

Supplementary Material

CLASSIFICATION FRAMEWORK FOR DATA EXTRACTION AND SYNTHESIS

To ensure consistency in data extraction and synthesis, all variables were classified according to predefined criteria developed by the review team before data extraction. The following classification framework was applied consistently across all included studies.

1. Classification of Disaster Types

Disaster types were classified according to the primary disaster scenario addressed in each educational intervention. Studies were categorized into earthquake, mass casualty incident (MCI), chemical, biological, radiological, nuclear, explosive, and hazardous materials (CBRNE/HAZMAT), infectious disease, natural disaster, bioterrorism, or complex disaster. When multiple disaster situations were included, classification was based on the principal educational focus.

2. Classification of Simulation Modalities

Simulation modalities were classified according to the primary mode of educational delivery of the intervention provided to the experimental group.

- Online simulation: Educational interventions delivered exclusively through digital platforms, including web-based simulations, virtual patient simulations, serious games, and virtual reality (VR), without mandatory face-to-face simulation activities.
- Face-to-face simulation: Educational interventions delivered entirely in person, including standardized patient simulations, high-fidelity manikin simulations, tabletop exercises, and other scenario-based simulations.
- Blended simulation: Educational interventions intentionally integrating both online simulation and face-to-face simulation as essential components of the educational intervention.

3. Classification of Technical Components

Because a single intervention could incorporate multiple technologies, technical components were classified independently of simulation modality. Technical components were categorized into:

- HMD-based virtual reality: Simulation delivered through an immersive head-mounted display (HMD), such as Oculus, Meta Quest, HTC Vive, or similar VR devices, providing a fully immersive virtual environment.
- Screen-based simulation: Simulation delivered via a computer, laptop, tablet, or other flat-screen device without the use of an HMD. This category included web-based simulations, virtual patient platforms, computer-based simulations, and desktop virtual environments.
- Game-based simulation: Simulation incorporating serious games, educational games, or gamified environments in which gameplay mechanics (e.g., missions, scoring, levels, or challenges) were integral to the learning activity.
- Standardized patient: Simulation involving trained individuals who consistently portrayed patients, family members, or other healthcare stakeholders for educational purposes.
- High-fidelity simulation: Simulation using advanced computerized mannequins capable of reproducing realistic physiological responses and clinical conditions (e.g., SimMan,

HAL, or equivalent high-fidelity patient simulators).

- Tabletop simulation: Discussion-based simulation using maps, diagrams, cards, written scenarios, or tabletop exercises to facilitate collaborative decision-making without physical or virtual patient interaction.

Studies using multiple technologies were assigned more than one technical component where appropriate.

4. Classification of Educational Objectives

Educational objectives were categorized according to the primary competencies targeted by each educational intervention.

The categories included:

- Disaster-related knowledge and theoretical understanding: Acquisition or improvement of disaster concepts, principles, and theoretical knowledge.
- Disaster response performance and technical skills: Development of psychomotor skills and practical competencies required for disaster nursing practice.
- Self-efficacy and confidence: Enhancement of learners' confidence and perceived capability to perform disaster nursing roles.
- Decision-making, critical thinking, and clinical judgment: Improvement of clinical reasoning, prioritization, and decision-making in disaster situations.
- Disaster preparedness: Strengthening preparedness for disaster response through planning, readiness, or emergency preparedness competencies.
- Learning motivation, satisfaction, and self-directed learning: Promotion of learning engagement, educational satisfaction, motivation, and autonomous learning.
- Non-technical skills such as communication, collaboration, and leadership: Development of interpersonal competencies required for effective teamwork during disaster response.

Studies addressing multiple objectives were classified into all relevant categories.

5. Classification of Scenario Components

Scenario characteristics were categorized according to the principal learning content represented in the simulation.

Scenario components included:

- Mass casualty triage: Triage and prioritization of multiple victims using disaster triage principles.
- Disaster management phases: Scenarios addressing disaster preparedness, response, recovery, or multiple disaster management phases.
- Hospital disaster response: Management of disasters occurring within or affecting hospital systems.
- Decontamination procedures: Simulation of hazardous material exposure and decontamination processes.
- Psychological first aid: Provision of psychological support for disaster victims.

Studies including more than one scenario component were classified into all applicable categories.

6. Classification of Educational Strategies

Educational strategies were classified according to the instructional approaches adopted in each intervention. Strategies were categorized into learning approach, participation structure, and operational characteristics.

Learning approach

- Experience-based learning: Learning through active participation in simulated disaster situations and reflective experience.
- Problem-based learning: Learning centered on solving disaster-related clinical problems or scenarios.

Participation structure

- Individual learning: simulation activities performed individually.
- Team-based collaborative learning: simulation conducted through collaborative teamwork.
- Mixed individual and team-based learning: interventions combining both individual and collaborative activities.

Operational characteristics

- Instructor-designed/facilitated learning: Instructors designed scenarios and actively facilitated learning throughout the simulation.
- Instructor-centered learning: Instructors primarily directed learning activities and provided guidance during the educational process.

Studies incorporating multiple educational strategies were classified into all applicable categories.

7. Classification of Simulation Implementation Strategies

Simulation implementation strategies were categorized according to the instructional design elements incorporated into the intervention.

These included:

- Pre-learning: Preparatory learning activities conducted before simulation (e.g., lectures, online modules, reading assignments).
- Structured debriefing: Guided reflective discussion following simulation using a structured framework.
- Immediate feedback: Prompt feedback provided during or immediately after simulation.

- Repetitive practice: repeated simulation experiences designed to reinforce learning and improve performance.
- Studies incorporating multiple instructional strategies were classified into all applicable categories.

8. Classification of Learning Theories

Educational theories explicitly described by the authors were extracted and grouped according to the theoretical framework adopted in each study, including experiential learning theory, simulation theory/frameworks, situated learning theory, flow theory, behavioral theories, and other educational theories.

9. Classification of Educational Outcomes

Educational outcomes were synthesized into six outcome domains.

- Disaster-related knowledge: Improvement or retention of disaster-related knowledge.
- Self-efficacy and confidence: changes in confidence or perceived ability to perform disaster nursing activities.
- Performance competency and technical skills: Objective or subjective assessment of disaster nursing performance and technical competency.
- Affective outcomes (e.g., attitudes, beliefs, motivation): Psychological or emotional outcomes, including attitudes, beliefs, motivation, and learning engagement.
- Process outcomes (e.g., task completion time, learning retention): Outcomes reflecting learning processes, such as task completion time, retention, or educational efficiency.
- Transfer-related outcomes (e.g., transfer of learning, problem-solving ability, self-leadership): Application of learning to clinical practice or broader competencies, including problem-solving ability, transfer of learning, self-leadership, and clinical adaptability.

When studies reported multiple outcomes, each outcome was classified into the corresponding domain.