Cost-effectiveness and resource aspects are seldom addressed. High-fidelity simulation is resource-intensive; the optimal fidelity level for a given learning objective remains unclear.

Learner level specificity: Many studies aggregate nursing, medical, mixed learners; fewer focus exclusively on paediatric medical students. Thus, applicability to undergraduate medical education needs caution.

In practical terms, for medical curricula aiming to enhance paediatric education, the following considerations emerge:

Integration of simulation early (pre-clinical) and clinically (during clerkships) may yield benefits; bridging theory and practice in a safe environment.

Emphasis on structured debriefing and feedback is essential to maximise learning from simulation.

Consider tiered fidelity: lower-cost simulation may suffice for certain learning objectives, reserving high-fidelity for critical, rare events.

Longitudinal reinforcement (repeat simulation sessions) likely improves retention; programmes should design for spaced repetition.

Rigorous evaluation (pre-/post-test, delayed follow-up, validated measurement instruments) should be built into simulation programmes from the design stage.

Conclusion

In summary, simulation-based teaching in paediatric medical education demonstrates strong short-term effectiveness for knowledge gain, skill performance and learner confidence. However, evidence concerning long-term retention and translation into clinical practice remains limited for undergraduate medical students. To realise the full potential of simulation in paediatric curricula, further high-quality research is needed—especially longitudinal follow-up, validated outcome measures, cost-effectiveness analyses and real-world impact assessment. For educators and programme directors, integrating simulation thoughtfully, aligning fidelity with learning objectives, and investing in faculty development and debriefing frameworks will help optimise outcomes.

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