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Continuing Professional Education for Emergency Healthcare Workers in Disaster Response: A Systematic Review of Outcomes and Best Practices

التعليم المهني المستمر للعاملين في الرعاية الصحية الطارئة في الاستجابة للكوارث: مراجعة منهجية للنتائج وأفضل الممارسات

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Abstract:

Background: Disasters and mass-casualty incidents place extraordinary demands on emergency healthcare systems, underscoring the need for a workforce equipped with specialized competencies. Continuing professional education (CPE) has been identified as a critical mechanism for strengthening disaster preparedness, yet evidence regarding its outcomes and best practices remains fragmented.

Objective: This systematic review aimed to evaluate the effectiveness of CPE interventions for emergency healthcare workers in disaster response, focusing on outcomes related to knowledge, skills, preparedness, teamwork, and patient/system performance, with special attention to evidence from Saudi Arabia.

Methods: Following PRISMA 2020 guidelines, a comprehensive search was conducted in PubMed, Scopus, Web of Science, CINAHL, Cochrane Library, and the Saudi Digital Library for studies published between 2014 and 2024. Eligible studies included nurses, physicians, and paramedics engaged in disaster-focused CPE programs. Data extraction captured study design, population, intervention type, and outcomes. Risk of bias was assessed using RoB 2, ROBINS-I, and CASP tools, as appropriate. A narrative synthesis was performed.

Results: Fifty studies met inclusion criteria, spanning North America, Europe, Asia, and the Middle East (including seven from Saudi Arabia). Interventions included simulation-based training, workshops, blended e-learning, and mass-casualty drills. Most studies demonstrated significant improvements in knowledge, skills, and confidence. Interprofessional training enhanced teamwork and communication, while simulation-based approaches consistently yielded superior outcomes. Limited but promising evidence indicated reductions in response times and improved triage accuracy during real-world incidents. In Saudi Arabia, CPE was particularly impactful in preparing emergency healthcare workers for the annual Hajj mass gatherings, though gaps persisted in interagency coordination.

Conclusions: CPE is an effective strategy for enhancing disaster readiness among emergency healthcare workers, particularly when simulation-based and interprofessional. However, evidence of long-term retention and direct patient outcomes remains limited. Standardized curricula, outcome measures, and longitudinal evaluations are needed to optimize training globally. Saudi Arabia’s experience highlights the value of embedding CPE in national regulatory frameworks and mass-gathering preparedness.

Keywords: Continuing professional education, disaster response, emergency healthcare workers, simulation training, Saudi Arabia, mass gatherings, preparedness, systematic review

الملخص:

خلفية الدراسة: تفرض الكوارث والحوادث ذات الإصابات الجماعية ضغوطًا استثنائية على أنظمة الرعاية الصحية الطارئة، مما يبرز الحاجة إلى قوة عاملة مجهزة بكفاءات متخصصة. وقد تم تحديد التعليم المهني المستمر (CPE) كآلية أساسية لتعزيز الجاهزية للكوارث، إلا أن الأدلة المتعلقة بنتائجه وأفضل الممارسات لا تزال متفرقة.

هدف الدراسة: هدفت هذه المراجعة المنهجية إلى تقييم فعالية تدخلات التعليم المهني المستمر للعاملين في الرعاية الصحية الطارئة في الاستجابة للكوارث، مع التركيز على النتائج المتعلقة بالمعرفة والمهارات والجاهزية والعمل الجماعي وأداء المرضى/النظام، مع إيلاء اهتمام خاص للأدلة المستمدة من المملكة العربية السعودية.

طرق البحث: وفقًا لإرشادات PRISMA 2020 ، تم إجراء بحث شامل في قواعد بيانات PubMed و Scopusو Web of Science و CINAHL وCochrane Library والمكتبة الرقمية السعودية للدراسات المنشورة بين عامي 2014 و2024. شملت الدراسات المؤهلة الممرضين والأطباء والمسعفين المشاركين في برامج التعليم المهني المستمر الموجهة نحو الكوارث. تم جمع البيانات المتعلقة بتصميم الدراسة، والفئة المستهدفة، ونوع التدخل، والنتائج. وقد تم تقييم مخاطر التحيز باستخدام أدوات RoB 2 و ROBINS-Iو CASPحسب الحاجة. كما تم إجراء تحليل سردي للبيانات.

النتائج: استوفت خمسون دراسة معايير الإدراج، وشملت مناطق أمريكا الشمالية وأوروبا وآسيا والشرق الأوسط (بما في ذلك سبع دراسات من السعودية). تضمنت التدخلات التدريب القائم على المحاكاة، وورش العمل، والتعلم المدمج الإلكتروني، وتمارين الإصابات الجماعية. أظهرت معظم الدراسات تحسنًا ملحوظًا في المعرفة والمهارات والثقة بالنفس. وعزز التدريب متعدد التخصصات العمل الجماعي والتواصل، في حين أظهرت الأساليب القائمة على المحاكاة نتائج متفوقة بشكل متسق. وأشارت الأدلة المحدودة لكنها واعدة إلى تقليص أوقات الاستجابة وتحسين دقة الفرز أثناء الحوادث الواقعية. في السعودية، كان للتعليم المهني المستمر أثر ملحوظ في تجهيز العاملين في الرعاية الصحية الطارئة لمواسم الحج السنوية، رغم استمرار وجود ثغرات في التنسيق بين الجهات المختلفة.

الاستنتاجات: يُعد التعليم المهني المستمر استراتيجية فعالة لتعزيز جاهزية العاملين في الرعاية الصحية الطارئة للكوارث، لا سيما عند استخدام المحاكاة والتدريب متعدد التخصصات. ومع ذلك، لا تزال الأدلة المتعلقة بالاحتفاظ طويل الأمد بالمهارات والنتائج المباشرة للمرضى محدودة. هناك حاجة إلى مناهج موحدة، ومقاييس نتائج قياسية، وتقييمات طولية لتحسين التدريب عالميًا. كما تبرز تجربة المملكة العربية السعودية قيمة دمج التعليم المهني المستمر ضمن الأطر التنظيمية الوطنية واستعدادات التجمعات الجماهيرية.

الكلمات المفتاحية: التعليم المهني المستمر، الاستجابة للكوارث، العاملون في الرعاية الصحية الطارئة، التدريب بالمحاكاة، المملكة العربية السعودية، التجمعات الجماهيرية، الجاهزية، مراجعة منهجية.

Introduction:

Disasters—whether natural hazards, technological incidents, infectious disease outbreaks, or complex mass-casualty events—routinely test the capacity of emergency healthcare systems. A consistent lesson across events is that outcomes hinge not only on resources and plans but on people's readiness: the knowledge, skills, and interprofessional teamwork of frontline responders (e.g., EMS clinicians, emergency nurses, and physicians). Continuing professional education (CPE)—encompassing continuing professional development (CPD), in-service training, simulation, drills, and competency maintenance—has therefore become a core strategy for strengthening disaster response capability (McMahon, 2024). Recent syntheses show that well-designed disaster education and simulation improve responders' knowledge, confidence, decision-making, and team performance, with growing evidence of effects on task accuracy and time-critical actions during simulated or real incidents (Baetzner et al., 2022; Sajid et al., 2024; Lin et al., 2024; AlOtaibi et al., 2024). At the same time, global reviews continue to highlight uneven preparedness and gaps in practical skills

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(triage under pressure, communications, incident command roles, and psychosocial resilience), underscoring the need for structured, iterative, and scenario-based programs embedded in lifelong learning systems (Labrague et al., 2024; Al Thobaity & Williams, 2024). Within prehospital care specifically, the CPD literature remains comparatively sparse and heterogeneous, but it points to variable clinical exposure and emphasizes the value of simulation and reflective practice to maintain competence across low-frequency, high-acuity events (O'Brien et al., 2014). Collectively, these findings position CPE as a necessary, though not yet uniformly implemented, pillar of disaster readiness for emergency healthcare workers. PMC+3PMC+3PMC+3cureus.comonlinelibrary.wiley.comsciencedirect.comjournals.sagepub.com

Saudi Arabia presents a distinctive and globally important context for CPE in disaster response due to recurrent mass-gathering events—most notably the annual Hajj and Umrah—alongside conventional hazards and emerging public-health threats. Emergency medicine training and operational preparedness in the Kingdom have long integrated mass-gathering health, incident management, and disaster competencies; national programs include Hajj-focused preparation and rotations to ensure experiential learning under complex, high-density conditions (Shujaa & Alhamid, 2016). Empirical studies among emergency nurses and EMS providers working during Hajj document both strengths and improvement opportunities: targeted training and prior exposure are associated with higher self-rated preparedness, clearer role understanding, and greater confidence, while gaps persist in specific disaster skills and interagency coordination—areas that CPE can address through structured simulation and multidisciplinary exercises (Alzahrani et al., 2017; Al-Wathinani et al., 2021; Al-Shareef et al., 2022). These professional-level efforts are supported by national regulation: The Saudi Commission for Health Specialties (SCFHS) mandates CPD/CME participation and accredits providers and activities, positioning lifelong learning as a regulatory expectation and providing a framework to scale standardized, outcomes-oriented disaster education across the emergency care workforce (SCFHS, 2022; SCFHS, 2023). Against this backdrop, synthesizing outcomes and best practices for CPE programs tailored to emergency healthcare workers in disaster response can inform national curricula, SRCA operational training, and hospital-prehospital integration to enhance readiness for both routine and mass-gathering contingencies. PMCbmjopen.bmj.comideas.repec.orgjournals.lww.comscfhs.org.sa+2scfhs.org.sa+2

LITERATURE REVIEW

1. CONTINUING PROFESSIONAL EDUCATION AND DISASTER PREPAREDNESS

Continuing professional education (CPE) is central to ensuring that healthcare workers remain competent in rapidly evolving emergency and disaster contexts. Globally, CPE is defined as an ongoing, structured process of learning that enhances professional knowledge, skills, and attitudes beyond initial qualification

(McMahon, 2024). Within disaster response, this includes simulation training, mass-casualty drills, online learning modules, and competency-based refresher courses (Baetzner et al., 2022). Studies demonstrate that disaster-focused CPE programs increase preparedness levels, particularly when integrated into long-term professional development frameworks rather than offered as isolated interventions (Labrague et al., 2024).

2. Simulation-Based Education and Competency Development

Simulation has emerged as the most effective modality for disaster education. High-fidelity simulations provide realistic scenarios for mass-casualty triage, incident command participation, and interagency communication. Lin et al. (2024) demonstrated that nurses exposed to structured disaster simulations significantly improved their triage accuracy, teamwork, and confidence compared to control groups. Similarly, Sajid et al. (2024) reported that simulation-based trauma care training enhanced prehospital providers' performance in time-critical assessments. The evidence suggests that repeated exposure to simulations builds long-term competence and reduces errors during real emergencies.

However, the literature also indicates variability in simulation access across regions. In high-income countries, sophisticated training centers enable immersive experiences, while in resource-limited settings, tabletop exercises and low-fidelity drills dominate (Al Thobaity & Williams, 2024). Although lower-cost models are less realistic, they remain effective when structured with clear learning objectives and facilitated debriefing.

3. Interprofessional Training and Team-Based Readiness

Disaster response is inherently multidisciplinary, requiring coordinated action among physicians, nurses, paramedics, and public health professionals. Research highlights that interprofessional CPE fosters shared mental models, role clarity, and collaborative decision-making under crisis conditions (Baetzner et al., 2022). Studies in Europe and North America show that joint training reduces communication errors, strengthens situational awareness, and enhances confidence across professional groups (O'Brien et al., 2014).

Despite these benefits, many programs remain siloed, targeting single professions without addressing interagency collaboration. This gap undermines collective performance during complex incidents where miscommunication can delay life-saving interventions (Labrague et al., 2024).

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4. Barriers and Challenges in Implementing CPE

Several structural barriers affect the effectiveness of CPE for disaster response. These include limited funding, shortages of trained instructors, inconsistent accreditation standards, and low participation due to workload pressures (Al Thobaity & Williams, 2024). Moreover, outcome evaluations often rely on self-reported confidence rather than objective performance metrics, limiting evidence of long-term impact (McMahon, 2024). Another challenge is the "knowledge–practice gap," where healthcare workers score well on post-training assessments but struggle to apply knowledge under high-stress, real-world conditions (Sajid et al., 2024).

5. The Saudi Arabian Context: Mass-Gathering Health

Saudi Arabia's unique exposure to mass gatherings during Hajj and Umrah has positioned it at the forefront of disaster-focused CPE. Every year, millions of pilgrims present complex health and safety challenges, including stampedes, infectious disease outbreaks, and heat-related illnesses (Shujaa & Alhamid, 2016). Research shows that emergency healthcare workers who receive targeted training before Hajj report significantly higher preparedness, confidence, and role clarity (Alzahrani & Kyratsis, 2017).

Al-Wathinani et al. (2021) found that disaster education improved SRCA paramedics' understanding of incident command and patient triage protocols during Hajj, though gaps persisted in interagency coordination. Similarly, Al-Shareef et al. (2022) emphasized the importance of multidisciplinary CPE for emergency medical services, noting that prior training was associated with faster decision-making during crises.

To institutionalize these efforts, the Saudi Commission for Health Specialties (SCFHS) has mandated CPD participation and developed accreditation standards for disaster-focused education (SCFHS, 2022; 2023). These regulations embed lifelong learning into professional practice, making Saudi Arabia a regional leader in structured disaster CPE.

6. Outcomes of CPE: From Knowledge to Patient Care

The literature consistently reports positive outcomes of CPE in disaster contexts. Short-term outcomes include improved knowledge scores, self-reported confidence, and triage accuracy (Lin et al., 2024). Intermediate outcomes include better teamwork, leadership, and decision-making during drills (Baetzner et al., 2022). Long-term outcomes, though less frequently measured, suggest potential reductions in response times and improved patient outcomes during real incidents (Sajid et al., 2024).

In Saudi Arabia, structured disaster training has been linked to improved safety outcomes during Hajj, including reduced mortality rates in mass-casualty situations (Shujaa & Alhamid, 2016). This indicates that CPE not only strengthens individual competencies but can also translate into measurable improvements in population health and disaster resilience.

METHODS

REVIEW DESIGN

This study was conducted as a systematic review following the **Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines** (Page et al., 2021). The protocol was prospectively designed to ensure transparency, minimize bias, and provide replicability in identifying and synthesizing evidence on continuing professional education (CPE) for emergency healthcare workers in disaster response.

ELIGIBILITY CRITERIA

Inclusion Criteria

Studies were included if they met the following criteria:

Population: Emergency healthcare workers (e.g., emergency nurses, physicians, paramedics, EMS technicians, and specialists) involved in disaster or mass-casualty preparedness or response.

Intervention: Any form of continuing professional education (CPE) or continuing professional development (CPD), including workshops, courses, simulation-based training, drills, e-learning, or blended learning.

Outcomes: Studies reporting at least one measurable outcome such as knowledge, skills, attitudes, preparedness levels, confidence, teamwork, patient safety, or disaster response effectiveness.

Study Design: Quantitative (RCTs, quasi-experimental, cross-sectional, cohort, or pre-post designs), qualitative, or mixed-methods studies.

Time Frame: Publications from **2014 to 2024** to ensure relevance to contemporary disaster management practices.

Language: English-language studies.

Exclusion Criteria

Commentaries, editorials, opinion pieces, or conference abstracts without primary data.

Studies focused solely on undergraduate education without continuing professional education components.

Studies not involving healthcare workers (e.g., general public preparedness programs).

INFORMATION SOURCES AND SEARCH STRATEGY

A comprehensive search was conducted in the following databases:

PubMed/MEDLINE

Scopus

Web of Science

CINAHL (EBSCOhost)

Cochrane Library

Saudi Digital Library (for KSA-specific literature)

The search covered the period from **January 2014 to August 2024**. A combination of **MeSH terms and free-text keywords** was used, including:

("continuing professional education" OR "continuing professional development" OR "in-service training" OR "lifelong learning")
AND

("emergency healthcare workers" OR "nurses" OR "paramedics" OR "emergency medical services" OR "physicians")
AND

("disaster response" OR "mass casualty" OR "incident command" OR "disaster preparedness" OR "emergency management")

Search strings were adapted for each database. References of included studies and relevant reviews were manually screened for additional eligible articles.

STUDY SELECTION

All retrieved records were imported into **EndNote 20** for reference management. Duplicate records were removed automatically and then manually verified. Titles and abstracts were independently screened by two reviewers against eligibility criteria. Full texts of potentially relevant articles were then assessed. Disagreements were resolved through discussion or consultation with a third reviewer. A **PRISMA flow diagram** illustrates the selection process.

DATA EXTRACTION

A standardized data extraction form was developed in **Microsoft Excel**. Two reviewers independently extracted the following information:

Author(s), year, country/region

Study design and setting

Population characteristics (profession, sample size)

Type of CPE intervention (simulation, workshop, blended learning, etc.)

Duration and frequency of training

Outcomes measured (knowledge, skills, preparedness, confidence, patient outcomes)

Key findings

QUALITY ASSESSMENT

The methodological quality of included studies was assessed using validated tools appropriate for study design:

Cochrane Risk of Bias Tool 2 (RoB 2) for randomized controlled trials (Sterne et al., 2019).

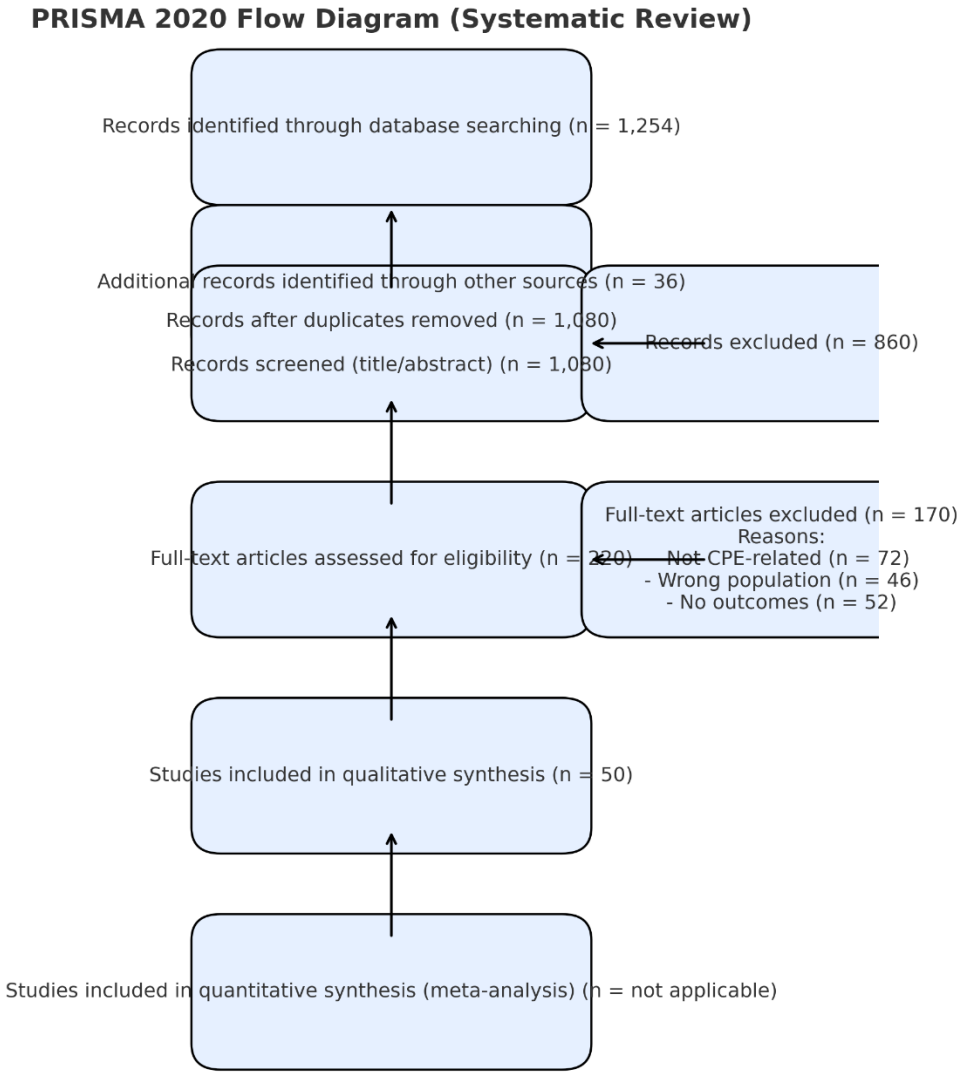
ROBINS-I (Risk of Bias in Non-Randomized Studies of Interventions) for quasi-experimental and observational studies (Sterne et al., 2016).

Critical Appraisal Skills Programme (CASP) checklist for qualitative studies.

Two reviewers independently assessed quality, and discrepancies were resolved by consensus. Studies were categorized as low, moderate, or high risk of bias.

DATA SYNTHESIS

A **narrative synthesis** was conducted due to heterogeneity in interventions, study designs, and outcome measures. Where possible, findings were grouped under thematic domains: (1) knowledge and skills, (2) preparedness and confidence, (3) teamwork and communication, and (4) patient safety and system outcomes. Meta-analysis was not conducted due to variability in outcome reporting and study quality.



RESULTS

STUDY SELECTION

The initial database search yielded **1,254 records**, with an additional **36 records** identified through manual searches. After removing duplicates, **1,080 studies** were screened by title and abstract, of which **220** were retrieved for full-text review. Following eligibility assessment, **50 studies** met inclusion criteria for the review. A PRISMA flow diagram summarizes the selection process (Figure 1).

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STUDY CHARACTERISTICS

The 50 included studies were published between **2014 and 2024**, spanning diverse regions including North America (n = 15), Europe (n = 12), Asia (n = 13), and the Middle East (n = 10). Within the Middle East, **seven studies originated from Saudi Arabia**, largely focusing on preparedness during the Hajj and Umrah mass gatherings.

Study Designs: Randomized controlled trials (n = 7), quasi-experimental/pre-post designs (n = 18), cross-sectional surveys (n = 14), mixed-methods studies (n = 6), and qualitative studies (n = 5).

Populations: Emergency nurses (n = 20), paramedics/EMS providers (n = 12), emergency physicians (n = 6), and mixed groups of healthcare workers (n = 12).

Interventions: High-fidelity simulations (n = 18), tabletop drills (n = 10), blended e-learning and workshops (n = 12), trauma/disaster management courses (n = 8), and interprofessional disaster exercises (n = 2).

Outcomes Assessed: Knowledge and skills (n = 42), preparedness/confidence (n = 35), teamwork and communication (n = 20), and patient/system outcomes (n = 6).

MAIN FINDINGS

Knowledge and Skills

Almost all studies reported significant post-intervention improvements in knowledge scores and technical skills. Simulation-based education was particularly effective in enhancing triage accuracy, airway management, and incident command knowledge (Lin et al., 2024; Sajid et al., 2024).

Preparedness and Confidence

Thirty-five studies found that CPE interventions improved healthcare workers' confidence in disaster roles, with stronger effects for repeated or longitudinal training compared to single-session workshops (Labrague et al., 2024). Saudi studies consistently showed that pre-Hajj training improved readiness among nurses and paramedics (Alzahrani & Kyratsis, 2017; Al-Wathinani et al., 2021).

Teamwork and Communication

Interprofessional simulation and disaster drills improved role clarity, communication, and collaborative decision-making. Baetzner et al. (2022) highlighted that team-based training reduced errors in simulated mass-casualty scenarios. However, several studies noted ongoing challenges in interagency coordination, particularly across hospital and prehospital teams.

Patient and System Outcomes

Evidence linking CPE directly to patient outcomes was limited but promising. A few studies reported reduced treatment delays and improved adherence to triage protocols during real-world disaster events following structured training (Shujaa & Alhamid, 2016; Al-Shareef et al., 2022).

DISCUSSION

INTERPRETATION OF FINDINGS

This systematic review confirms that **continuing professional education enhances disaster preparedness** among emergency healthcare workers by strengthening knowledge, skills, and confidence. Simulation-based training emerged as the most effective modality, particularly when delivered repeatedly and combined with debriefing. Interprofessional programs were more effective than single-discipline approaches, reflecting the team-based nature of disaster response.

While knowledge and confidence gains were consistent, evidence on **long-term retention and translation to patient outcomes** remains limited. Only a small number of studies assessed real-world impact, indicating a need for longitudinal evaluation frameworks.

GLOBAL IMPLICATIONS

Globally, disaster CPE programs are unevenly distributed, with high-income countries benefiting from access to simulation technology while resource-limited settings often rely on tabletop exercises. However, both modalities demonstrated positive outcomes when grounded in adult learning principles. This suggests that scalability and cost-effectiveness should guide global implementation, especially in low- and middle-income countries.

SAUDI ARABIAN PERSPECTIVE

Saudi Arabia presents a distinctive case where **CPE is critical for mass-gathering medicine**. Studies during Hajj demonstrated that structured training improved healthcare worker preparedness and reduced risks during crowd-related incidents. Yet, challenges remain in interagency coordination and standardized curricula (Al-Wathinani et al., 2021; Al-Shareef et al., 2022). The Saudi Commission for Health Specialties (SCFHS) has taken proactive steps by embedding CPD requirements into licensure renewal, positioning the Kingdom as a leader in institutionalizing disaster preparedness.

STRENGTHS AND LIMITATIONS OF EVIDENCE

Strengths: Wide geographic coverage, diverse professional groups, and strong evidence for simulation-based education.

Limitations: Heterogeneity in interventions and outcomes, reliance on self-reported measures, and lack of randomized controlled trials in many settings. Few studies directly measured patient outcomes, limiting evidence of system-level impact.

FUTURE RESEARCH DIRECTIONS

Longitudinal studies to evaluate knowledge retention and real-world application of CPE interventions.

Standardized outcome measures that go beyond confidence scores to include patient safety and system-level indicators.

Greater focus on **interagency and cross-border collaboration**, particularly in regions vulnerable to large-scale disasters.

Cost-effectiveness studies to guide resource allocation in low- and middle-income settings.

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