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The Effectiveness of Simulation-Based Training in Improving Emergency Medical Technicians' Clinical Competencies: A Systematic Review

فاعلية التدريب القائم على المحاكاة في تحسين الكفاءات السريرية لفنيي طب الطوارئ: مراجعة منهجية

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Abstract:

Background: Emergency Medical Technicians (EMTs) and paramedics must demonstrate procedural proficiency, rapid clinical judgment, effective communication, and coordinated team performance in unpredictable prehospital environments. Simulation-based training (SBT) is widely used to rehearse uncommon, time-critical emergencies without exposing patients to educational risk. However, results vary across learner groups, clinical domains, simulation modalities, and assessment periods.
Aim: To synthesize empirical evidence on the effectiveness of simulation-based training for improving clinical competencies among EMTs, paramedics, and learners enrolled in prehospital emergency-care programs, with particular attention to objective skills, clinical decision-making, teamwork, retention, and transfer to actual practice.
Methods: A structured evidence synthesis was undertaken for English-language primary studies published from January 2016 through October 2026. PubMed-indexed records and original publisher reports were examined using combinations of emergency medical technician, paramedic, simulation, clinical competence, skills, resuscitation, trauma, and related terms. Fourteen directly relevant empirical studies were analyzed using a narrative, domain-based approach. Their designs and reported outcomes were critically compared using design-sensitive risk-of-bias principles.
Results: Across the 14 studies, scenario-based instruction was generally associated with improvements in measured technical skills, procedural decision-making, or knowledge, particularly in inexperienced learners. A trauma course involving 25 EMS students increased mean observed skill scores from 57.44 to 122.24; a pediatric EMS curriculum involving 187 providers increased mean knowledge scores by 9.8 percentage points. Repeated virtual-reality rehearsal improved scenario-specific anaphylaxis performance among 125 trainees. Nevertheless, a 106-paramedic resuscitation study showed no significant improvement in overall chest-compression performance, and comparative trials did not consistently establish superiority of newer immersive modalities over conventional simulation. Long-term clinical transfer and patient-outcome evidence remained limited.
Conclusion: Simulation-based training is a valuable component of competency-based EMS education when aligned with clinical objectives, repeated deliberate practice, structured feedback, and objective assessment. Evidence supports important short-term and scenario-specific benefits, but simulator fidelity alone does not guarantee superior performance, sustained skill retention, or improved patient outcomes. Programs should integrate simulation with workplace learning, refresher training, and longitudinal competency monitoring.

Keywords: Emergency Medical Technicians; Paramedics; Simulation-Based Training; Clinical Competence; Prehospital Care; Cardiopulmonary Resuscitation; Trauma Management; Clinical Decision-Making; Virtual Reality; Patient Safety; Emergency Medical Services.

الملخص

الخلفية :يجب أن يُظهر فنيو طب الطوارئ (EMTs) والمسعفون مهارةً في تنفيذ الإجراءات الطبية، وسرعةً في التقدير السريري، وفاعليةً في التواصل، وأداءً جماعيًا منسقًا في بيئات ما قبل المستشفى التي تتسم بعدم القدرة على التنبؤ. ويُستخدم التدريب القائم على المحاكاة (SBT) على نطاق واسع للتدرب على حالات الطوارئ النادرة والحساسة للوقت، دون تعريض المرضى للمخاطر التعليمية. ومع ذلك، تتباين النتائج باختلاف فئات المتعلمين، والمجالات السريرية، وأنماط المحاكاة، وفترات التقييم.
الهدف :تهدف هذه الدراسة إلى تجميع الأدلة التجريبية المتعلقة بفاعلية التدريب القائم على المحاكاة في تحسين الكفاءات السريرية لدى فنيي طب الطوارئ، والمسعفين، والمتعلمين الملتحقين ببرامج الرعاية الطارئة قبل المستشفى، مع التركيز بصورة خاصة على المهارات الموضوعية، واتخاذ القرارات السريرية، والعمل الجماعي، والاحتفاظ بالمهارات، ونقل أثر التدريب إلى الممارسة الفعلية.
المنهجية :أُجري تجميع منظم للأدلة المتعلقة بالدراسات الأولية المنشورة باللغة الإنجليزية خلال الفترة من يناير 2016 إلى أكتوبر 2026. وجرت مراجعة السجلات المفهرسة في قاعدة بيانات PubMed والتقارير الأصلية الصادرة عن الناشرين، باستخدام مجموعة من المصطلحات المرتبطة بفنيي طب الطوارئ، والمسعفين، والمحاكاة، والكفاءة السريرية، والمهارات، والإنعاش، والإصابات، والمصطلحات ذات الصلة. وحُلّلت أربع عشرة دراسة تجريبية ذات صلة مباشرة باستخدام منهج سردي قائم على المجالات، مع إجراء مقارنة نقدية لتصميماتها ونتائجها المعلنة بالاستناد إلى مبادئ تقييم مخاطر التحيز الملائمة لكل تصميم بحثي.

النتائج :أظهرت الدراسات الأربع عشرة عمومًا ارتباط التدريب القائم على السيناريوهات بتحسن المهارات التقنية المقاسة، أو اتخاذ القرارات الإجرائية، أو المعرفة، ولا سيما لدى المتعلمين قليلي الخبرة. فقد أسهمت دورة تدريبية في مجال الإصابات، شارك فيها 25 طالبًا من طلاب خدمات الطوارئ الطبية، في رفع متوسط درجات المهارات المرصودة من 57.44 إلى 122.24. كما أدى منهج تدريبي في طب طوارئ الأطفال، شمل 187 مقدمًا للرعاية، إلى زيادة متوسط درجات المعرفة بمقدار 9.8 نقاط مئوية. كذلك، أسهم التدريب المتكرر باستخدام الواقع الافتراضي في تحسين الأداء المرتبط بسيناريوهات التأق لدى 125 متدربًا. ومع ذلك، لم تُظهر دراسة شملت 106 مسعفين في مجال الإنعاش تحسنًا ذا دلالة إحصائية في الأداء العام لضغطات الصدر، كما لم تثبت التجارب المقارنة بصورة متسقة تفوق أنماط المحاكاة الغامرة الحديثة على أساليب المحاكاة التقليدية. وظلت الأدلة المتعلقة بالانتقال طويل الأمد للمهارات إلى الممارسة السريرية والنتائج الصحية للمرضى محدودة.

الخلاصة :يُعد التدريب القائم على المحاكاة عنصرًا مهمًا في التعليم الطبي الطارئ القائم على الكفاءة، عندما يكون متوافقًا مع الأهداف السريرية، ومدعومًا بالممارسة المتعمدة المتكررة، والتغذية الراجعة المنظمة، والتقييم الموضوعي. وتدعم الأدلة وجود فوائد مهمة على المدى القصير وفي سيناريوهات محددة، إلا أن مستوى واقعية المحاكاة وحده لا يضمن أداءً أفضل، أو احتفاظًا مستدامًا بالمهارات، أو تحسنًا في النتائج الصحية للمرضى. وينبغي للبرامج التدريبية دمج المحاكاة مع التعلم في بيئة العمل، والتدريب التنشيطي، والمتابعة الطولية للكفاءات.

الكلمات المفتاحية: فنيو طب الطوارئ؛ المسعفون؛ التدريب القائم على المحاكاة؛ الكفاءة السريرية؛ الرعاية قبل المستشفى؛ الإنعاش القلبي الرئوي؛ تدبير الإصابات؛ اتخاذ القرارات السريرية؛ الواقع الافتراضي؛ سلامة المرضى؛ خدمات الطوارئ الطبية.

Introduction

Emergency Medical Technicians (EMTs) and paramedics are central to modern emergency medical services (EMS). They are frequently the first clinicians to evaluate seriously ill or injured patients, initiate life-saving interventions, and determine how quickly advanced resources and definitive care are required. Their responsibilities involve a combination of technical skills, scene assessment, communication, prioritization, and situational awareness. These abilities must often be demonstrated under time pressure, with limited information and in environments that are less predictable than controlled hospital settings. Consequently, preparation for prehospital practice cannot rely on theoretical knowledge alone (Farrell et al., 2022; Bell, 2025).

Traditional EMS education integrates lectures, supervised clinical exposure, skills stations, and workplace experience. Although these methods provide essential foundations, emergency case exposure is highly variable. Cardiac arrest, pediatric critical illness, severe hemorrhage, complicated airway emergencies, and mass-casualty events are uncommon for individual learners but demand accurate performance when they occur. A student may graduate with adequate classroom knowledge yet have had few opportunities to coordinate a pediatric resuscitation, lead a trauma team, or manage a rapidly evolving anaphylactic emergency. Simulation-based training addresses this educational gap by offering repeated, standardized encounters that can be paused, observed, assessed, and discussed after the scenario (Heuer et al., 2022; Farrell et al., 2022).

Simulation includes a broad family of educational activities rather than a single technology. Low- and high-fidelity manikins, standardized patients, in-situ ambulance scenarios, task trainers, virtual reality, immersive projections, computer-based cases, and visually enhanced mental simulation may all be appropriate depending on the learning objective. High physical realism is not necessarily superior to a simpler scenario when the competency of interest is recognition of a hazard, prioritization of treatment, or correct application of a clinical algorithm. The educational intervention also depends on prebriefing, the opportunity for active participation, the quality of feedback, and the number and spacing of practice attempts (Donathan et al., 2024; Vella et al., 2025).

Clinical competence is itself multidimensional. Procedural competence encompasses the correct use of equipment, technique, infection-control precautions, and timely completion of an intervention. Cognitive competence includes recognizing abnormal findings, forming a working diagnosis, and selecting appropriate management. Nontechnical competence includes leadership, closed-loop communication, teamwork, workload management, and clinical handover. Confidence or learner satisfaction may support engagement but should not be treated as equivalent to observable technical

performance or patient safety. Likewise, improvement within a practiced simulation does not automatically prove that a clinician will perform better in an unfamiliar field emergency (Giese et al., 2026; Bell, 2025).

The empirical evidence now includes stronger comparisons of teaching modality as well as longitudinal studies of actual EMS personnel. For example, a multicenter randomized comparison of virtual and in-person simulation in 174 paramedic students found comparable cognitive examination scores (Donathan et al., 2024). A longitudinal study of 106 Australian paramedics found high baseline chest-compression quality and no significant change in the overall compression score after simulator deployment (Zucca et al., 2024). Conversely, studies of trauma training, pediatric resuscitation, anaphylaxis management, and repeated practice have reported meaningful improvements in measured competence (Häske et al., 2022; Jam et al., 2025; Giese et al., 2026). This pattern demonstrates why claims about effectiveness must be linked to the specific outcome, comparator, and follow-up interval.

Several broader reviews have supported simulation for short-term skill acquisition, while noting limited evidence for sustained competence and real patient outcomes. A systematic review of selected allied health professions found substantial attention to paramedics and EMTs but few studies assessing long-term retention or patient-level effects (Heuer et al., 2022). Contemporary reviews of paramedic simulation-based assessment and prehospital debriefing have further highlighted variability in assessment instruments and educational reporting (Bell, 2025; Williams & AlShammari, 2026). The present review therefore examines simulation effectiveness through the clinically relevant distinction between immediate learning gains, retention, and transfer to everyday EMS practice.

Problem Statement

Reliable competence in prehospital emergency care is difficult to develop and maintain because real clinical exposure depends on case mix, geographical deployment, patient volume, and the unpredictability of emergencies. A training system that relies predominantly on opportunistic exposure may leave important deficiencies in uncommon but high-risk procedures. Simulation offers a means of mitigating these gaps, yet programs differ greatly in technology, practice intensity, feedback, and evaluation. Some studies report large improvements immediately after training, whereas others find little additional benefit when participants already perform near the competency ceiling. Moreover, students' confidence and test scores do not consistently establish safe performance during actual ambulance encounters. A focused synthesis of evidence is therefore necessary to determine which outcomes improve, in which populations, and under what educational conditions.

Aim of the Review

This review aims to critically synthesize published evidence concerning the effectiveness of simulation-based training in improving the clinical competencies of EMTs and paramedics, and to identify educational approaches that support objective performance, retention, and readiness for prehospital emergency care.

Objectives

1. To describe simulation modalities used in EMT and paramedic education and continuing professional development.
2. To evaluate the reported effects of simulation-based training on technical procedures, clinical assessment, triage, and resuscitation performance.
3. To examine nontechnical outcomes such as clinical reasoning, communication, teamwork, and self-perceived competence.
4. To compare findings from randomized and nonrandomized studies, including positive, neutral, and unfavorable results.
5. To identify evidence concerning retention of competence, transfer to field practice, and the relationship with patient safety.

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6. To develop practical recommendations for EMS educators, ambulance-service leaders, and professional regulators.

Research Questions

1. What types of simulation-based training are used to develop clinical competencies among EMTs and paramedics?
2. How effectively does SBT improve measurable technical and cognitive performance in prehospital emergencies?
3. What is the comparative effectiveness of technology-enhanced simulation and conventional simulation?
4. What evidence supports repeated practice, structured debriefing, and longer-term skill retention?
5. To what extent do improvements measured in simulated environments translate into clinical practice or patient outcomes?

Significance of the Review

This topic is relevant to ambulance services, professional education programs, EMS accreditation bodies, and organizations responsible for patient safety. Evidence-based simulation design can improve the allocation of training resources and help prioritize competencies that are both clinically important and difficult to acquire through routine patient contact. The findings are also applicable to institutions serving large geographical areas, where exposure to complex emergencies varies among personnel. In the Gulf region and the Saudi Red Crescent Authority context, they may inform locally adapted programs addressing cardiac arrest, trauma, airway management, pediatric care, and major-incident response. However, local evaluation is necessary before assuming that published results from other systems will apply unchanged to different staffing models, protocols, and clinical environments.

Methodology

Study Design

The study used a structured, systematic-question approach to evidence identification, eligibility assessment, critical comparison, and narrative synthesis. Reporting domains were informed by the PRISMA 2020 statement (Page et al., 2021). The focus was on direct empirical evaluations of simulation-based educational interventions, rather than purely descriptive discussions of simulation technologies. Because interventions and outcome definitions varied substantially, findings were analyzed by clinical competency domain instead of being combined into a single pooled effect size.

Eligibility Criteria

Primary studies were eligible when they involved practicing EMTs, paramedics, ambulance personnel, or students enrolled in clearly identified prehospital emergency-care programs; evaluated a simulation-based educational exposure or practice approach; and reported an observable performance measure, knowledge or assessment result, clinical communication outcome, or documented competence-related follow-up. Randomized comparisons, prospective pre-post evaluations, quasi-experimental studies, longitudinal cohorts, and structured educational evaluations were relevant. English-language studies published between January 2016 and October 2026 were considered.

Inclusion Criteria

1. Participants were EMTs, paramedics, prehospital emergency healthcare workers, or paramedicine/EMS students.
2. Training involved manikin-based, scenario-based, computer-based, virtual, immersive, or similarly structured clinical simulation.
3. The report presented measurable education-related outcomes, with clear relevance to competence in prehospital care.

4. The design was an empirical primary study and identifiable publication details could be verified.
5. The publication date fell within the defined 2016–October 2026 interval.

Exclusion Criteria

1. Studies limited to hospital physicians or nurses without a distinguishable prehospital group.
2. Commentaries, purely conceptual papers, research protocols, and conference-only abstracts lacking sufficient empirical detail.
3. Simulations used solely to test equipment, physiology, or workload without evaluating an educational intervention or competence-related question.
4. Reports containing no identifiable simulation exposure or no measurable learning/performance outcome.
5. Review articles, which were used for context rather than counted as primary investigations.

Search Strategy

Relevant articles were identified through targeted searches of PubMed and the indexed original publication pages of established journals, supported by citation-following for studies of EMS simulation. The searches combined terms for population, educational intervention, and competence: ("emergency medical technician" OR EMT OR paramedic OR "prehospital emergency" OR "emergency medical services") AND (simulation OR "scenario-based training" OR manikin OR "virtual reality" OR "high-fidelity simulation") AND ("clinical competence" OR skills OR resuscitation OR trauma OR triage OR assessment OR teamwork). Publication records were checked for titles, authors, publication year, setting, study design, sample size, and main outcomes. The date boundary for the present evidence synthesis was 1 November 2026.

Study Identification and Selection

Fourteen empirical reports were retained for detailed narrative synthesis because each directly addressed an EMS learner or practitioner population and a relevant training or performance outcome. These studies covered conventional scenario training, high-fidelity manikins, pediatric simulation, mass-casualty triage, trauma management, virtual-reality practice, emergency airway procedures, and comparative teaching modalities. Reviews and methodological guidance were separated from the primary-study table and used only for interpretation and framing.

Data Extraction

For each primary report, the following information was recorded from its abstract and, where available, its full text: author and publication year, country and training population, study design, sample size or unit of analysis, simulation method, primary comparison, assessment method, principal numerical results, and limitations relevant to interpretation. No pooled denominator was constructed, because participant counts, training-session counts, and dyad-level assessments are not directly interchangeable.

Quality Appraisal

Methodological credibility was evaluated with reference to design-appropriate JBI risk-of-bias domains, especially clear eligibility criteria, comparability of groups, intervention and outcome measurement, follow-up, and statistical analysis (Barker et al., 2024; JBI, 2026). Particular attention was given to uncontrolled pre-post change, ceiling effects, small samples, attrition, self-report, unblinded assessment, and repeated exposure to an identical test scenario. Instead of assigning an unsupported aggregate quality score, the evidence table and critical-appraisal section report specific, study-relevant limitations. Findings from randomized comparisons were distinguished from associations observed in uncontrolled educational programs.

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Data Synthesis

A narrative thematic synthesis grouped findings into: (1) procedural skills and clinical assessment; (2) resuscitation and airway competence; (3) trauma, hemorrhage, and triage; (4) decision-making and nontechnical skills; (5) virtual and immersive training comparisons; and (6) retention, performance transfer, and patient-outcome relevance. The synthesis emphasized whether the outcome was objectively measured, merely self-reported, assessed within the rehearsed scenario, or observed after a meaningful delay. Statistical significance was reported only when available in the source; otherwise findings were described qualitatively.

Limitations of Included Studies

1. Uncontrolled Pre–Post Designs

Several studies compared performance before and after a course without allocating participants to an independent, concurrent control group. Although this design documents learning progress, it cannot fully separate the training effect from repeated testing, maturation, familiarity with the checklist, or other simultaneous instruction. Large pre-post score differences, particularly among beginners, may also be influenced by low baseline performance.

2. Heterogeneous Competency Measures

The studies measured knowledge tests, task checklists, instructor ratings, automated manikin outputs, team performance, perceived confidence, and time to treatment. Even when all measures were labelled "competence," they represented different constructs. Consequently, raw effects should not be compared as if a percentage gain in knowledge, a reduction in intubation time, and improvement in confidence were interchangeable.

3. Incomplete Assessment of Clinical Transfer

Most investigators evaluated participants in laboratories, training environments, or virtual scenarios. Very few linked educational exposure to prospectively collected patient outcomes or actual out-of-hospital performance. Improved execution of a rehearsed scenario therefore supports simulation-specific skill acquisition more strongly than improved safety during unscripted emergencies.

4. Restricted Generalizability

Some investigations enrolled only 20–25 learners from a single university, whereas others evaluated experienced EMS personnel or multiple accredited programs. Differences in professional scope, clinical protocols, previous experience, educational resources, and country-specific EMS systems may modify intervention effects. Findings from paramedic students should not be attributed to experienced EMTs without qualification.

5. Ceiling Effects and Skill Decay

High initial competence may constrain observable improvement, as illustrated by the Australian compression-quality study. By contrast, short-term improvement after introductory courses may diminish without refresher training. Studies assessing retention after six months or longer were relatively uncommon and reported mixed patterns across individual skill components.

6. Reporting and Measurement Bias

Participants and faculty often knew the training condition, raising expectancy and assessment effects. Self-reported confidence and satisfaction are particularly vulnerable to response bias. Some virtual-reality trials measured performance within the same digital environment used for teaching, which improves standardization but also increases the risk of scenario familiarity being mistaken for generalized competence.

Table 1. Characteristics of Primary Studies (2021–2026)

Study / setting	Participants / design	Simulation intervention	Main reported result
Yaylaci & Guven (2021); Türkiye	60 paramedic students; randomized educational comparison	Neonatal CPR simulation with video versus slide prelearning	Video group: higher knowledge (p<.001) and observed simulation scores (p=.002).
Häske et al. (2022); Germany	146 evaluated training episodes; prospective longitudinal	Prehospital trauma team simulation; pre/immediate/1-year evaluation	Simulated-care score 28.8→65.1 immediately; 59.6 at 1 year (p<.001).
Farrell et al. (2022); USA	187 EMS providers (78 EMTs; 109 paramedics); single-arm curriculum	Pediatric critical-care scenarios and structured debriefing	Mean knowledge +9.8 percentage points (95% CI 7.2–12.4); 93% reported higher confidence.
Demir et al. (2023); Türkiye	20 paramedic students; single-group pre-post	Online visually enhanced mental simulation for triage	Pre-post triage/management assessment improved (p<.05).
Donathan et al. (2024); USA	174 paramedic students; multicenter randomized comparison	3D VR patient simulation vs. traditional simulation	Identical median cognitive posttest (70%); p=.396.
Meskus et al. (2026); Finland	390 respondents among 450 EMS personnel; post-training observational	Lecture and 1-hour simulated ten-second mass-casualty triage	Correct triage 88–94% in 3 simple cases, 28% in complex case.
Zucca et al. (2024); Australia	106 practicing paramedics; longitudinal single-group	Advanced CPR manikins across 95 NSW Ambulance locations	No significant change in overall compression score; high baseline ≥95%.
Jam et al. (2025); Iran	25 EMS students; single-group pre-post	Two-day scenario-based prehospital trauma course	Mean clinical skills 57.44→122.24; p=.0001.
Vella et al. (2025); Australia	20 analyzed of 37 randomized paramedic students; pilot trial	360° projection vs. conventional simulation	Self-rated performance favored conventional training (p=.04); 9-week p=.02.
Turan & Pekmezci (2026); Türkiye	60 paramedic students; single-group pre-post	Repeated procedural simulation, 8 observed skills	All assessed skills improved (p<.001); 90% successful intubation at posttest.
Veronese et al. (2026); Australia	89 paramedicine students; secondary analysis of graded practice	Weekly simulation with performance-based feedback	Practice frequency predicted practical examination scores (B=3.46, p<.05).
Çinar et al. (2026); Türkiye	98 paramedic students; randomized simulation comparison	Video-laryngoscopy with vs. without remote teleguidance	First-attempt success 79% vs. 49% (p=.002); median 30 vs. 61 sec.
Giese et al. (2026); Germany	125 paramedic trainees; randomized repeated-VR exposure	Repeated identical VR anaphylaxis scenario vs. first exposure	Scenario checklist 42.6 vs. 31.1/62; diagnosis and epinephrine faster.
Pala et al. (2026); Türkiye	97 prehospital emergency workers; matched quasi-experiment	Computer-based vs. manikin pandemic preparedness simulation	Both improved selected domains; no significant overall between-group difference.

Results

The fourteen directly relevant investigations ranged from small single-site educational studies to multicenter randomized comparisons and longitudinal evaluations across ambulance stations. Study populations included undergraduate paramedicine students, EMTs, practicing paramedics, and broader prehospital emergency-care teams. The interventions were clinically diverse, but the outcomes clustered into five recurring patterns: improved performance after structured scenario practice; benefits of repetition and feedback; mixed results for expensive or immersive technology; dependence on baseline competency; and a persistent distinction between simulated outcomes and real clinical effectiveness.

Theme 1: Technical and Procedural Competence

1.1 Acquisition of Essential Prehospital Skills

Students with limited prior clinical exposure often demonstrated improvements after practice in structured environments. Turan and Pekmezci (2026) studied 60 paramedic students using repeated simulation-supported training, observing significant gains in procedural performance and self-perceived competence. Their reported posttraining success was 100% for oxygen administration and fracture stabilization, 90% for intubation, 81.7% for life-support procedures, and 76.7% for defibrillation. Although these results are encouraging, the study lacked a concurrent control group and measured performance over a short period. It therefore illustrates acquisition under training conditions more directly than lasting workplace proficiency.

The Iranian prehospital trauma management course likewise reported considerable improvements in an observation-based skill checklist after twelve hours of scenario-based instruction. For 25 EMS students, the mean clinical skills score increased from 57.44 to 122.24, with improvements in trauma assessment, hemorrhage control, splinting, spinal motion restriction, airway management, and ventilation (Jam et al., 2025). These are clinically relevant domains, but the uncontrolled design does not isolate the effect of simulation from content exposure, instructor guidance, and repeat assessment.

1.2 Specific Procedures and Timeliness

Some studies examined objectively measurable actions rather than broad impressions of competence. In a randomized study of 98 paramedic students performing videolaryngoscopy in a moving ambulance simulator, teleguidance from a remote expert was associated with higher first-attempt intubation success (79% vs. 49%; p=.002) and a shorter median procedure time (30 vs. 61 seconds; p=.003) compared with standard support (Çinar et al., 2026). This experiment demonstrates that the combination of simulation and real-time procedural assistance can improve performance in a highly standardized airway exercise. Its experimental contrast, however, tested teleguidance rather than simulation education itself, so the observed difference should not be interpreted as a pure effect of simulation versus conventional instruction.

Theme 2: Resuscitation Skills and Pediatric Emergencies

2.1 Cardiopulmonary Resuscitation

Resuscitation is especially well suited to simulation because observable elements such as compression depth, release, rate, interruptions, equipment preparation, and team communication can be measured without endangering a patient. However, improvement is not guaranteed when a workforce is already proficient. In the Australian study involving 106 paramedics from 95 ambulance sites, the average external chest-compression score was at least 95% at each observation. Training and deployment of advanced simulator manikins produced no significant improvement in overall compression performance, and the odds of meeting the appropriate compression rate were lower 6–11 months after the immediate posttraining assessment (Zucca et al., 2024). These findings caution against assuming every new simulator purchase generates measurable additional benefit.

In contrast, interventions targeting specific subgroups or skills may produce measurable improvements. The available literature supports using baseline assessments to identify the need for practice, rather than

administering identical instruction to all personnel regardless of their prior ability. A provider who already achieves consistent compression quality may benefit more from rehearsing a rare pediatric resuscitation, a team leadership role, or complex airway management than from repeated basic compression practice alone.

2.2 Pediatric and Neonatal Resuscitation

Low-frequency pediatric emergencies present significant educational challenges. Farrell and colleagues (2022) delivered a pediatric critical-care simulation curriculum to 187 EMS providers, including 78 EMTs and 109 paramedics. Adjusted mean knowledge increased by 9.8 percentage points (95% CI 7.2–12.4), while 93% of respondents reported greater confidence in pediatric care. The curriculum included expert-facilitated scenarios and structured debriefing across multiple teaching sites. The results support feasibility and learning benefits at a statewide level, although direct clinical performance and patient outcomes were not measured.

Yaylaci and Guven (2021) assessed a blended neonatal cardiopulmonary resuscitation curriculum among 60 paramedic students. Both groups completed classroom instruction and simulation assessment, but one group used video clips as an additional teaching component while the other used slides. The video-enhanced group achieved higher knowledge and observed performance scores, including algorithm adherence, teamwork, and communication. Because both arms participated in simulation, the study primarily addresses the design of pre-simulation learning rather than the isolated effect of simulation versus no simulation. Its practical implication is that preparation for scenarios can influence the quality of subsequent simulation performance.

Theme 3: Trauma Assessment, Mass-Casualty Triage, and Clinical Decision-Making

3.1 Structured Trauma Management

The prospective longitudinal EPPTC investigation evaluated simulated prehospital trauma-team training using videotaped assessments before instruction, immediately afterward, and one year later. Across 146 evaluated training episodes, mean performance increased from 28.8 ± 5.6 at baseline to 65.1 ± 7.9 immediately after training and remained 59.6 ± 6.6 at one year (Häske et al., 2022). Improvements included primary assessment, procedural performance, and nontechnical skills. The durability of the gains is important because many educational interventions are evaluated only within the same day. Nevertheless, these results were produced in simulated trauma situations, not as direct estimates of prevented patient harm.

3.2 Mass-Casualty Triage

Mass-casualty incidents require rapid categorization and resource allocation, but individual EMS clinicians may encounter few real events during their training. Demir and colleagues (2023) tested an online visually enhanced mental simulation program with 20 paramedic students and observed significant improvement in postintervention triage and scene-management scores. The method has practical relevance for distributed or resource-limited teaching programs, since online case-based rehearsal may reduce the need for specialist simulation facilities. However, a single-group design, small sample, and immediate assessment limit confidence about causality, retention, and performance during a real disaster.

A more recent Finnish observational study examined the adoption of the Ten Second Triage method among operational EMS personnel after pre-course material, a lecture, and one hour of simulation (Meskus et al., 2026). Of 450 employees, 390 completed the assessment. Correct classification was 88–94% across three relatively straightforward case vignettes, but only 28% for a more complex case. This result emphasizes that training may support correct application in simple scenarios while complex or overlapping presentations remain difficult. Because performance was assessed only after the combined educational package, the study cannot isolate the simulation component or quantify the change from pretraining performance.

3.3 Clinical Judgment and Assessment

The SMARTSIM multicenter trial assessed whether three-dimensional virtual patient simulation differed from traditional in-person simulation after paramedic students completed the same advanced medical life-support scenarios. Among 174 students from ten accredited programs, median posttest scores were 70% in both groups (p=.396) (Donathan et al., 2024). This neutral finding is relevant to curriculum design: the technology-enhanced method did not produce a detectable cognitive advantage, but it achieved a comparable outcome and may provide a practical option where personnel, floor space, or physical simulation equipment are constrained. The cognitive examination was not a direct observation of emergency clinical behavior, so equivalence on this test should not be extended to every performance domain.

Theme 4: Nontechnical Competencies and Confidence

4.1 Communication and Teamwork

Competence in EMS involves shared mental models, anticipation of deterioration, concise role assignment, and clear communication under pressure. Training scenarios can make these behaviors visible through team-based checklists and video-supported debriefing. In the EPPTC study, nontechnical-skills scores improved over repeated observations alongside technical trauma-care processes (Häske et al., 2022). The neonatal resuscitation educational trial also measured teamwork and communication within an observed clinical megacode scenario, with higher performance after video-enhanced preparation (Yaylaci & Guven, 2021). Both investigations suggest benefits from rehearsing not only what a clinician should do but how care should be coordinated.

4.2 Confidence Is Not Equivalent to Clinical Competence

Several reports evaluated self-confidence, and increased confidence is an important educational outcome when learners face unfamiliar emergencies. For example, the statewide pediatric curriculum documented increased confidence in most respondents (Farrell et al., 2022). Yet confidence is influenced by previous familiarity, the supportive training environment, and expectations of success. It may increase without corresponding improvement on an objective skill measure. For this reason, clinical competence should be assessed with checklists, performance ratings, task accuracy, timing, and—when possible—real-world follow-up rather than with participant satisfaction alone.

4.3 Structured Feedback and Deliberate Practice

Repeated scenario exposure appears especially useful when learners receive formative feedback and have opportunities to correct errors. Veronese and colleagues (2026) examined high-frequency simulation with structured performance-based assessment in two paramedicine courses. The sample included 48 second-year and 41 third-year students; simulation frequency predicted practical examination outcomes (B=3.46; p<.05). These associations are consistent with a learning model in which practice, feedback, correction, and reassessment build competence over time. However, the underlying analysis was observational and cannot establish whether students who practiced more would have achieved the same improvement through other methods.

Theme 5: Virtual Reality and Immersive Learning Approaches

5.1 Rehearsal of Time-Critical Scenarios

Giese and colleagues (2026) conducted a randomized trial with 125 German paramedic trainees, comparing repeat exposure with first exposure to an identical multi-user virtual-reality anaphylaxis scenario. Teams allocated to repeat practice achieved a higher scenario checklist score (42.6 vs. 31.1 out of 62; mean difference 11.5, 95% CI 9.8–13.3). They also identified the correct diagnosis sooner (1.45 vs. 2.90 minutes) and administered intramuscular epinephrine earlier (4.58 vs. 7.43 minutes). These results support deliberate repetition within a controlled virtual environment. However, the intervention tested familiarity with the same case, rather than generalization to new clinical problems, field performance, or superiority over conventional manikin training.

5.2 Immersive Technology Versus Conventional Simulation

The comparison literature does not support a simple hierarchy in which greater immersion always produces better learning. Donathan et al. (2024) found no difference in cognitive outcomes for three-dimensional virtual and traditional simulation. Vella, Simpson, and Thyer (2025) compared a 360-degree projection environment with conventional simulation in a small randomized pilot study; only 20 of 37 randomized students completed all study requirements, and self-rated performance favored conventional simulation, including after nine weeks. The outcome was subjective and attrition was substantial, but the result challenges the assumption that highly immersive environments inevitably improve learner confidence or competence.

Similarly, Pala and colleagues (2026) used matched quasi-experimental comparison of computer-based and manikin-based pandemic preparedness instruction among 97 prehospital emergency workers. Both groups improved in selected performance domains, but the overall between-group improvement did not significantly differ. The investigators identified complementary patterns: computer-based training was more favorable for some infection-control and transfer actions, whereas manikin-based training was associated with improvement in some assessment and communication tasks. A practical approach may therefore combine modalities based on competency goals rather than selecting a single platform for all training needs.

Theme 6: Retention, Transfer, and Patient Safety

6.1 Retention of Clinical Skills

Sustained competence requires reinforcement, especially for procedures that clinicians rarely perform. Häske et al. (2022) demonstrated improvement in simulated trauma-team treatment capacity one year after training, although scores had declined from their immediate postcourse peak. Zucca et al. (2024) found stable high overall compression scores over 6–11 months but a lower probability of correct compression rate at later assessment. Vella et al. (2025) observed modality-related differences in self-perceived performance after a nine-week interval. These results indicate that retention is competency-specific and can be obscured when investigators rely on a single total assessment score.

6.2 Translation to Clinical Practice

Only limited evidence directly connects simulation training to objective clinical performance during actual ambulance encounters. Farrell et al. (2022) collected six-month self-reports suggesting that some participants used curriculum content in practice, but direct patient encounters were not independently assessed. The majority of other studies measured simulated skill or knowledge immediately after education. Therefore, findings demonstrate the educational usefulness of simulation more confidently than they establish fewer adverse events, lower mortality, or faster treatment in patients.

6.3 Patient Safety and Educational Governance

Simulation has a plausible patient-safety role because errors can be identified and corrected before clinicians face the same challenge during real emergencies. Nevertheless, a safer simulated resuscitation or more accurate virtual diagnosis is not a measured patient-outcome effect. Programs should use safety-relevant surrogate measures—correct dose selection, time to critical treatment, closed-loop communication, compression quality, procedural attempts, and adherence to clinical guidelines—while separately monitoring field indicators such as adverse events, clinical audit outcomes, and protocol deviations. Where feasible, patient-level data linkage would strengthen future evaluations.

Table 2. Interpretation of Effectiveness by Competency Domain

Competency domain	Most directly informative studies	Overall interpretation
Procedural and trauma skills	Jam 2025; Turan 2026; Çinar 2026	Short-term skill gains are frequently positive, especially in inexperienced learners; uncontrolled designs limit causal attribution.
Resuscitation quality	Zucca 2024; Yaylaci & Guven 2021; Farrell 2022	Benefits vary with baseline skill and curriculum design; high baseline CPR quality can constrain improvement.
Triage and clinical decisions	Demir 2023; Meskus 2026; Donathan 2024; Giese 2026	Basic triage scenarios are easier than complex cases; VR does not consistently outperform traditional simulation.
Communication and teamwork	Häske 2022; Yaylaci & Guven 2021	Observed team behaviors can improve after structured practice; evidence remains concentrated in simulation settings.
Retention	Häske 2022; Zucca 2024; Vella 2025	Some gains persist, but individual measures may decay or differ by training modality.
Clinical field and patient outcomes	Farrell 2022; context from Heuer 2022	Transfer is mainly self-reported or indirect; objective patient-safety effects remain uncertain.

Critical Appraisal of the Evidence

Study designs provide unequal strength of causal inference. The randomized comparisons by Donathan et al. (2024), Vella et al. (2025), Çinar et al. (2026), Giese et al. (2026), and Yaylaci and Guven (2021) offer a more direct evaluation of their assigned intervention contrasts than uncontrolled before–after studies. However, the contrasts vary: they test simulation modality, digital repetition, supplemental procedural coaching, or preparatory teaching, and they do not necessarily estimate simulation versus no training. Blinding was often impractical, sample sizes differed markedly, and assessment outcomes ranged from knowledge tests to dyad-level scenario performance.

Quasi-experimental and single-arm studies provided valuable information about implementation and learning trajectories, but are more vulnerable to confounding. For example, Turan and Pekmezci (2026) reported large gains after repeated procedural practice, but the absence of a parallel control arm prevents separation of simulation from exposure to standard coursework. Jam et al. (2025) similarly reported large trauma-skill gains in a small group following an intensive course. The EPPTC longitudinal results are strengthened by follow-up at one year, whereas the absence of independent field outcomes still limits safety conclusions. Zucca et al. (2024) provide an especially useful counterexample: null change with high baseline quality suggests that effectiveness is influenced by starting competence and measurement sensitivity.

Several virtual-reality investigations also face a risk of overgeneralization. The SMARTSIM trial reported comparable examination results between teaching modalities, not clinical equivalence across every skill. The Giese trial measured repeated exposure to the same anaphylaxis scenario, increasing the possibility of task-specific learning; this is a legitimate educational outcome but not proof of transfer to new emergencies. In the Vella pilot, losses between randomization and analysis limited precision

and may have introduced selection bias. These design differences preclude a defensible pooled estimate of "simulation effectiveness" for the present group of studies.

Table 3. Study-Design Appraisal and Principal Interpretation Risks

Study group	Key methodological strengths	Principal interpretation risks
Randomized comparisons: Yaylaci & Guven; Donathan	Concurrent intervention groups, prespecified performance comparisons	Contrast tests modality or added teaching, not SBT versus no SBT; varied blinding and outcomes.
Randomized comparisons: Vella; Çinar; Giese	Explicit allocation and comparative results	Vella: small analyzed sample/attrition; Çinar: teleguidance effect; Giese: identical-scenario rehearsal.
Longitudinal cohorts: Häske; Zucca	Follow-up enables assessment of time trends	Nonrandomized changes and possible learning or ceiling effects; field outcomes not observed.
Single-group education: Demir; Jam; Turan; Farrell	Defined interventions and measured change in target domains	Repeated testing, selection, no independent comparison, short follow-up or self-report.
Observational: Meskus; formative: Veronese; matched: Pala	Practice-based implementation and measurable performance	No pretest for Meskus; practice self-selection, residual confounding, and modality uncertainty.

Discussion

This review indicates that simulation-based training can improve a range of competencies relevant to prehospital care, particularly when the program targets an identified skill deficit and provides repeated opportunities to perform, receive feedback, and apply corrective action. Yet the evidence does not justify describing simulation as uniformly effective across every learner, setting, or technology. Positive short-term findings coexist with robust neutral results, which should be interpreted as important evidence about instructional design rather than as failures of simulation itself.

Simulation as a Structured Learning Process

The strongest recurring educational mechanism is not technological novelty but active practice linked to standards of performance. In trauma-management curricula, learners had opportunities to assess patients, prioritize life threats, and rehearse correct sequences. In pediatric resuscitation, standardized scenarios were combined with expert-led debriefing. In high-frequency paramedicine education, repeated performance-based assessments allowed progress to be tracked. These different interventions share a cycle of rehearsal, feedback, and correction that is consistent with the broader deliberate-practice literature (McGaghie et al., 2011; Häske et al., 2022; Farrell et al., 2022; Veronese et al., 2026).

Importance of Baseline Competence

The contrast between beginner-focused studies and the Australian workforce compression study is instructive. When participants initially perform poorly or have little experience, simulation can produce large and easily observable gains. In personnel already exceeding 95% on a composite compression metric, added resources may yield little change on that metric, even if they enhance confidence or reveal other nonmeasured competencies. A needs assessment should therefore precede simulation investment, and course outcomes should match the expected margin for improvement. Training priorities should also account for low-frequency, high-consequence procedures rather than simply repeating familiar tasks.

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Digital platforms have potential advantages in geographic reach, scheduling flexibility, scenario standardization, and access for dispersed ambulance services. However, virtual reality and 360-degree projection should not be selected solely because they create a more immersive experience. Comparative trials suggest that conventional simulation may perform equally well or better on selected outcomes, and that a new platform can change how students perceive their own performance. Cost-effectiveness, hardware availability, motion sickness, faculty time, debriefing quality, maintenance, and learner accessibility should therefore be considered alongside measured educational results (Donathan et al., 2024; Vella et al., 2025; Pala et al., 2026).

Technical and Nontechnical Integration

Emergency management is a coordinated process rather than a sequence of isolated procedures. A clinician can perform endotracheal intubation skillfully yet fail to assign roles, communicate deterioration, or recognize an incorrect treatment priority. Likewise, confidence with a task trainer does not ensure timely action when the scenario changes. Effective curricula should therefore progress from isolated procedural teaching to integrated scenarios that evaluate clinical judgment, communication, leadership, and patient reassessment. The outcome framework should be explicit enough to distinguish failures of individual technique from failures of teamwork or recognition.

Comparison With Previous Evidence Syntheses

Broader allied-health syntheses have described consistent short-term gains in simulation-related skill and confidence, alongside sparse direct evidence of long-term practice change or patient benefit (Heuer et al., 2022). A paramedic assessment scoping review highlighted the need to define what simulation tests measure (Bell, 2025). Research on prehospital debriefing has likewise found variable approaches and incomplete reporting, with many studies relying on self-report (Williams & AlShammari, 2026). The present synthesis adds a clinically organized comparison of recent primary investigations and makes the neutral technology comparisons and ceiling effects central rather than peripheral findings.

Implications for EMS Education and Competency Assessment

Competency-based simulation should begin with a defined performance standard, use scenarios matched to real EMS responsibilities, and deliver feedback specific enough for the learner to correct errors. An airway session should record initial recognition, device preparation, attempt count, oxygenation safeguards, and time to effective ventilation rather than merely whether the participant felt comfortable. A major-incident session should evaluate triage accuracy, command structure, time to life-saving intervention, and interprofessional coordination. These observable indicators create a stronger basis for curriculum improvement and professional accountability.

Evaluation should extend beyond the training day. Reassessment at three, six, or twelve months can reveal decay in procedure-specific performance. Where services have access to electronic patient-care records, future program evaluations can prospectively examine selected patient-care process measures, while controlling for patient acuity, case mix, setting, and concurrent operational changes. Such designs would help determine whether the immediate educational benefits of simulation translate into sustained prehospital performance.

Relevance to Saudi Arabia and the Gulf

Large EMS organizations such as the Saudi Red Crescent Authority operate across urban, rural, and remote environments with varying case volumes and resource constraints. Simulation may offer a scalable approach to standardize preparation for high-acuity, low-frequency emergencies across locations. Potential priorities include pediatric resuscitation, trauma assessment, hemorrhage control, difficult-airway management, mass-casualty triage, handover communication, and safe transport. An educational framework could combine centralized advanced simulation centers with regional skills stations, supervised in-situ exercises, remote scenario rehearsal, and periodic assessment. The reviewed studies do not establish the effectiveness of any particular Saudi program; local implementation should therefore include baseline competency analysis, validated performance checklists, and evaluation of both training outcomes and operational feasibility.

Summary of Findings

The research supports five core conclusions. First, targeted simulation frequently improves immediate observable skill and knowledge, most clearly in less experienced learners. Second, repeated practice and structured feedback are plausible determinants of successful training, with some longitudinal evidence of lasting benefit. Third, simulation modality matters less than a good match between learning goals, learners, and assessment design: virtual and immersive systems do not consistently outperform conventional approaches. Fourth, apparent gains must be interpreted in light of baseline competence, sample size, comparator design, and risk of scenario familiarity. Finally, evidence for real-world clinical transfer and patient outcomes remains considerably weaker than evidence for performance within educational settings.

Conclusion

Simulation-based training occupies an important place in the preparation and professional development of Emergency Medical Technicians and paramedics. The evidence reviewed indicates that appropriately structured simulation can strengthen technical procedures, trauma assessment, clinical decision-making, and coordinated emergency response. Improvement is particularly apparent when learners initially have limited experience, scenarios are clinically meaningful, and opportunities for repetition and feedback are available. Nevertheless, high-fidelity technology is not intrinsically superior to traditional simulation, and high baseline competence can limit measurable gains. The most effective approach is therefore a competency-driven educational model that selects training methods according to the required skill, evaluates performance objectively, and revisits critical abilities over time. Further controlled, longitudinal evaluation of actual ambulance-care performance is essential for defining the relationship between educational outcomes and patient safety.

Recommendations

1. Simulation Curriculum Design

• Map simulation scenarios to nationally or locally approved EMT and paramedic scope-of-practice competencies.
• Prioritize low-frequency, high-consequence emergencies such as pediatric critical illness, major hemorrhage, difficult airway events, and mass-casualty triage.
• Combine procedural stations with integrated scenarios that require clinical reasoning, communication, scene leadership, and reassessment.
• Select manikin, standardized-patient, computer-based, or virtual simulation according to educational objective, practical feasibility, and assessment needs.

2. Assessment and Feedback

• Use objective checklists and timed safety-critical indicators in addition to learner confidence surveys.
• Provide structured debriefing focused on actions, underlying decisions, team coordination, and corrective practice.
• Document baseline competence before deciding the intensity or complexity of training.
• Maintain individualized competency records to identify recurrent errors and target remedial exercises.

3. Refresher Training and Retention

• Introduce spaced practice and scheduled reassessment for infrequently used high-risk skills.
• Assess retention beyond the immediate end-of-course period and report both composite and component skill scores.
• Use short high-frequency scenarios to sustain competence where facilities and faculty resources permit.
• Evaluate whether scenarios remain transferable to unfamiliar cases rather than relying on repetition of a single identical task.

4. Organizational and Policy Initiatives

• Support regional access to simulation through shared facilities, mobile programs, and blended learning.

• Establish governance for equipment maintenance, clinical guideline updates, instructor training, and evaluation of program effectiveness.

• Avoid assuming that expensive technology produces better results without a locally relevant comparison.

• Develop ethical, de-identified approaches to linking training participation with field performance and patient-care quality metrics.

5. Priorities for Future Research

• Conduct multicenter randomized or controlled quasi-experimental evaluations with transparent reporting of allocation and follow-up.

• Use validated observer-rated competence tools and report clinically meaningful effect sizes with confidence intervals.

• Measure transfer to different clinical cases, workplace performance, and patient safety rather than only rehearsed simulation success.

• Examine cost, equity, feasibility, instructor burden, and retention when comparing conventional simulation with immersive technologies.

Implications for Practice and Policy

For EMS Practice

Ambulance organizations can use simulation to rehearse standardized treatment pathways and identify latent errors before clinical exposure. Programs should include multidisciplinary response, communications during handover, safe medication administration, high-risk procedural decision points, and structured postscenario review. The effectiveness of the program should be judged by observable behavior and relevant practice indicators rather than attendance or satisfaction alone.

For Professional Education

Universities and EMS academies should embed simulation longitudinally across the curriculum, beginning with basic procedural competence and progressing to complex decision-making and team leadership. Assessment rubrics should be transparent, calibrated across faculty, and linked to approved competencies. Virtual platforms may extend access but should complement—not automatically replace—supervised hands-on practice where tactile or interpersonal skills are central.

For Policy

Competency assurance can be strengthened through periodic assessment of high-risk, infrequently performed clinical procedures and clear training standards for simulation instructors. Regulators and ambulance-service leaders should encourage evaluation designs that identify the educational value of training programs before scale-up. National initiatives should allow flexibility in technology choice while maintaining consistent standards of clinical competence and patient safety.

Strengths and Limitations of the Review

Strengths

This synthesis focuses specifically on prehospital learners and clinicians rather than extrapolating broadly from hospital-based simulation. It integrates procedural, cognitive, and team-based competency domains, includes recently published randomized and longitudinal studies, and discusses important null or contrary findings alongside positive results. The use of directly traceable primary research supports clear attribution of numerical findings, while the separation of simulation performance from actual clinical outcomes reduces the risk of overstating patient benefit.

Limitations

The evidence base was heterogeneous in training content, participant experience, design, outcome measurement, and follow-up interval. A number of studies were small and single-center, and many positive findings came from nonrandomized before–after evaluations. The literature identification

approach emphasized verified accessible primary reports rather than a pooled multi-database screening denominator, and the resulting synthesis should not be treated as a quantitative estimate of all published studies. Non-English publications and potentially relevant unpublished evaluations may not be represented. Most importantly, direct measurement of real-world prehospital patient outcomes was uncommon. These limitations favor careful, outcome-specific interpretation over a universal claim of effectiveness.

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Appendix A. Reproducible Search Framework

A population–intervention–outcome framework provides a consistent approach for literature identification. Population: EMTs, paramedics, EMS personnel, and prehospital students. Intervention: scenario-based or simulation-based education, manikin or task trainer, virtual reality, computer-based simulation, or repeated deliberate practice. Outcomes: objectively observed procedural performance, knowledge, clinical assessment, triage accuracy, resuscitation quality, teamwork, retention, and measured practice change. The date range applied to the synthesis was 2016–October 2026.

Example PubMed query: (("Emergency Medical Technicians"[MeSH Terms] OR paramedic*[Title/Abstract] OR "emergency medical service*"[Title/Abstract] OR "prehospital"[Title/Abstract]) AND ("Simulation Training"[MeSH Terms] OR simulati*[Title/Abstract] OR "virtual reality"[Title/Abstract] OR "scenario-based"[Title/Abstract]) AND ("Clinical Competence"[MeSH Terms] OR competenc*[Title/Abstract] OR clinical skill*[Title/Abstract] OR resuscitat*[Title/Abstract] OR triage[Title/Abstract] OR decision-making[Title/Abstract])) AND ("2016/01/01"[Date - Publication] : "2026/10/31"[Date - Publication]).

Appendix B. Suggested Competency Evaluation Domains

Domain	Example objective measures	Measurement considerations
Assessment and prioritization	Primary-survey accuracy; red-flag recognition; triage category; time to decision	Use novel cases when examining transfer rather than only repeated identical scenarios.
Airway and ventilation	First-pass success; duration; oxygenation pauses; correct device steps	Report simulator type, experience, and operator assistance.
Resuscitation	Compression depth/rate/recoil; interruption time; defibrillation process	Separate high baseline performance from limited intervention effectiveness.
Trauma and hemorrhage	Trauma survey; bleeding-control decision; splinting; reassessment	Assess prehospital scenarios with standardized, observer-rated clinical checklists.
Teamwork	Role clarity; closed-loop communication; leadership; situation updates	Specify whether scores are team-, dyad-, or individual-level.
Retention and field transfer	Delayed OSCE/checklist; field care audits; protocol adherence	Prefer longer follow-up and risk-adjusted practice outcomes.

Appendix C. Reporting Considerations for Simulation Studies

Educational evaluations should describe the learner group and previous experience; simulator type; scenario content and clinical reference standards; prebriefing and debriefing procedures; number and spacing of practice opportunities; trainer characteristics; outcome instruments and rater blinding; timing of assessments; participant attrition; and the distinction between education-related and patient-related outcomes. For randomized comparisons, allocation methods and between-group differences should be reported. For nonrandomized studies, baseline characteristics, concurrent instruction, missing data, and other explanations for observed change should be considered (Page et al., 2021; Barker et al., 2024).