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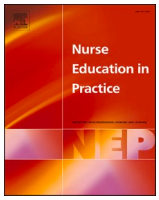
Nurse Education in Practice 69 (2023) 103583

Contents lists available at ScienceDirect

Nurse Education in Practice

journal homepage: www.elsevier.com/locate/issn/14715953



Review

Disaster preparedness in healthcare professionals amid COVID-19 and beyond: A systematic review of randomized controlled trials

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ARTICLE INFO

Keywords:
Disaster preparedness
COVID-19
Coronavirus
Healthcare professionals
Emergency management
Randomized controlled trials
RCTs

ABSTRACT

Background: Disasters like COVID-19 are oftentimes inevitable, which makes disaster preparedness indispensable to global health and social stability. However, there is a dearth of understanding of how well healthcare professionals, who often have to work at the epicenter of disasters as they evolve, are trained to be sufficiently prepared for these crises. To this end, this study aims to examine the characteristics and effectiveness of existing interventions that aim to improve healthcare professionals' disaster preparedness.

Methods: We searched RCTs that aim to improve healthcare professionals' disaster preparedness in databases including PubMed, PsycINFO, CINAHL and Scopus. Results were screened against the eligibility criteria. The review was registered with PROSPERO (CRD42020192517) and conducted following the PRISMA guidelines.

Results: A total of 7382 articles were screened for eligibility, among which, 27 RCTs, incorporating 35,145, met the inclusion criteria. Review results show that most of the eligible RCTs were conducted in high-income countries. Only two RCTs were developed in disaster contexts that share similarities with COVID-19. Most of the interventions did not address critical disaster coping abilities, such as how can healthcare professionals protect or improve their personal or the general public's mental health amid pandemics. Furthermore, almost half of the disaster preparedness RCTs failed to generate statistically significant outcomes.

Conclusions: Albeit inevitable, disasters are preventable. Our study results underscore the imperative of designing and developing effective and comprehensive interventions that could boost healthcare professionals' disaster preparedness, so that these frontline workers can better protect personal and public health amid global crises like COVID-19.

1. Introduction

Disaster preparedness is indispensable to social stability. Disaster could be understood as the "occurrence of a sudden or major misfortune, which disrupts the basic fabric and normal functioning of a society" (World Health Organization, 2003). Disaster preparedness, in turn, is the degree to which individuals and organizations are, preferably pre-emptively, equipped with the mindset, know-how and resources needed to offset or mitigate the adverse effects of crises or calamities like COVID-19 (Su et al., 2021e). It is important to note that everyday disaster preparedness strategies, ranging from fire insurance, hurricane preparation kits, to portable power generators, all fall under the concept of disaster preparedness (Gowan et al., 2015). However, for healthcare professionals, who often have to work at the epicenter of disasters as they evolve, disaster preparedness usually entails a structured, systematic and comprehensive understanding of and readiness for threats associated with the disasters (Elhadi et al., 2020; Baack and Alfred, 2013; Hsu et al., 2006). Even though disasters vary in terms of scale and scope of destruction, almost all disasters require healthcare professionals' assistance to address both personal emergencies and public health crises that are caused or magnified by disasters (Cutter et al., 2003; Galea et al., 2005; Tierney et al., 2001a; Su et al., 2021a, 2021b;

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https://doi.org/10.1016/j.nepr.2023.103583
Received 22 July 2022; Accepted 15 February 2023
Available online 26 February 2023
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Liu et al., 2020; Li et al., 2020). The need for disaster preparedness is particularly evident amid global health crises of COVID-19′s magnitude, a time when healthcare professionals' abilities to monitor and manage the pandemic is instrumental to societies' ability to curb and control COVID-19 (Su et al., 2020; Yang et al., 2020; Krishnamoorthy et al., 2020).

2. Background

COVID-19 is a once-in-a-century catastrophe (Gates, 2020) and, as of October 15th, 2021, at least 219 million people had contracted COVID-19, with 4.55 million people died from their infections (Johns Hopkins University, 2021). The economic consequences of COVID-19 may further compound its destructions on people's psychological and physical health; estimates suggest that COVID-19 could cost the world economy approximately $28 trillion (Elliott, 2021). While pandemics like COVID-19 can upend lives, livelihoods and economics, it is important to note that, with adequate disaster preparedness, especially among frontline workers like healthcare professionals, these adverse impacts can be significantly mitigated (Anderson et al., 1992; Honigsbaum, 2019; Lederberg, 1997; Heesterbeek et al., 2015; Tierney et al., 2001a; 2021b; World Health Organization, 2007; Snowden, 2019). Overall, a rich body of evidence shows that interventions such as education and training programs can improve healthcare professionals' disaster preparedness (Liu et al., 2020; Behar et al., 2008; Cheng et al., 2020). Research on 400 healthcare professionals in Pakistan, for instance, shows that even simple educational interventions like a short-term exposure to COVID-19 preparedness guidelines, can help improve these frontline workers' knowledge on how to best cope with COVID-19 (Li et al., 2020). However, while disaster preparedness in healthcare professionals is often the first line of defense amid public health crises, emerging evidence shows that disaster preparedness in doctors and nurses is often suboptimal (Elhadi et al., 2020; Suleiman et al., 2020; Al-Ashwal et al., 2020; Biswas et al., 2020; Jamir et al., 2020).

In a study of 1,572 healthcare professionals in Libya, researchers similarly found that 79.4% of the doctors and 73.7% of the nurses surveyed believe they lack preparedness for the COVID-19 outbreak (Elhadi et al., 2020). Again, analyzing 308 Jordanian COVID-19 frontline doctors' disaster preparedness, 43.8% of the participants do not have institutional protocols for COVID-19 patients (Suleiman et al., 2020). Even though healthcare professionals should set the example of preventive health practice amid disasters, research on 226 members of the general public and healthcare professionals found that both groups have a poor COVID-19 safety measures practice (e.g., maintaining hand hygiene and wearing face masks) (Jamir et al., 2020). While healthcare professionals' lack of disaster preparedness is alarming, there is a shortage of research that could answer questions such as "What rigorously-tested interventions are available for improving healthcare professionals' disaster preparedness?" Thus, bridging this research gap, this study examines the following research question:

- What are the characteristics and effectiveness of interventions that aim to improve healthcare professionals' disaster preparedness?

3. Methods

3.1. Registration and reporting guidelines

Registered with the International Prospective Register of Systematic Reviews (PROSPERO) system (CRD42020192517), this systematic review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) procedures in the reporting process (Moher et al., 2015).

3.2. Data sources and search strategy

Databases were searched for relevant articles published between January 1st, 2003 and June 23rd, 2020. Four databases were included as the primary data source: PubMed, PsycINFO, the Cumulative Index to Nursing and Allied Health Literature (CINAHL) and Scopus. The year 2003 was chosen purposefully as the severe acute respiratory syndrome (SARS) outbreak was first declared a global pandemic in 2003 (LeDuc and Barry, 2004). Considering the similarity between SARS and the Middle East respiratory syndrome (MERS), both from a virus characteristics perspective (Shereen et al., 2020; Park et al., 2020; Petrosillo et al., 2020) and a disaster preparation standpoint (Wilder-Smith et al., 2020; Peeri et al., 2020; Keshvardoost et al., 2020), making the review timeframe inclusive of interventions that are aware of the impact of SARS and MERS can help enrich the relevance and rigor of this study. The search strategy was developed in consultation with a librarian from [*** university name removed]. Search terms centered on the following key concepts: disaster preparedness, healthcare professionals and randomized controlled trials. An example search query used for PubMed could be found in Table 1.

3.3. Inclusion and exclusion criteria

In the context of this study, healthcare professionals are defined as adults who have a certification, registration, or a similar rigorously validated credential or earned experience that allows them to work in a healthcare field as a profession, such as nurses and doctors. A disaster is defined as the "occurrence of a sudden or major misfortune, which disrupts the basic fabric and normal functioning of a society," whereas emergency events describe "situations featuring armed conflict, population displacement and food insecurity with increases in acute malnutrition prevalence and crude mortality rates" (World Health Organization, 2003). Although a wide array of applications of the terms is available in the literature, in this study, disasters refer to disruptive conditions that are naturally occurring (e.g., infectious diseases (Su et al., 2021f)), whereas emergencies or emergency events refer to human-manufactured misfortunes (e.g., biodisasters (Su et al., 2021c)).

As often seen in the real world, disasters could often lead to emergency events and vice versa. For instance, the COVID-19 pandemic, which is a global disaster (i.e., naturally occurring), could trigger emergency events (i.e., caused by human actions or inactions) like the dysfunctioning of many communities' medical systems amid the pandemic (e.g., shortages of medical goods like oxygen, sickening of healthcare workers like nurses and their spillover effects on patients and caregivers (Farrell et al., 2021; Ranney et al., 2020; World Health Organization, 2021; Cancino et al., 2020; Su et al., 2021d). Therefore, it is important to underscore that though disasters and emergency events could be used in a mutually exclusive manner, their connectedness

Table 1
Example PubMed search queries.

Theme	Search string
Disaster preparedness	"disaster* "[MeSH] OR "disaster* "[TIAB] OR "emergenc* "[MeSH] OR "emergenc* "[TIAB] OR "COVID-19″[MeSH] OR "COVID-19″[TIAB] OR "coronavirus"[MeSH] OR "coronavirus"[TIAB] OR "severe acute respiratory syndrome" OR "SARS" OR "Middle East respiratory syndrome" OR "MERS"
Healthcare professionals	nurse[MeSH] OR nurse* [TIAB] OR doctor[MeSH] OR doctor* [TIAB] OR clinician* OR "healthcare professional* " OR "healthcare worker* " OR "healthcare practitioner* "
Randomized controlled trials	randomized controlled trial[PT] OR randomized controlled trials as topic[MH] OR random allocation [MH] OR double-blind method[MH] OR single-blind method[MH] OR random* [tw] OR "Placebos"[MeSH] OR placebo[TIAB] OR ((singl*[tw] OR doubl*[tw] OR trebl*[TW] OR tripl*[TW]) AND (mask*[TW] OR blind*[TW] OR dumm*[TW]))

should not be dismissed, which is often influenced by factors such as a society's disaster preparedness. In the context of this study, disaster preparedness is defined as the "activities and measures taken in advance of an event to ensure an effective response to the impact of hazards" (Diab and Mabrouk, 2015).

The abovementioned conceptualizations, along with the eligibility criteria, forged the parameters of the current review. Overall, the inclusion criteria were determined a priori and listed in Table 2. Overall, articles were excluded if they (1) did not focus on disaster preparedness interventions for healthcare professionals, (2) did not adopt a randomized controlled trial as research design, (3) did not provide detailed information on the intervention design and application and (4) did not report original and empirical data on study outcomes.

3.4. Data extraction and synthesis

Data extraction was conducted by all four authors independently. Data points were extracted in a spreadsheet and analyzed using descriptive statistics and narrative synthesis. Descriptive analyses were used to gain a concise and connected understanding of the characteristics of the interventions (e.g., epidemic studied). A narrative synthesis approach was adopted to review how well healthcare professionals are prepared to tackle emerging and re-emerging epidemics or pandemics. A meta-analysis was not performed for the present study as no meaningful results can be yielded due to pronounced heterogeneity found in all eligible articles.

4. Results

The initial search yielded 7382 publications. After removing duplicates (n = 1077), 6305 publications remained and were subsequently screened based on titles and abstracts. A total of 122 papers were eligible for full-text review against the inclusion and exclusion criteria. After applying the eligibility criteria, 27 RCTs (Chambers et al., 2012, 2015; Conner et al., 2011; Loeb et al., 2009; Chuang et al., 2014; Lee et al., 2018; MacIntyre et al., 2017; Christensen et al., 2020; Borgey et al., 2019; Lemaitre et al., 2009; Rothan-Tondeur et al., 2010; Pesiridis et al., 2015; Aluisio et al., 2016; Fudzi et al., 2019; Sijbrandij et al., 2020; Andreatta et al., 2010; Baseman et al., 2016; Bordley et al., 2003; Doratotaj et al., 2008; Ten Eyck et al., 2009; Wallace et al., 2010; Zaveri et al., 2016; Radonovich et al., 2019) were included in the final review. Two principal reviewers (ZS and DMD) independently reviewed the records, while the final eligible articles were coded by all four principal reviewers (ZS, DMD, JA and AC). Discrepancies were resolved by group discussions till a consensus was reached. Details of the screening process can be seen in Fig. 1.

A total of 27 RCTs, incorporating 35,145 healthcare professionals, met the eligibility criteria. Review results showed that most of the RCTs were conducted in high-income countries (18/27; 66.7%), with the remaining carried out in low- and middle-income countries (9/27; 33.3%). Infectious diseases were the most frequently studied research context (18/27; 66.7%), followed by emergency events (5/27; 18.5%) and general disasters such as fire and flood (5/27; 18.5%). Among all disease contexts, seasonal influenza is the most studied one (9/27; 33.3%), while each of the following disease contexts conducted one trial: the Ebola epidemic, pandemic influenza, MRSA (methicillin-resistant Staphylococcus aureus), viral respiratory infections, infectious diseases in general, HIV, as well as malaria, pneumonia, tuberculosis and HIV.

Overall, there is a lack of consistent outcome measures across the studies—a wide array of evaluations was adopted to gauge the efficacy of the study RCTs. only 59.3% (16/27) of the RCTs had shown statistically significant improvement in outcome measures (e.g., don and off personal protective gears). In other words, nearly half of the eligible RCTs (11/27; 40.7%) reported nonsignificant findings. In particular, it appears that either virtual or live "mock codes" and "case-based learning" were interventions that could generate satisfactory outcomes. Alarmingly, most of the interventions did not address critical disaster coping abilities such as mental health resiliency in their programs (e.g., how can healthcare professionals protect or improve their personal or the general public's mental health amid pandemics). A detailed summary of the eligible RCTs reviewed is listed in Table 3. A graphic representation of the included studies can be found in Fig. 2.

Table 2
Study inclusion criteria.

Category	Criteria
Study population	Healthcare professionals (≥18 years)
Intervention	Non-technology-based or technology-based interventions related to disaster preparedness
Key variable	Detailed descriptions of the interventions (i.e., country, study design, epidemic studied, participants, tools or intervention studies and outcomes).
Study type	Original research (i.e., research that reports original and empirical research findings)
Study design	Randomized controlled trials (RCTs)
Study outcome	Empirical reporting of the effects of the interventions

5. Discussion

The purpose of this systematic review is to investigate interventions that could improve healthcare professionals' disaster preparedness amid crises like COVID-19. To our knowledge, this is the first study that investigated healthcare professionals' disaster preparedness with a close focus on rigorously-evaluated interventions (i.e., RCTs). The findings of our study show that there is a shortage of rigorously-tested interventions for healthcare professionals' disaster preparedness, especially in low- and middle-income countries. Furthermore, findings also indicate that most available interventions failed to address key disaster preparedness abilities needed for healthcare professionals to effectively tackle disasters like COVID-19, such as mental health resiliency. Alarmingly, nearly half of the RCTs reviewed (40.7%) did not introduce significant improvements in healthcare professionals' disaster preparedness.

Our first research question aims to examine the characteristics and effectiveness of available RCTs for improving healthcare professionals' disaster preparedness. The findings of the review show that most of the eligible interventions were conducted in high-income countries. Infectious diseases are the most studied research context, compared with other disasters such as fire and flood. Noticeably, most RCTs conducted in infectious diseases focused on healthcare professionals' disaster preparedness amid seasonal influenza. It is important to note that only two RCTs investigated pandemics (i.e., pandemic influenza and the Ebola epidemic), a disaster category that COVID-19 fall within and when the need for healthcare professionals' disaster preparedness might be more pronounced than endemics (e.g., seasonable influenza) or epidemics (e.g., Zika outbreaks). Furthermore, most interventions did not address critical issues such as healthcare professionals' mental health resiliency when facing disasters.

These findings are worrisome, as mounting evidence shows that, when working at the front and center amid pandemics like COVID-19, healthcare professionals often have to shoulder unprecedented stress that could take a substantial toll on their psychological and physical health and wellbeing (Goldmann and Galea, 2014; Hacimusalar et al., 2020; Pearman et al., 2020). The tsunami of fake news from social media, negative reports from legacy news outlets and conflicting directives from government officials may further deepen healthcare professionals' lack of confidence and trust in pandemic efforts, all of which exacerbate the psychological and physical health burdens of frontline workers (Su et al., 2021b; Kwok et al., 2020; Fancourt et al., 2020). Equally, if not more alarmingly, the study results also show that nearly half of the RCTs (40.7%) failed to generate significant improvements in

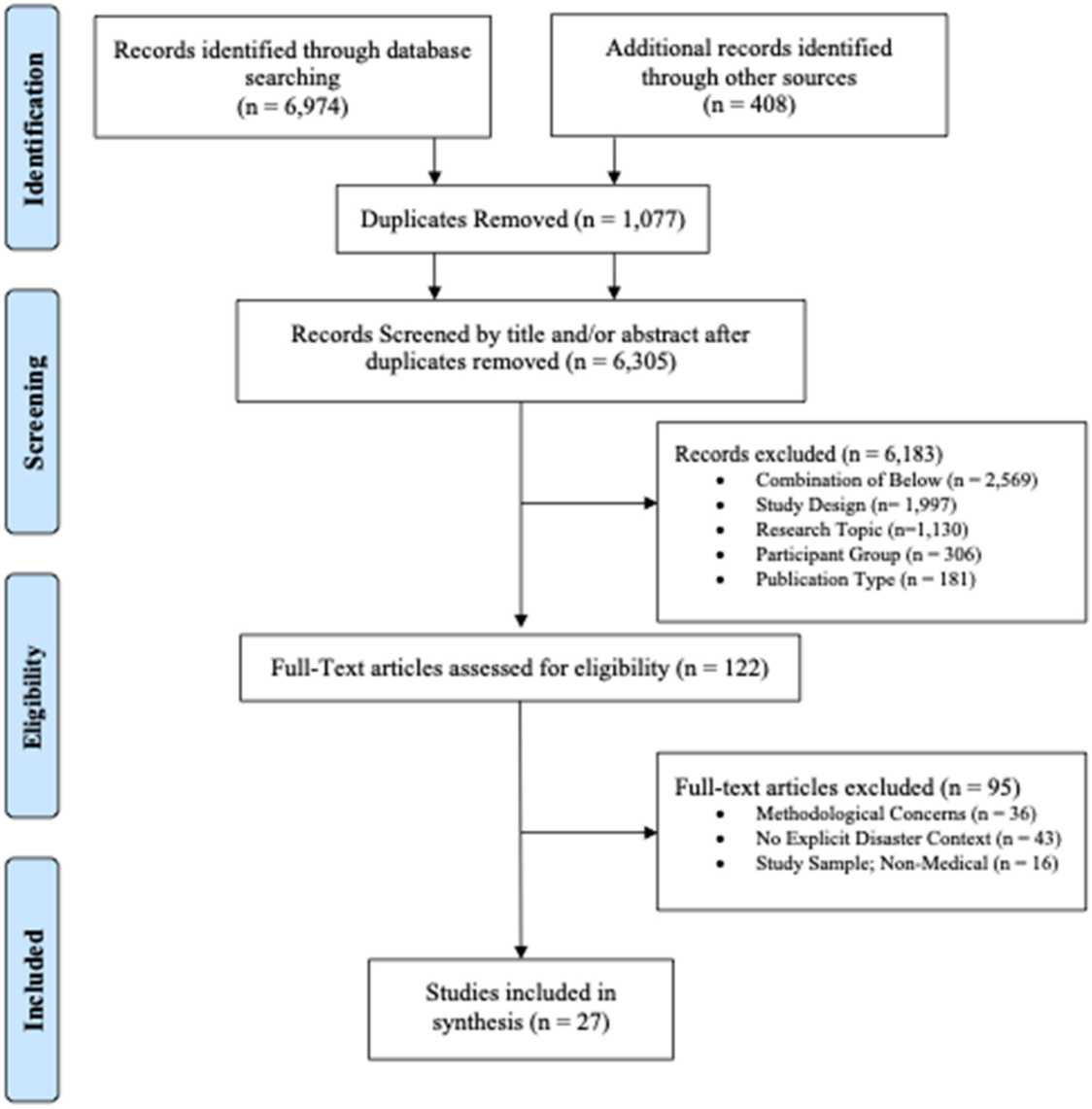

Fig. 1. PRISMA flow chart.

healthcare professionals' disaster preparedness. As there was significant heterogeneity in the included studies, it is difficult to gauge what might contribute to this phenomenon. However, what is clear is that more systematic and comprehensive research is needed to expand our understanding of which intervention mechanisms might generate the most promising outcomes in healthcare professionals' disaster preparedness.

Amid the COVID-19 pandemic, healthcare professionals face an array of challenges, ranging from lack of training on how to use personal protective equipment like masks properly (declarative knowledge), lack of understanding of the need for staged COVID-19 testing, tracing and vaccination responses (procedural knowledge) and lack of psychological readiness and resilience to cope with the consequences associated with morally compromising decisions (Truog et al., 2020; Dunham et al., 2020; Martínez-López et al., 2020; Borges et al., 2020). Combing insights of our study, it is then important for government and health officials to integrate both tailored education and training opportunities (e.g., online seminars) and targeted systematic support (e.g., free mental health services) to boost healthcare professionals' disaster preparedness, so that society at large can better cope with disasters like COVID-19.

6. Limitations

While our study fills a critical research gap, it is not without limitations. First, due to noticeable heterogeneity, a meta-analysis was not performed in this study; this, in turn, limited insights the current research can add to the literature. Only eligible RCTs published between 2003 and 2020 were reviewed. Studies conducted outside our review timeline or adopted a non-RCT research design were not included in our review. In addition to the types of research investigated, another limitation of our study centers on the strengths and weaknesses of evidence provided by RCTs. It is important to note that while an RCT reduces allocation bias in a study and has the potential to produce rigorous evidence (Akobeng, 2005), randomization does not control for many other biases that might occur in education studies (Jadad and Enkin, 2007; Saturni et al., 2014; Deaton and Cartwright, 2018).

For instance, baseline variations across healthcare workers like non-intervention training experiences, effects of pretests on learning, or dropout rates may have as much of an impact on the robustness of the evidence as allocation bias (Jadad and Enkin, 2007; Saturni et al., 2014; Deaton and Cartwright, 2018). Additionally, in light of the urgency associated with providing healthcare services to emergency settings (Vincent, 2010; Oldenburg and Doan, 2020), along with potential

Table 3
Characteristics of eligible studies reviewed.

Author (Year)	Research aim	Disaster context	Participant	Country	Intervention	Study outcomes
(Aluisio et al., 2016)	To gauge the effectiveness of case-based learning or CBL compared with simulation exercises or SEs when added to standard didactic instruction in knowledge acquisition regarding disaster triage preparedness.	Disasters: General disasters	Nursing trainees (n = 48)	India	Disaster preparedness course (intervention group 1: didactic & CBL vs. intervention group 2: didactic & simulation exercises vs. control: didactic teaching)	Nursing trainees in the CBL group yielded significant improvement in disaster triage knowledge. SEs generated no significant improvement in knowledge acquisition among nursing trainees studied.
(Andreatta et al., 2010)	To examine interventions based on virtual reality (VR) compared with standardized patients in terms of emergency response to mass disaster triage.	Disasters: General disasters	Postgraduate year 1 residents (n = 15)	U.S.A.	VR group (intervention) vs. standardized patient drill (control: in a mock-up live disaster drill with standardized victims)	VR-based intervention can yield similar results compared with traditional standardized patient training.
(Baseman et al., 2016)	To examine the effectiveness of traditional compared with mobile communication strategies in terms of delivering timely health messages to providers.	Emergency events	Healthcare Providers (HCPs) (n = 848)	U.S.A.	Effective of traditional (intervention group 1: fax or SMS) vs. mobile communication (intervention group 2: email) vs. no communication (control) strategies in terms of generating awareness and recall of emergency messages	Both traditional and mobile communication methods yielded greater levels of awareness and recall than the control condition.
(Bordley et al., 2003)	To examine the effectiveness of an office-based intervention program for improving primary care healthcare practitioners' preparation for pediatric emergencies.	Emergency events	39 pediatric practices (n = 172 healthcare practitioners)	U.S.A.	An unannounced "mock code" emergency situation (intervention) vs. no emergency situation (control)	Intervention was effective in generating significant changes in the practice of written office protocols and more training sections in the staff, but not in new equipment or medication purchasing.
(Borgey et al., 2019)	To evaluate the effectiveness of an intervention campaign on the improvement of the influenza vaccination rate of professionals	Infectious diseases: Seasonal flu	26 nursing homes (residents: n = 1878; healthcare professionals: n = 1336)	France	Seasonal flu vaccination promotion campaign (intervention) vs. no campaign (control)	The intervention significantly increased healthcare professionals' flu vaccination adoption rates.
(Burnett et al., 2018)	To compare effectiveness of training alone and training combined with OSS in a HIV context.	Infectious diseases: HIV care and management	35 health facilities (patients: n = 680)	Uganda	Clinical effectiveness in treating HIV patients: training combined with on-site support (intervention) vs training alone (control)	Compared with the control group, the intervention showed significant improvement in clinical response in training HIV patients.
(Chambers et al., 2012)	To examine the impact of the Ottawa Influenza Decision Aid (OIDA) on HCPs confidence in making vaccination-related decisions and their intention to uptake the vaccine	Infectious diseases: Seasonal flu	Healthcare personnel (n = 107)	Canada	Effectiveness of OIDA in improving healthcare personnel's seasonal flu vaccination: have OIDA (intervention) vs. no OIDA (control)	OIDA yielded no significant improvement in flu vaccination adoption rates, though it increased healthcare personnel's confidence in making vaccination decisions.
(Chambers et al., 2015)	To evaluate the impact of a seasonal flu vaccine guide's impact on HCPs' vaccination adoption rates	Infectious diseases: Seasonal flu	26 health organizations (Healthcare professionals: intervention mean=2971 (SD=2779) vs. control mean= 5950 (SD=9,497)	Canada	Effectiveness in increasing flu vaccination rates: The Guide, workshops and support (intervention) vs. program as usual (control)	Though no difference was found at initial adoption times, a 7% increase was found in the intervention group and a 6% decrease was found in the control group in year 2.
(Christensen et al., 2020)	To compare an instructor-led and a video-based intervention in promoting healthcare professionals' performance in proper donning and doffing of personal protective equipment (PPE)	Infectious diseases: No specific context	Medical students and junior doctors (n = 19)	Denmark	Practice of proper donning and doffing of PPE: a video-based (intervention) vs. an instructor-led intervention (control)	No significant differences between two groups, meaning video-based intervention can deliver the same results with the advantage of fast and contactless delivery during disasters.
(Chuang et al., 2014)	To examine whether a multifaceted intervention bundle for residential care homes for the elderly (RCHEs) can reduce the methicillin resistant Staphylococcus aureus (MRSA) transmission	Infectious diseases: MRSA transmission outbreak	36 RCHEs (residents: n = 2,776)	China	Effectiveness of interventions in controlling MRSA transmission in RCHEs: hand hygiene enhancement, environmental decontamination and modified contact precautions	No significant decrease in MRSA was observed, though staff hand hygiene compliance increased from 5.9% to 45.6% in the intervention group.

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Table 3 (*continued*)

Author (Year)	Research aim	Disaster context	Participant	Country	Intervention	Study outcomes
					(intervention) vs. usual care (control)	
(Chughtai et al., 2016)	To examine factors that shape healthcare workers' (HCWs) mask wearing behaviors.	Infectious diseases: No specific context	14 hospitals (healthcare workers: n = 1,607)	Vietnam	Investigate factors that influence HCWs mask wearing behaviors: hospital guidelines and availability of masks (intervention) vs. normal practices (control)	No significant effects were shown in the intervention group. Interestingly, HCWs' mask wearing compliance declined during the 4-week intervention period (medical masks: 77–68%; cloth masks: 78–69%).
(Conner et al., 2011)	To investigate the effectiveness of question-behavior-effect (QBE) based interventions on disease prevention adoption among HCPs	Infectious diseases: Seasonal flu	Study 1 (patients: n = 384); Study 2 (healthcare workers: n = 1,024)	Canada	Effectiveness in promoting flu vaccination rates: QBE survey (intervention) vs. no exposure to QBE survey	Seasonal flu vaccine adoption is higher in intervention group (42.0%) vs. control group (36.3%)
(Doratotaj et al., 2008)	To investigate a novel approach for improving influenza vaccination rates among HCW.	Infectious diseases: Seasonal flu	HCWs (n = 800)	U.S.A.	Compare efficacies of the strategies to promote flu vaccination adoption rates: a letter explaining the importance of influenza vaccine for HCWs (intervention group 1), a ticket for a raffle of a free Caribbean vacation for 2 (intervention group 2), both the educational letter and the raffle ticket (intervention group 3), vs. no intervention (control)	Mailed educational letters and/or a single large raffle prize does not improve the number of HCW receiving influenza vaccination.
(Fudzi et al., 2019)	To gauge the effectiveness of IMP (Integrated Medical Response Protocol) on knowledge, attitude and practice of healthcare providers (HCP) involved in managing patients during flood disasters in Kelantan.	Disasters: Flood	HCPs (n = 102)	Malaysia	Response in flood disasters: exposure to IMP (intervention) vs. standardized disaster response protocol (control)	The intervention improved knowledge level and an increase of 120% in knowledge level was recorded after the intervention. No significant change of attitude scores over time was recorded. There was no significant change of practice scores after intervention.
(Lee et al., 2018)	To investigate strategies to promote HCWs' knowledge of fire prevention and evacuation	Disasters: Fire	HCWs (n = 128)	China	Strategies to improve HCWs' knowledge of fire prevention and evacuation: basic response to a hospital fire (intervention) or introduction to volcanic disasters (control)	The intervention significantly improved healthcare workers' knowledge of fire prevention and evacuation.
(Lemaitre et al., 2009)	To assess the impact of staff influenza vaccination on nursing home residents' mortality rates.	Infectious diseases: Seasonal flu	40 nursing homes (residents: 3,483)	France	The effects of nursing home staff's flu vaccination on nursing home residents' mortality rates: vaccinated nursing home staff (intervention) vs. staff with no vaccination (control)	Staff influenza has a significant impact on nursing home residents' mortality rates (20% lower, compared with the control)
(Loeb et al., 2009)	To compare the surgical mask and the N95 respirator in terms of their abilities to protect HCWs against seasonal influenza	Infectious diseases: Seasonal flu	Nurses (n = 446)	Canada	Effectiveness of facial coverings in protection against the flu: surgical masks (intervention) vs. N95 respirators (control)	No significant differences were found between the surgical mask and the N95 respirator in protecting HCWs against the flu virus.
(Mbonye et al., 2016)	To test the effect of on-site support on changes in workload	Infectious disease: No specific context	36 health facilities (669,580 eligible outpatient visits)	Uganda	Evaluate the effect of on-site support on HCPs' efficacy: with on-site support (intervention) vs. an off-site course on infectious disease management (control)	No significant differences with the intervention and the control conditions on pre/post workload differences, however, on-site support has a significant effect on HCPs' facility performance.
(Pesiridis et al., 2015)	To develop, implement and evaluate an educational program for nurses on the provision of healthcare amid disasters.	Disasters: General disasters	Nurses (n = 207)	Greece	An 8-h tailored educational program was delivered to both the intervention and the control groups, the main difference is when these groups were primed with the survey (e.g., different from the intervention, a second pre-test was given to the control group	The intervention group performed significantly better than the control group in terms of disaster knowledge gained.

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Table 3 (*continued*)

Author (Year)	Research aim	Disaster context	Participant	Country	Intervention	Study outcomes
					before the training). Both the intervention	
(Sijbrandij et al., 2020)	To examine the effectiveness of a one-day intervention on HCPs' knowledge acquisition and retention on the Psychological first aid (PFA).	Infectious diseases: The Ebola epidemic	HCPs (n = 333)	Sierra Leone	The effectiveness of the PFA training on HCPs' knowledge of PFA: PFA training (intervention) vs. No PFA training till the completion of the study (control)	The intervention improved (1) healthcare professionals' knowledge acquisition and retention of PFA and (2) understanding of appropriate psychosocial responses and skills in offering support to individuals in need in the face of acute adversity
(Ten Eyck et al., 2009)	To determine the effect of a simulation-based curriculum on medical students' test performance and satisfaction during an emergency medicine clerkship.	Emergency events	Fourth-year medical students (n = 90)	U.S.A.	A crossover between two teaching formats: simulation vs. group discussion.	The simulation-based curriculum yielded more benefits for the students, such as improvement in learning and greater satisfaction, compared with the discussion group.
(Wallace et al., 2010)	To compare the times required to resuscitate simulator patients and human actor patients in a surge setting.	Infectious diseases: A pandemic influenza	Physicians (n = 12)	U.S.A.	Evaluate the effectiveness of patient options for practicing disaster drills: simulator patients (intervention) vs. and human actor (control)	Compared with human actors, simulator patients can create more realistic training scenarios for physicians.
(Weaver et al., 2014)	To assess the effects of two interventions on improving facility performance on emergency triage assessment and treatment (ETAT)	Infectious diseases: ETAT [Malaria, pneumonia, tuberculosis or TB and HIV]	36 health facilities	Uganda	Evaluation of the effectiveness of on-site support on health facilities' abilities to manage infectious diseases: IMID and on-site support (intervention) vs. IMID (control)	On-site support significantly improved health facilities' abilities to manage infectious diseases.
(Zaveri et al., 2016)	To develop and evaluate the effects of a VR-based in preparing pediatric residents for sedation procedures.	Emergency events	Pediatric residents (n = 14)	U.S.A.	Exposure to educational programs: VR module (intervention) vs. the web-based module (control)	No significant differences were found between the VR and the web-based module—the VR module performed on par with the web-based module.
(Rothan-Tondeur et al., 2010)	To assess a tailored program's ability to increase HCWs' flu vaccination rates.	Infectious diseases: Seasonal flu	43 geriatric wards (HCWs: n = 3,646)	France	Evaluation of the tailored program: exposure to the educational active program (intervention) vs. no programs (control)	No significant increase in HCWs' vaccination rates. Interestingly, more vaccinated HCWs wanted to quit the program after the intervention.
(MacIntyre et al., 2017)	To examine the efficacy of medical masks and respirators in protecting HCWs against respiratory infections.	Infectious diseases: Viral respiratory infections	HCWs (n = 3,591)	China	Efficacy of medical masks and respirators in prevention respiratory infections among HCWs: Continuous N95 respirator use (intervention group 1), targeted N95 respirator use (intervention group 2), medical mask use (intervention group 3) vs. no masks (control)	Infection rates were significantly lower in continuous N95 and/or targeted N95 groups.
(Radonovich et al., 2019)	To evaluate differences in N95 respirators and medical masks in terms of their abilities to prevent influenza and other viral respiratory infections in outpatient HCP.	Infectious diseases: Seasonal influenza and other viral respiratory infections	Outpatient HCPs (n = 2,862)	U.S.A.	N95 respirators (intervention) vs. medical masks (control)	No significant differences were found between N95 respirators and medical masks' effects for influenza and other viral respiratory infections protection.

ethical issues related to the RCT design in response to a disaster (e.g., COVID-19 human challenge studies (Kahn et al., 2020); Jamrozik and Selgelid, 2020; Jamrozik et al., 2021), more comprehensive discussions should be carried out to determine the utility of RCTs amid pandemics of COVID-19′s scale. Furthermore, all of the studies reviewed were published in English, which means that useful insights published in other languages cannot be found in this study. Future research could adopt a more inclusive list of eligibility criteria in their review to address this issue.

7. Conclusions

Disasters, such as the COVID-19 pandemic are both destructive and challenging to predict. It is essential that societies at large have a frontline of healthcare professionals who are sufficiently- trained to cope with emergency events of COVID-19′s scale. The findings of our study show that there is a shortage of rigorously-tested interventions for improving healthcare professionals' disaster preparedness, especially in low- and middle-income countries. This revelation is alarming as disaster preparedness training programs could reveal how well nations worldwide are prepared for emergency events that could exert hefty health and economic consequences across societies. Our results also show that almost half of the eligible RCTs failed to improve these frontline workers' disaster preparedness significantly. Furthermore, findings also indicate that most of the available interventions did not address key disaster coping abilities in their programs, such as improving healthcare professionals' psychological and physical health resiliency amid disasters. Overall, the study results underscore the imperative of designing and developing effective and comprehensive interventions for healthcare professionals' disaster preparedness so

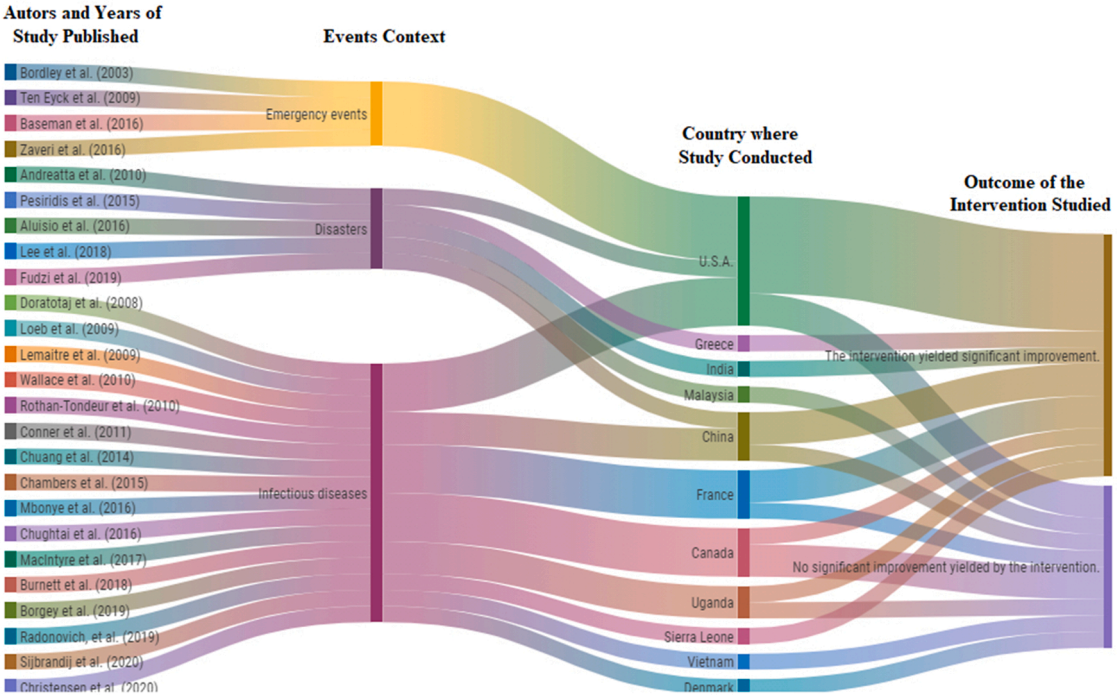

Fig. 2. A graphic representation of eligible studies reviewed.

frontline workers can better tackle crises like the COVID-19 pandemic.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.nepr.2023.103583.

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