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EMERGENCY SIMULATION-BASED TRAINING IN MULTIDISCIPLINARY HEALTH PROFESSIONS EDUCATION: A SYSTEMATIC REVIEW OF EFFECTIVENESS ACROSS DENTAL ASSISTING, MEDICAL LABORATORY, PHARMACY, NURSING, OBSTETRICS & GYNECOLOGY, AND RADIOLOGY

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Abstract

Background: Simulation-based training (SBT) is widely adopted in health professions education to improve skill acquisition, clinical reasoning, and readiness for practice. Evidence, however, remains dispersed

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across professions and simulation modalities. **Objective:** To synthesize evidence from PubMed Central original studies on the effectiveness of SBT across dental assisting, medical laboratory education, pharmacy, nursing, obstetrics & gynecology (OB/GYN), and radiology. **Methods:** A PRISMA-aligned systematic review was conducted using PMC (searched February 2, 2025). Eligible studies were original quantitative evaluations of SBT (including standardized patient simulation, mannequin-based simulation, virtual simulation, AR/VR, and computer-based simulation) involving learners in the target professions. Outcomes included knowledge, skill performance, competency assessments, pass rates, time metrics, and learner perceptions. Data were extracted into standardized tables and synthesized narratively due to heterogeneity. **Results:** Ten original studies met eligibility criteria: dental assisting (n=1), medical laboratory (n=1), pharmacy (n=2), nursing (n=2), OB/GYN (n=1), radiology (n=2), plus one multi-professional computer-simulation evaluation (n=1). Across professions, SBT consistently improved procedural/communication performance and competency-based outcomes compared with baseline or traditional instruction. Stronger gains were observed when SBT included structured supervision, deliberate practice, and performance assessment. **Conclusion:** Within PMC-indexed original studies, SBT demonstrates effectiveness in improving skill-based outcomes across multiple health professions. Future research should prioritize standardized outcome measures, longer follow-up, cost-effectiveness, and evidence of transfer to workplace performance.

Keywords: Simulation-Based Education; Health Professions Education; Virtual Simulation; Standardized Patient; Nursing Education.

INTRODUCTION

Simulation-based training (SBT) is now a core strategy in health professions education because it can provide safe, repeatable, feedback-rich practice without direct patient risk. Across disciplines, SBT is commonly justified by the need to improve competency, reduce errors, and accelerate readiness for clinical environments. Broad evidence supports that simulation with deliberate practice improves learning outcomes, particularly for skills that require repetition, feedback, and structured assessment (McGaghie et al. 2011).

However, effectiveness may vary depending on simulation modality (mannequin-based, standardized patient, virtual simulation, AR/VR), curriculum integration, supervision intensity, and assessment rigor. Virtual simulation has expanded rapidly, creating new opportunities but also increasing variability in study designs and outcomes (Wu et al. 2022). These differences make cross-profession synthesis necessary, particularly for applied fields where psychomotor performance and workflow coordination are central outcomes (dental assisting and radiology). In medical education and allied health training, simulation has also been linked to improved downstream clinical outcomes in certain contexts, though transfer is not uniform and depends heavily on implementation quality (Zendejas et al. 2013). A persistent challenge is heterogeneity: studies measure “effectiveness” using non-standard tools, short-term post-tests, or learner satisfaction. Yet, carefully designed simulation—particularly when linked to competency assessment—appears more reliable in producing measurable performance gains (Cleland et al. 2017; Sørensen et al. 2017). This systematic review focuses on SBT effectiveness across dental assisting, medical laboratory education, pharmacy, nursing, OB/GYN, and radiology, using only PMC full-text evidence, and separating original effectiveness studies from supporting literature. The aim is to provide a practical synthesis for educators designing simulation curricula across diverse health programs.

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METHODS

Protocol and reporting standard:

This review was designed and reported in alignment with PRISMA principles (transparent search strategy, explicit eligibility criteria, and structured synthesis). Because this manuscript was restricted to PMC-only retrieval and conducted as a single-reviewer rapid systematic review, formal PRISMA flow counts were not fully captured in a reproducible audit trail; included studies are fully listed and justified below.

Data source and search strategy

Database: PubMed Central, Scopus, WOS full-text archive.

Core concepts: simulation-based training AND education AND (dental assistant OR medical laboratory OR pharmacy OR nursing OR obstetrics OR gynecology OR radiology OR radiography) AND effectiveness/competency/outcome.

Eligibility criteria: Inclusion criteria (original studies): Original quantitative evaluation (randomized, quasi-experimental, pre/post, controlled trial, or comparative cohort). Learners in at least one target profession: dental assisting, medical laboratory, pharmacy, nursing, OB/GYN, radiology/radiography. Simulation modality explicitly described (training management system with simulated workflow/skills assessment; standardized patient simulation; virtual simulation; AR/VR; computer simulation; simulator-based ultrasound). Reported measurable outcomes (skills/competency, pass rates, OSCE/structured assessment, knowledge scores, time metrics, or defined performance outcomes).

Exclusion criteria: Non-original articles (reviews, editorials) for the Results section. Studies not reporting measurable outcomes. Simulation used only as a minor component without evaluative comparison.

Study selection: Titles/abstracts were screened within PMC search outputs. Full-text review was conducted for potentially eligible studies, and inclusion was confirmed against the criteria above.

Data extraction: A standardized extraction form captured: profession/learner group, setting, study design, sample size, simulation modality, comparator, outcome measures, key quantitative findings, and major conclusions. Extracted outcomes were summarized in two tables.

Quality appraisal: Because included studies varied by design and reporting, quality appraisal was conducted narratively (risk of bias considerations included randomization clarity, baseline comparability, outcome assessor blinding, attrition reporting, and objectivity of performance measures). Due to the PMC-only rapid approach, full checklist scoring outputs are not appended.

Synthesis approach: Meta-analysis was not performed due to heterogeneity in simulation modalities and outcome measures. A structured narrative synthesis was used, emphasizing objective performance outcomes where available.

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RESULTS

Included studies

Ten original effectiveness studies were included (Table 1–2), spanning: dental assisting, medical laboratory, pharmacy, nursing, OB/GYN ultrasound, radiology/radiography, and one cross-cutting computer simulation-based evaluation in pharmacy education.

Table 1: Characteristics of included original studies

Study	Profession	Design	Sample	Simulation modality	Comparator	Primary outcomes
Yan et al. 2025	Dental assisting	Pre/post + implementation evaluation	137 dental assistants (participation)	Electronic training management + workflow/ skills assessments	Manual management / pre-implementation	Participation rate, test pass rate, response time, satisfaction
Altinbas et al. 2025	Nursing	Pre/post	83 students	Simulation-based clinical skill training	Baseline	Skill scores, satisfaction, self-confidence
Abdali et al. 2024	Nursing	RCT	81 students	Simulation-based education to train inhaler technique teaching	Traditional instruction	Knowledge and inhaler-teaching skills
Wang et al. 2025	Medical laboratory	Comparative cohort	54 (control) + 54 (intervention)	Virtual Simulation Operation (VSO) platform for clinical microbiology	Traditional teaching	Test scores, learning interest, classroom participation, satisfaction
Basheti et al. 2014	Pharmacy	Parallel-group randomized	54 vs 55	Simulation including counseling real asthma patients	Skills training without patient simulation	Correct device technique (3 inhaler devices)
Bindoff et al. 2014	Pharmacy	Pre/post with comparison	134 students (year 2) + 100 students (year 3)	Computer simulation (MyDispense)	No-simulation baseline/ standard	Dispensing, history-taking, counseling competency
Tong et al. 2024	Nursing (multi-center)	RCT (multi-center)	(see study report)	Simulation-based nursing education	Usual teaching	Knowledge/ skills/ competency outcomes
Weimer et al. 2024	OB/GYN	Prospective evaluation	Target n≈90 planned	Simulator-based ultrasound curriculum (GynSim)	Pre-training baseline	Practical test performance, image quality, time metrics
Rowe et al. 2023	Radiography	Comparative cohort	First-year radio-graphy students	VR simulation vs physical simulation	Physical simulation	OSCE timing and error metrics
Nagamata et al. 2025	Radiologic technology	Randomized comparative	(see study report)	AR-based training for radiographic positioning	Traditional methods	Skill/ knowledge and self-efficacy outcomes

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Table 2: Effectiveness outcomes

Profession	Study	Key findings
Dental assisting	Yan et al. 2025	Participation improved from 80.29% (manual) to 100% (system), P<0.01. Supervisor statistical time reduced (94.8±28.95 min to 8.3±3.3 min, P<0.01). N2-level promotion pass rate improved to 100% post-implementation (P<0.01). Reaction time shortened from 5.42±0.83 s to 3.73±0.76 s (P<0.01).
Nursing	Altinbas et al. 2025	Clinical skill median increased from 56.63 to 68.67 (out of 100), p<0.001. Satisfaction increased (56.22 to 65.05, p<0.001). Self-confidence increased (52.50 to 58.04, p<0.001).
Nursing	Abdali et al. 2024	Simulation group improved knowledge and inhaler-teaching skill significantly more than controls; post-test differences favored simulation (P<0.001).
Medical laboratory	Wang et al. 2025	Intervention outperformed control in theoretical/skill outcomes: microbiology test scores 93.61±3.99 vs 88.65±4.44 (p<0.001). Interest and participation were higher; overall satisfaction (very satisfied + satisfied) 92.6% vs 72.2% (p=0.004).
Pharmacy	Basheti et al. 2014	Correct technique improved substantially more with patient-counseling simulation: post-intervention correct technique in simulation group 60.0–70.9% across devices vs 27.8–42.6% in comparator (p<0.005).
Pharmacy	Bindoff et al. 2014	After computer simulation, counseling competency improved significantly (p=0.005 overall; year 3 counseling p=0.008; history taking p=0.029). Quiz score changes were not statistically significant.
Radiography	Rowe et al. 2023	Outcomes were measured via OSCE timing and error metrics (machinery movement, positioning errors, exposure errors) and compared between VR and physical simulation cohorts.
OB/GYN	Weimer et al. 2024	Practical ultrasound outcomes included pass/fail identification tasks, quantitative measurement deviation from reference, and time-to-completion metrics within a structured simulator platform.
Nursing (multi-center)	Tong et al. 2024	Multi-center RCT evaluated simulation-based nursing education and reported improved competency-oriented outcomes versus usual teaching (per study report).
Radiologic technology	Nagamata et al. 2025	AR-based training was reported as superior to traditional methods for radiographic positioning–related outcomes (per study report).

DISCUSSION

This review synthesized PMC-based original evidence indicating that SBT improves skill-based outcomes across diverse health professions. The most consistent benefits were seen in procedural performance, competency assessment scores, and time/efficiency measures, particularly when simulation was embedded in structured training with supervision and feedback. The dental assisting study demonstrated that a simulation-enabled training management approach can improve participation, reduce supervisory workload, and shorten response times for four-handed techniques—outcomes closely tied to real clinical workflow demands (Yan et al. 2025). Similarly, in pharmacy, engaging students in simulated counseling with real asthma patients yielded markedly higher correct inhaler technique compared with a non-patient simulation approach, suggesting

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that interaction realism and practice of communication + demonstration may be critical for transferable competence (Basheti et al. 2014).

Virtual simulation and AR/VR are attractive due to scalability and reduced reliance on physical equipment and faculty time. In medical laboratory education, a virtual simulation operation platform produced higher test scores and satisfaction compared with traditional teaching (Wang et al. 2025). This aligns with wider observations that virtual simulation is proliferating rapidly, but requires careful instructional design and outcome standardization to avoid “tech novelty” without measurable competency gains (Wu et al. 2022). In radiography education, the VR-versus-physical simulation comparison used OSCE-based error and time metrics to evaluate performance differences, reflecting an important move away from satisfaction-only endpoints toward competence and error reduction (Rowe et al. 2023). AR-based positioning training in radiologic technology was also reported as effective in comparison with conventional methods (Nagamata et al. 2025), supporting the plausibility of AR/VR approaches for spatial and positioning skills that are difficult to master through lecture alone.

A major limitation in simulation research remains the definition of effectiveness. Some studies focus on knowledge tests, others on skills checklists, and fewer still on patient-level outcomes. The broader literature suggests simulation can improve patient-related outcomes in some contexts, but effect magnitude depends on training intensity and implementation quality (Zendejas et al. 2013; Kononowicz et al. 2019). In the included original studies, objective skill gains were often clear, but longer-term transfer (retention, workplace performance, patient outcomes) was rarely assessed. These principles are consistent with higher-level recommendations emphasizing fidelity-for-purpose, feedback, integration into curriculum, and alignment with desired outcomes (Cleland et al. 2017; Sørensen et al. 2017; Al-Elq et al. 2010).

CONCLUSION

Across PMC-indexed original studies spanning dental assisting, medical laboratory, pharmacy, nursing, OB/GYN, and radiology, simulation-based training is generally effective for improving skills, competency assessments, and efficiency-related outcomes. The most consistent benefits occur when simulation includes deliberate practice, structured supervision, and objective performance assessment. Future studies should prioritize standardized outcome metrics, longer follow-up, and evidence of real-world transfer, including patient-level outcomes where feasible.

List of abbreviations

AR: Augmented reality

HPE: Health professions education

OB/GYN: Obstetrics and gynecology

OSCE: Objective structured clinical examination

PMC: PubMed Central

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PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

RCT: Randomized controlled trial

SBT: Simulation-based training

VSO: Virtual Simulation Operation

VR: Virtual reality

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