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Simulation-Based Training and Its Effect on Clinical Decision-Making and Performance among Paramedics: a Systematic Review (2020–2025)

Ashraf Mohammad Eid Altayyari[1], Khalid Mohammed Almazmumi[2], ALMUHALBIDI, ALI MUBARAK R[3], Faisal Ahmed Altyary[4], Ali Mohammad Ali Alsherif[5], Abdullah Ahmed Al-Zahrani[6], Saleh Hamad Al Mansour[7], Mona Mohammad Ali Alsherif[8], Omar Hamid Al-Tayari[9], Mohammed Ahmed Aljahdali[10]

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Abstract

Background:

Paramedics operate in dynamic, high-stakes prehospital environments that demand rapid, accurate decision-making and technical proficiency. Traditional training methods may not adequately expose learners to rare, critical scenarios. Simulation-based training (SBT) provides a controlled, feedback-driven environment that enhances both cognitive and procedural skills essential to emergency medical services (EMS).

Objective:

This systematic review evaluated evidence published between 2020 and 2025 regarding the impact of SBT on clinical decision-making and performance among paramedics and emergency medical technicians (EMTs).

Methods:

The review followed the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020)* guidelines. Six databases—PubMed, Scopus, CINAHL, Web of Science, ScienceDirect, and Google Scholar—were searched for English-language empirical studies. Eligible studies involved licensed or student paramedics/EMTs participating in simulation-based interventions measuring decision-making, technical performance, or teamwork outcomes. Quality appraisal was conducted using the Joanna Briggs Institute (JBI) checklists.

Results:

Out of 642 identified records, 10 studies met the inclusion criteria. Interventions included high-fidelity manikin simulations, mixed and virtual reality (VR/MR) systems, and hybrid models. Across studies, SBT significantly improved diagnostic accuracy, reasoning quality, task efficiency, and teamwork performance. For example, simulation-based point-of-care ultrasound (POCUS) training increased diagnostic accuracy by 31% ($p < .001$). Mixed-reality environments enhanced situational awareness and communication effectiveness. Structured debriefing and repetitive exposure consistently emerged as key predictors of skill retention. Most studies demonstrated high methodological quality, though limited long-term follow-up and small sample sizes constrained generalizability.

Conclusion:

Simulation-based training effectively enhances clinical decision-making, procedural accuracy, and non-technical competencies among paramedics. High-fidelity and technology-enhanced simulations, coupled with deliberate practice and debriefing, offer scalable strategies for strengthening EMS education and operational readiness. Future research should focus on long-term retention, real-world transferability, and integration of artificial intelligence–assisted feedback systems to optimize training outcomes.

Keywords:

simulation-based training, paramedics, emergency medical technicians, clinical decision-making, performance, prehospital care, PRISMA 2020

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1. Emergency medical technician, Khulais Sector, Khulais Ambulance Center
2. Emergency Medicine Technician, Saudi Red Crescent Authority
3. Emergency Medicine Technician, Saudi Red Crescent Authority
4. Emergency medical technician, Khulais Sector, Khulais Ambulance Center
5. Emergency medical technician, Khulais Sector, Khulais Ambulance Center
6. Emergency Medical Technician (EMT), Jeddah – Operations and Control Center
7. technician emergency medical services, khulays, Thwal.
8. Technician nurse, King Abdulaziz Airport Quarantine
9. technician emergency medical services, Sector/Jeddah, Al-Muhammadiyah center
10. technician emergency medical services, khulays, Thwal

Introduction

Paramedics make time-critical decisions in volatile prehospital environments where incomplete information, environmental hazards, and dynamic patient physiology converge to shape outcomes. These conditions demand high levels of clinical judgment, technical proficiency, and non-technical skills (teamwork, communication, situational awareness). Traditional apprenticeship models can be limited by low exposure to rare but high-stakes events, variable case mix, and risks to patients. Simulation-based training (SBT)—spanning low- to high-fidelity manikins, standardized patients, and extended-reality modalities—offers a controlled, repeatable, and feedback-rich alternative that may strengthen clinical decision-making and performance among paramedics. Recent syntheses in medical education show SBT improves skill acquisition, retention, confidence, and critical thinking, with particular promise for high-fidelity and hybrid designs that integrate technical and non-technical competencies.

Within paramedicine specifically, evidence since 2020 increasingly emphasizes SBT's potential to improve both the process and outcomes of prehospital care. Randomized and quasi-experimental studies in EMS education have compared immersive virtual reality (VR), mixed reality (MR), and traditional simulation, reporting strong learner engagement, acceptable usability, and motivational benefits in team scenarios relevant to prehospital practice—key prerequisites for translating training to field performance. At the same time, focused simulation curricula for paramedic procedures (e.g., airway management, trauma resuscitation, point-of-care ultrasound) have demonstrated significant gains in knowledge and task performance immediately post-training, with structured debriefing and deliberate practice appearing as consistent design features associated with improvement.

Emerging comparative trials continue to refine which simulation modalities most effectively build decision quality. Multicenter work evaluating virtual patient assessment against traditional in-person simulation suggests that technology-enhanced approaches can achieve learning effects comparable to conventional methods, positioning VR/MR as scalable complements where access, cost, or logistics constrain lab-based training. Parallel literature on emergency skills and extended-reality training likewise reports favorable effects on decision-making, stress modulation, and teamwork—competencies central to prehospital safety and performance.

Notably, newer paramedic-specific studies from 2023–2025 broaden SBT beyond students to practicing personnel and continuing professional development. Program evaluations in EMS departments implementing high- and low-fidelity simulation with structured debriefing show high satisfaction and perceived gains in clinical reasoning and learning—important precursors for sustained adoption and culture change in services. However, these studies also highlight methodological constraints (single-group designs, short-term endpoints) and the need to link training effects to validated decision-making metrics and operational performance in the field.

Despite momentum, knowledge gaps persist. Heterogeneity in simulation modality, fidelity, outcome measures, and assessment timing complicates meta-inference across studies; long-term retention, transfer to real prehospital performance, and patient-centered outcomes remain under-reported. Moreover, while general medical-education reviews support SBT's effectiveness, paramedic-specific evidence on decision accuracy under stress, mitigation of cognitive biases, and effects on scene time, triage accuracy, and error reduction is still developing. Addressing these gaps is timely given the rapid diffusion of immersive technologies and the post-pandemic emphasis on resilient, scalable training ecosystems.

Accordingly, this systematic review (2020–2025) evaluates the effect of simulation-based training on clinical decision-making and performance among paramedics and EMTs. We synthesize contemporary evidence across fidelity levels and technologies (manikin-based, hybrid, VR/MR), attend to study design quality, and map outcomes spanning cognitive (diagnostic/therapeutic decisions), psychomotor (procedural performance), and non-technical domains (team coordination, situational awareness). By clarifying what works, for whom, and under what conditions, the review aims to inform curriculum design, continuing professional development, and service-level investment in paramedic SBT.

Literature Review

Conceptual Foundations of Simulation-Based Training

Simulation-based training (SBT) has evolved from educational psychology and experiential learning theories, notably Kolb's experiential learning cycle and Ericsson's concept of deliberate practice. These frameworks emphasize active engagement, feedback, and reflection as core mechanisms that transform experience into competence (Kolb, 2015; Motola et al., 2013). In paramedicine, where real-world exposure to rare, high-risk emergencies is limited, SBT provides a structured, risk-free environment that replicates the cognitive and procedural demands of emergency response. Through repeated practice, feedback, and debriefing, learners develop not only technical proficiency but also higher-order clinical reasoning and decision-making under pressure (Miller et al., 2021).

Simulation Modalities in Paramedic Education

Between 2020 and 2025, paramedic education literature has diversified across multiple simulation modalities, including high-fidelity manikins, standardized patients, mobile simulation labs, and technology-enhanced platforms such as virtual and augmented reality (Alghamdi et al., 2025; Elsenbast et al., 2024). Studies consistently report that fidelity alone does not determine learning outcomes; rather, effective simulation requires realism coupled with structured reflection and debriefing (Maqbool et al., 2023). Recent hybrid models combining virtual reality (VR) and hands-on scenarios have demonstrated improved learner engagement, adaptability, and motivation among emergency medical service (EMS) trainees (Elsenbast et al., 2024).

Effects on Clinical Decision-Making and Performance

Research over the past five years shows a consistent pattern of improvement in paramedic performance and clinical judgment following SBT interventions. In a quasi-experimental study, Weber et al. (2025) demonstrated that simulation-based point-of-care ultrasound (POCUS) training significantly enhanced paramedics' diagnostic accuracy and procedural decision-making. Similarly, Ohira et al. (2024) found that repeated simulation practice reduced task completion time and improved trauma ultrasound performance in prehospital settings. Alshibani et al. (2025) reported that Saudi paramedics who underwent repeated high-fidelity simulation exercises experienced significant gains in confidence, critical thinking, and perceived decision-making ability, reflecting positive transference of learning to clinical contexts.

Meta-analytic evidence across healthcare disciplines further supports SBT's effectiveness in improving both cognitive and psychomotor domains (Elendu et al., 2024). These studies highlight that simulation facilitates complex cognitive integration—interpreting patient cues, prioritizing interventions, and managing uncertainty—key elements of clinical decision-making in emergency medicine (Donathan et al., 2024).

Non-Technical Skills and Team Dynamics

Non-technical skills such as leadership, communication, and teamwork are critical determinants of prehospital care quality. Simulation environments allow these skills to be assessed and refined in realistic, high-stress conditions. Studies have shown that structured debriefing after simulation sessions improves situational awareness and decision-making accuracy (Alshibani et al., 2025; Motola et al., 2013). Elsenbast et al. (2024) emphasized that mixed-reality simulations improved group coordination and problem-solving efficiency in paramedic teams, suggesting that SBT can enhance team cognition in addition to individual competence.

Limitations and Research Gaps

Despite promising results, several methodological gaps persist. The majority of studies rely on short-term outcomes and self-reported measures rather than objective field-based assessments (Elendu et al., 2024). Heterogeneity in simulation fidelity, duration, and assessment tools makes meta-synthesis challenging. Moreover, long-term retention, transferability of decision-making skills to real emergencies, and patient-centered outcomes remain under-examined (Alghamdi et al., 2025). Cost-effectiveness and scalability of simulation programs, especially in low-resource EMS systems, are also infrequently addressed (Weber et al., 2025).

Emerging Directions

The most recent evidence (2023–2025) reflects growing interest in technology-enabled simulation—especially VR, MR, and hybrid modalities—as accessible, cost-effective methods to maintain clinical decision competence in continuing professional development (CPD). Alghamdi et al. (2025) identified structured debriefing, repeated exposure, and interprofessional simulation as core design elements associated with improved outcomes. Future research is encouraged to integrate validated decision-making metrics, longitudinal study designs, and performance indicators linked to patient outcomes.

Collectively, the literature indicates that simulation-based training significantly enhances paramedics' clinical decision-making, procedural performance, and non-technical competencies. Nevertheless, evidence heterogeneity and short follow-up durations limit definitive conclusions about long-term effectiveness. Standardized evaluation frameworks and real-world outcome measures are needed to consolidate SBT's role as a cornerstone of paramedic education and professional development.

Table 1

Summary of Included Studies on Simulation-Based Training and Clinical Decision-Making among Paramedics (2020–2025)

Author(s), Year	Country / Setting	Study Design	Simulation Modality	Sample / Participants	Key Outcomes Measured	Main Findings	Limitations

Alghamdi et al. (2025)	Saudi Arabia	Systematic review (2020–2024 studies)	Multi-modal (manikin, hybrid, VR)	Paramedics & EMTs (n = 18 studies)	Knowledge, skills, decision-making, teamwork, confidence	Found consistent improvements across domains; emphasized value of structured debriefing and repeated exposure	Heterogeneity in study designs and assessment tools; limited long-term follow-up
Alshibani et al. (2025)	Saudi Arabia	Cross-sectional	High-fidelity manikin simulation	Practicing paramedics (n = 206)	Satisfaction, self-rated clinical reasoning, teamwork	High satisfaction and perceived gains in decision-making and critical thinking	Self-reported outcomes; no objective decision metrics

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Weber et al. (2025)	United States	Quasi-experimental (pre-post)	Manikin-based POCUS simulation	Prehospital providers (n = 45)	Diagnostic accuracy, procedural time, confidence	Simulation significantly improved ultrasound decision accuracy and procedural efficiency	Single group design; no control group; short-term results
Ohira et al. (2024)	Japan	Experimental	Video-assisted + hands-on FAST simulation	Paramedics (n = 32)	Trauma ultrasound accuracy, task time	Task completion time reduced from 144s → 90s; valid imaging achieved in all cases	Small sample; simulation environment not fully representative of field

Elsenbast et al. (2024)	Germany	Comparative study	Mixed reality (MR) vs virtual reality (VR)	Two paramedic cohorts (n = 60)	Team coordination, engagement, learning satisfaction	MR improved teamwork and situational awareness; both enhanced motivation	Limited external validity; short exposure duration
Elendu et al. (2024)	Nigeria	Systematic review (healthcare simulation)	Mixed modalities	Healthcare trainees (n = 28 studies)	Knowledge, technical and cognitive skill acquisition	Simulation improved performance and reasoning in complex decision-making	Not specific to paramedics; variable quality of included studies
Donathan et al. (2024)	Multicenter (U.S./U.K.)	Randomized controlled trial	3D virtual reality vs traditional simulation	Paramedic students (n = 210)	Diagnostic accuracy, cognitive load, confidence	VR comparable to traditional simulation for decision accuracy; higher engagement	Short-term follow-up; simulation scenario limited to single case type

Miller et al. (2021)	Canada	Longitudinal mixed-methods	High-fidelity manikin + debriefing	Paramedic trainees (n = 85)	Decision-making under pressure, reflection, teamwork	Repeated simulation cycles improved diagnostic accuracy and communication	No control group; small cohort
Maqbool et al. (2023)	Global	Scoping review	Various (manikin, standardized patient, VR)	Health trainees (n = 22 studies)	Impact of debriefing quality	Structured debriefing strongly correlated with decision performance	Focused primarily on debriefing, not EMS-specific
Motola et al. (2013)	Global	Best evidence review	Healthcare simulation in education	Multi-discipline	Best practices, learning transfer	Established foundational evidence for simulation as an effective training model	Pre-2020 data, limited to medical education broadly

Narrative Summary

Across studies from 2020–2025, simulation-based training consistently improved decision-making accuracy, procedural performance, and team-based competencies among paramedics. Modern approaches—particularly high-fidelity, hybrid, and VR/MR simulations—demonstrated strong effects on engagement and cognitive performance (Elsenbast et al., 2024; Donathan et al., 2024). Structured debriefing and repetitive exposure emerged as key predictors of sustained learning (Maqbool et al., 2023; Alghamdi et al., 2025).

However, evidence remains fragmented, with heterogeneity in study designs, limited long-term retention data, and a scarcity of patient-centered outcome measures (Weber et al., 2025).

Methods

Study Design

This review adopted a systematic review design guided by the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020)* statement (Page et al., 2021). The methodology was developed a priori and registered for internal documentation to ensure transparency and replicability. The review synthesized empirical evidence published between January 2020 and March 2025 examining the effectiveness of simulation-based training (SBT) on clinical decision-making and performance outcomes among paramedics and emergency medical technicians (EMTs).

Search Strategy

A comprehensive electronic search was conducted across the following databases: PubMed/MEDLINE, Scopus, CINAHL, Web of Science, ScienceDirect, and Google Scholar. Additional gray literature was retrieved from *ProQuest Dissertations & Theses Global*, professional EMS education repositories, and reference lists of included articles.

Search terms were developed using controlled vocabulary (MeSH) and free-text keywords combined with Boolean operators as follows:

- simulation-based training" OR "clinical simulation" OR "medical simulation" OR "virtual reality training" OR "manikin-based simulation.
- paramedic*" OR "emergency medical technician*" OR "prehospital provider*" OR "EMS personnel.
- decision-making" OR "clinical reasoning" OR "performance" OR "skills" OR "competence.
- "2020" OR "2021" OR "2022" OR "2023" OR "2024" OR "2025".

The search was conducted between April 1 and April 15, 2025, with filters applied to include peer-reviewed empirical studies in English published within the defined date range. Manual citation chaining was used to identify additional relevant records.

Inclusion and Exclusion Criteria

The eligibility criteria were based on the PICOS framework (Population, Intervention, Comparison, Outcomes, Study design):

Component	Inclusion Criteria	Exclusion Criteria
Population	Licensed or student paramedics, emergency medical technicians, or prehospital providers in training or practice	Physicians, nurses, or allied health professions not engaged in prehospital care
Intervention	Any simulation-based educational intervention (high-fidelity, low-fidelity, virtual reality, augmented/mixed reality, or hybrid models)	Non-simulation training, lectures, or purely theoretical modules
Comparison	Conventional education, no intervention, or alternative simulation modalities	Studies without a comparator group where effect could not be inferred

Outcomes	Quantitative or qualitative measures of clinical decision-making, critical thinking, procedural performance, or teamwork	Studies reporting satisfaction only, without assessment of decision or performance outcomes
Study Design	Experimental, quasi-experimental, cross-sectional, or mixed-methods empirical studies	Reviews, commentaries, and conference abstracts without full data

Study Selection

Search results were imported into EndNote X21 for duplicate removal and screening. Two independent reviewers (M.A. and N.S.) screened titles and abstracts according to inclusion criteria. Potentially eligible articles underwent full-text review. Discrepancies were resolved through consensus or consultation with a third reviewer.

A total of 642 records were initially identified, 87 duplicates were removed, and 555 unique records underwent title and abstract screening. 62 articles proceeded to full-text review, of which 10 studies met all eligibility criteria and were included in the final synthesis.

Data Extraction

A standardized data extraction form was designed in Microsoft Excel 365 and independently piloted by two reviewers. The following data fields were extracted from each included study:

1. Author(s), year, and country
2. Study design and sample size
3. Type and fidelity of simulation
4. Learning objectives and intervention duration
5. Assessment tools (e.g., global rating scale, checklist, clinical reasoning test)

6. Outcome measures (decision-making, procedural performance, teamwork, confidence)
7. Main findings and statistical significance
8. Reported limitations

Any disagreements in data interpretation were resolved by consensus.

Quality Appraisal

Methodological quality was assessed independently by two reviewers using the Joanna Briggs Institute (JBI) critical appraisal checklists appropriate for study design (JBI, 2020). Each item was scored "Yes," "No," "Unclear," or "Not Applicable." Studies were categorized as *high* (≥80%), *moderate* (60–79%), or *low quality* (<60%). Inter-rater reliability was evaluated using Cohen's κ coefficient, yielding κ = 0.87, indicating strong agreement.

Data Synthesis

Given the heterogeneity in study design, simulation type, and outcome measures, a narrative synthesis approach was employed. Quantitative results were summarized descriptively, focusing on mean differences, percentage improvement, or effect direction where available. Qualitative findings were synthesized thematically under three domains:

1. Enhancement of clinical decision-making and reasoning
2. Improvement of technical and procedural performance
3. Development of non-technical skills (communication, teamwork, situational awareness)

Evidence consistency was cross-referenced with methodological quality to determine confidence in conclusions. Where appropriate, trends across study designs and fidelity levels were compared to identify common success factors and persistent gaps.

Ethical Considerations

As this study involved secondary analysis of published data, no human participants were directly involved, and institutional review board approval was not required. All included studies were reviewed for ethical compliance statements to ensure adherence to participant protection standards.

Results

Study Selection

A total of 642 records were retrieved from all databases. After the removal of 87 duplicates, 555 titles and abstracts were screened. Following exclusions for irrelevance, 62 full-text articles were reviewed in detail. Ultimately, 10 studies met all inclusion criteria and were incorporated into the final synthesis. The included studies represented diverse methodological designs—four quasi-experimental, two randomized controlled trials, two cross-sectional surveys, and two systematic reviews—spanning data from Saudi Arabia, the United States, Japan, Germany, Nigeria, and Canada (Table 1).

Characteristics of Included Studies

All included studies evaluated simulation-based training (SBT) interventions targeting paramedics or prehospital emergency medical technicians (EMTs). Simulation modalities ranged from high-fidelity manikin simulations to virtual and mixed reality systems. The training duration varied from single-session interventions (30–90 minutes) to longitudinal programs extending over multiple weeks.

Outcome measures were grouped into three major domains:

1. **Clinical decision-making** – e.g., diagnostic accuracy, response prioritization, and reasoning quality.
2. **Procedural performance** – e.g., task time, technical accuracy, and adherence to protocols.
3. **Non-technical skills** – e.g., teamwork, situational awareness, and communication.

Quantitative Findings

Clinical Decision-Making: Eight studies directly measured decision-making outcomes. Across these, simulation training produced statistically significant improvements in reasoning accuracy, scenario-based diagnostic decisions, and protocol adherence.

- In the quasi-experimental study by Weber et al. (2025), paramedics' diagnostic accuracy in POCUS increased by 31% ($p < .001$) following simulation exposure.
- **Ohira et al. (2024)** reported a **37% reduction** in procedural time and universal achievement of valid trauma ultrasound images post-simulation, demonstrating improved efficiency and decision sequencing.
- **Donathan et al. (2024)** found that paramedic students trained via 3D virtual-reality simulations achieved decision accuracy equivalent to traditional manikin simulation groups ($p = .68$), but reported higher cognitive engagement and satisfaction.

Procedural and Performance Outcomes: All experimental studies reported notable gains in procedural accuracy and task completion time.

- **Alghamdi et al. (2025)** summarized an average 25–40% improvement in performance indicators across included trials.
- **Miller et al. (2021)** observed measurable enhancement in psychomotor coordination and on-scene prioritization after repeated simulation cycles.

Non-Technical Skills: Five studies addressed non-technical domains.

- **Elsenbast et al. (2024)** found that mixed reality (MR) environments significantly improved teamwork and situational awareness scores ($p < .05$).
- **Alshibani et al. (2025)** reported high satisfaction and perceived gains in critical thinking, team communication, and leadership among Saudi EMS personnel.

Quality Assessment: According to the JBI critical appraisal, 70% of studies were rated high quality, 20% moderate, and 10% low. Common limitations included small sample sizes, reliance on self-reported measures, and lack of long-term follow-up.

Discussion

Interpretation of Findings

This systematic review demonstrates compelling evidence that simulation-based training enhances both clinical decision-making and performance among paramedics. Across multiple modalities—particularly high-fidelity and technology-enhanced simulations—participants consistently demonstrated superior reasoning accuracy, faster procedural execution, and greater team coordination. These findings align with experiential learning theory, suggesting that immersive, feedback-rich environments strengthen cognitive integration and adaptive expertise (Kolb, 2015; Motola et al., 2013).

The data support the growing consensus that simulation is not merely a technical rehearsal but a cognitive apprenticeship that refines critical reasoning under stress. In the context of prehospital emergency care—where decision windows are narrow and uncertainty is high—simulation allows paramedics to repeatedly practice triage, assessment, and intervention prioritization without patient risk.

Comparison with Previous Literature

Findings from 2020–2025 extend earlier evidence from nursing and critical care domains (Issenberg et al., 2019; Motola et al., 2013) by demonstrating domain transferability of simulation benefits to paramedicine. Studies such as Weber et al. (2025) and Ohira et al. (2024) confirm measurable gains in diagnostic speed and procedural precision, which mirror patterns reported in prior high-fidelity simulation research across emergency disciplines.

However, some divergence remains regarding the superiority of one modality over another. While Donathan et al. (2024) showed equivalence between VR and traditional manikin training, Elsenbast et al. (2024) emphasized

MR's advantage in team coordination. This suggests that pedagogical design elements—particularly debriefing quality, scenario realism, and repetition—may be more influential than simulation type alone.

Implications for Paramedic Education and Policy

These findings have direct implications for paramedic curricula and continuing professional development (CPD) programs. First, integrating SBT into certification and re-certification cycles can standardize exposure to rare critical events (e.g., cardiac arrest, multi-trauma, airway failure). Second, structured debriefing should be treated as an educational intervention itself, as it consolidates reasoning and fosters self-reflection (Maqbool et al., 2023). Third, the increasing feasibility of virtual and mixed reality platforms provides scalable training options for geographically dispersed EMS systems—especially relevant for Saudi Arabia's Vision 2030 initiative emphasizing digital transformation and healthcare workforce development.

Limitations of Evidence

Despite encouraging outcomes, current research remains constrained by methodological heterogeneity. Most studies utilized short-term post-tests without longitudinal follow-up, limiting conclusions on retention and transfer to real-world practice. Additionally, small sample sizes and convenience sampling reduce generalizability. Few studies measured patient-level outcomes (e.g., morbidity, mortality, scene time reduction), and cost-effectiveness analyses remain scarce. Addressing these limitations will be essential for translating simulation gains into operational EMS improvement.

Future Research Directions

Future investigations should:

1. Employ multicenter randomized controlled trials with larger paramedic cohorts.
2. Standardize decision-making assessment tools and link them to validated performance metrics.
3. Explore longitudinal retention of decision competence beyond initial training.

4. Examine the cost–benefit ratio of implementing high-fidelity versus hybrid simulation models.
5. Investigate the integration of artificial intelligence (AI)-driven adaptive feedback into simulation curricula for individualized skill reinforcement.

Conclusion

Simulation-based training offers a robust pedagogical strategy to strengthen clinical decision-making and operational performance among paramedics. When designed with high fidelity, structured debriefing, and deliberate practice, SBT enhances both cognitive and procedural competence. Although the evidence base continues to evolve, its cumulative trajectory underscores simulation's potential to become a cornerstone of prehospital education and continuous professional development within modern EMS systems.

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