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Learning interventions and training: providing support during health emergencies

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Learning interventions and training: providing support during health emergencies

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Editorial: Learning interventions and training: providing support during health emergencies

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Editorial on the Research Topic
Learning interventions and training: providing support during health emergencies

In an increasingly globalized and interconnected world, health emergencies have grown in scale and complexity. From humanitarian crises to natural disasters and emerging epidemics, our goal is simple: to advance the wellbeing of the world's people and keep them safe in emergencies.

As part of this effort, a high priority has to be placed on providing timely and equitable access to knowledge, science and evidence. Just-in-time learning is about delivering specific training to support professionals with the information, knowledge and skills they need for emergency situations that impact public health (see Figure 1). Providing just-in-time learning can enable policymakers, health professionals and emergency workers to proactively mitigate the effects of health hazards.

The COVID-19 pandemic reaffirmed the importance of just-in-time learning on a massive scale. Since the beginning of the pandemic, people sought trusted information and knowledge to protect themselves, their families and their communities from this new and emerging health threat. The World Health Organization's OpenWHO.org learning platform saw a surge in demand, growing from thousands of enrolments to more than 9 million across free online courses on the pandemic and public health topics.

Affected communities must also be empowered to ensure information reaches the people who need it most, as evidenced in the recent World Health Organization's just-in-time guidance (1). Drawing on available evidence and operational insights, the guidance provides practical strategies to empower health professionals, policy-makers, emergency responders, volunteers and communities. Production of the guidance also identified large gaps in what we know and need to know to better respond to health emergencies where just-in-time learning is required. This Research Topic provides a mechanism for researchers and practitioners to publish additional and much needed evidence.

The articles in this Research Topic describe how public health and learning professionals have provided learning interventions to strengthen health emergency response by addressing and mitigating the impacts of infectious threats, natural

FIGURE 1
Just-in-time learning elements during the emergency cycle.

hazards, humanitarian crises and armed conflicts. In all of these contexts, it has been vital to provide learning opportunities to support health professionals, emergency responders and the public with life-saving information, tools and skills to respond effectively.

More specifically, the 16 articles in the Research Topic "*Learning interventions and training: providing support during health emergencies*" focus on various strategies for enhancing healthcare workers' capacity to manage health emergencies. They cover themes such as continued education, just-in-time learning for healthcare workers, the evolving role of innovative, digital tools and mobile platforms and virtual simulations. The breadth of research across these areas provides diverse insights through different contexts, geographical focuses and explorations of specific health crises and interventions.

New frameworks and initiatives are identified that can support further interventions in future health emergencies (D'Andrea, Fadul, Struminger et al.; Mills et al.; Mayigane et al.). D'Andrea, Fadul, Struminger et al. and D'Andrea, Fadul, Dery et al. highlight the benefits of virtual learning in low-resource and conflict-affected settings and provide a framework for anticipatory digital learning. Strehlow et al. demonstrate the potential of massive open online courses (MOOCs) to rapidly provide access to emerging medical knowledge during public health emergencies particularly in high- and middle-income countries. Barnadas et al. explore the usefulness of knowledge sharing sessions specific for the laboratory workforce held between 2020 and 2023. Elhakim et al. highlight the existing frameworks provided by the WHO, including through voluntary tools provided under the International Health Regulations' Monitoring and Evaluation Framework, and their

benefits to enhancing resilience and country readiness for health emergencies. Balde et al. explore the lessons learned from the emergency medical teams' initiative noting a need for enhanced training and capacity-building programs. Pandya et al. highlight the usefulness of simulation exercises to support low-cost and low-resource learning for disaster preparedness.

Common challenges to learning and knowledge transfer are cited across these articles including internet connectivity, different contexts, resource limitations, and additional training needs (Barnadas et al.; Bonkoungou et al.; Southworth et al.; Zhu et al.; Reynolds et al.; Balde et al.). Common benefits to the successful deployment of learning interventions and training to provide support during or for future health emergencies are similarly uncovered. These include cost-efficiency and adaptability of online learning, more timely responses, greater access and equity among learners, and positive responses of learners to the relevance and usefulness of the learning itself (Barnadas et al.; Bonkoungou et al.; Tian et al.; Walldorf et al.; Zhong et al.).

Sharing knowledge and enhancing just-in-time learning will make a difference in the health crises of the future. We hope to encourage more health emergency response institutions and professionals to invest in capabilities for just-in-time learning and continue producing evidence of this critical work, acknowledging it is a huge task amidst the hours of response.

Author contributions

HU: Conceptualization, Visualization, Writing – original draft. MS: Writing – review & editing. JJ: Writing – review & editing. QZ:

Writing – review & editing. JN: Writing – review & editing. BS: Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Composition and influencing factors of professionals' capacity in public health emergency rescues: a qualitative study

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Objective: To explore the composition and influencing factors of professionals' capacity in public health emergency rescues.

Methods: A descriptive qualitative design was used in this study. Medical workers, managers, and members of an emergency rescue team in Hangzhou, Zhejiang, were recruited for participation through a purposive sampling method. The data were collected using semi-structured interviews and analyzed using a conventional content analysis method.

Findings: A total of 2 themes and 13 sub-themes emerged from the analysis: ability composition (knowledge reserve, early warning assessment, information reporting, emergency response, self-protection, personal ability, coordination and cooperation, health education) and influencing factors (educational background, region, experience, hospital level, human resources, and financial investment).

Conclusion: These findings offer a basis for the construction of a related indicator system and provide a reference for relevant departments to further optimize their emergency education and training, strengthen their emergency drills, and improve their emergency rescue abilities. The findings indicate that it is necessary to pay attention to the construction of an emergency rescue team, adjust the ratio of personnel, improve their remuneration, and promote work enthusiasm to improve the emergency rescue ability of an organization.

KEYWORDS

professional, public health emergencies, emergency rescue, ability composition, influencing factor, qualitative research

Introduction

A public health emergency refers to a sudden surge in major infectious diseases, mass unexplained diseases, significant food poisoning or occupational poisoning, and other events that seriously affect public health (1). Since the beginning of the 21st century, with economic development and rapid population growth, several major public health emergencies, including SARS, Ebola virus, COVID-19, and others, have occurred worldwide (1–3). The sudden and unpredictable nature of public health emergencies (4) can significantly affect human lives, property, safety, and physical and mental health. Furthermore, it can also jeopardize social and economic development and national security (5, 6).

Emergency rescues form an integral part of emergency management. Emergency rescues encompass emergency responses, emergency rescues, medical treatments, logistics, and other activities to protect the lives and properties of individuals and maintain social order and public safety in the case of natural disasters, accidents, public health incidents, social security incidents, and other emergencies (7). Medical personnel, rescue teams, and other professionals are the driving forces behind clinical frontline rescues, and their emergency rescue abilities directly affect the smooth operations of on-site rescuers and the safety of patients (8). One study demonstrated that the emergency rescue capacities of medical personnel, public health personnel, and other relevant professionals in public health emergencies were not high, especially in primary medical departments (9–11). The objective of this study was to explore the composition and factors affecting the capacity of professionals in public health emergency rescues. It was hoped that the findings would provide a theoretical basis for constructing an emergency rescue competence index system for professionals dealing with public health emergencies and developing relevant continuing education and training.

Methods

Design and sample

A descriptive qualitative design was used in this study. Such an approach avoids preconceived categories and allows the researchers to immerse themselves in the data, generating novel insights and providing a richer understanding of phenomena (12). A targeted sampling method was used in this study to recruit clinical medical workers, community medical workers, and rescue team members from Hangzhou, Zhejiang. The recruitment of a sample with maximum variation (gender, age, education level, and position) was

facilitated using the targeted sampling method. The inclusion criteria for this study included: (1) in-service clinical medical workers, community medical workers, and rescue team members aged between 18 and 60 years; (2) over 5 years of work experience in this field; and (3) a good language communication ability and voluntarily agrees to participate in the study. The exclusion criteria were: (1) unable to cooperate with the investigator due to physical conditions.

Participant characteristics

After data saturation, the final sample comprised 15 clinical medical workers, community medical workers, and rescue team members. Six participants were male, and nine were female, with an age range of 28 to 54 years. Detailed demographic data are shown in Table 1.

Interview outline

Data were collected using semi-structured interviews that were conducted face-to-face. The interview guide was developed based on a literature review. The interviews were focused on the following seven questions: (1) Do you know what a public health emergency is? (2) What do you think "emergency rescue" is? (3) What public health emergencies have you experienced in your career? Can you tell me something about your experience and how you participated in the emergency rescue? (4) How did you participate in the emergency response during the last COVID-19 pandemic? What abilities do these jobs require of professionals? Can you elaborate on this? (5) What roles and responsibilities do professionals play in the course of public health emergencies (before, during, and after)? (6) In your opinion, what abilities and qualities must professionals possess during different types of public health emergencies (such as infectious diseases, food

TABLE 1 Detailed demographic data of the participants.

Participant	Age (years)	Gender	Professional Title	Duty	Working years	Education	Emergency rescue experience
1	42	Female	Nurse-in-charge	Vice Head Nurse	20	Master's degree	Yes
2	40	Male	Assistant director physician	Head of health section	11	Master's degree	Yes
3	49	Male	Assistant director physician	None	28	Bachelor's degree	Yes
4	47	Female	Associate senior nurse	Head Nurse	29	Bachelor's degree	Yes
5	28	Female	Nurse practitioner	None	6	Bachelor's degree	No
6	48	Female	Associate senior nurse	None	31	Bachelor's degree	Yes
7	30	Female	Nurse practitioner	None	7	Bachelor's degree	Yes
8	38	Female	Nurse-in-charge	None	17	Bachelor's degree	Yes
9	29	Female	Physician-in-charge	None	4	Master's degree	No
10	35	Female	Physician-in-charge	None	9	Doctor	Yes
11	31	Male	Nurse-in-charge	None	8	Bachelor's degree	Yes
12	54	Female	Assistant director physician	Head of the health service	32	Bachelor's degree	Yes
13	29	Male	Nurse practitioner	None	6	Bachelor's degree	No
14	31	Male	Nurse-in-charge	None	8	Bachelor's degree	Yes
15	36	Male	Rescue worker	None	13	Bachelor's degree	Yes

poisoning, occupational poisoning, accidents, and leakage)? Could you give specific examples of behaviors that reflect these abilities? (7) What factors do you think will affect the emergency rescue abilities of professionals? What can you suggest to improve the emergency rescue abilities of professionals?

Data collection methods

The research team consisted of nursing postgraduate students and an associate professor both of whom have extensive experience in conducting qualitative research studies. To protect the privacy of the interviewees and avoid their concerns, the interviews were conducted in a quiet, independent room or a conference room at the interviewees' workplace. Before the formal interviews, the researcher (ZFF) communicated fully with the interviewees, informed them of the purpose and content of the interviews, and audio-recorded the entire interview after obtaining their consent. They were also told that the relevant data would only be used for statistical analysis and that the researcher would maintain strict confidentiality. Before the interviews, the interviewer did not establish relationships with the participants prior to the interviews. The interviewer mastered the interview outline and adjusted the order and content according to the interviewees' answers but kept it related to the topic. The non-verbal expressions of the interviewees were focused on and recorded at any time, and the follow-up questions were asked promptly. Each interview lasted 30–40 min.

Data analysis

Data collection and analysis were performed simultaneously. The traditional content analysis method was used to analyze the qualitative data. The traditional content analysis research begins with observation, and the coding is defined in the data analysis, and the coding comes from the data. It has the advantage of obtaining information directly from the interviewees without imposing the researcher's point of view (12). The specific steps were as follows (13): (1) Immediately after each interview, the researcher (ZFF) transcribed the recording verbatim and compared it with the original recording to ensure accuracy. According to P1 ~ P15, the interview records of each interviewee were numbered, and their independent Word documents were established. The emotional changes and action expressions of the interviewees during the interview were marked in the corresponding position, and a researcher (CY) was invited to proofread the text and recording content. Two researchers (ZFF and LY) repeatedly read the text to understand the participants' ability to respond to public health emergencies. (2) Two researchers (ZFF and LY) independently encoded the essential and recurring words and phrases (units of meaning) in the text, and the code of similar content formed a sub-theme. (3) The sub-topics were jointly summarized by two researchers (ZFF and LY) to form a theme. Some representative examples were excerpted from the qualitative data. (4) All members of the research team reached a consensus on the research topic and discussed whether the research topic had reached theoretical saturation, which means no new findings or themes occurred from an analysis of newly collected materials. The NVIVO11.0 software was used to store and manage the qualitative data obtained.

Rigour and reflexivity

First, the researcher received systematic training in qualitative research, with proficiency in interviewing skills. The interviewer was supervised by an associate professor proficient in qualitative research methods. Second, the interviewer encountered unclear or questionable information during the interview, and asked or recounted the interviewee several times in time. Third, all transcripts were returned to the interviewees to validate the interview content. The actual information was verified to ensure the authenticity, integrity, and accuracy of the data. While encoding data, the researchers held a neutral position and did not bring their values and professional identity. The data were independently analyzed by two researchers. Finally, the final coding and theme were determined from the discussion of the research team members. This reporting was guided by the Comprehensive Standard for Reporting Qualitative Research (COREQ) (14).

Ethical considerations

This study was approved by the Ethical Review Board (ERB) of the Zhejiang Chinese Medical University (DSRB-Ref 20200529-1).

Findings

Based on the qualitative data, 2 themes and 13 sub-themes about the composition and factors that affect the capacity of professionals were developed.

Theme1: the emergency rescue ability of professionals in public health emergencies

Knowledge reserve ability

Solid theoretical knowledge is essential for emergency rescues. All participants mentioned that participating in an emergency rescue requires a rich reserve of knowledge. Some participants reported that in addition to relevant first aid knowledge, professionals should also deeply understand public health emergencies, emergency rescues, emergency plans, and related laws and regulations. Such knowledge expectations are consistent with the public health personnel competency standards proposed by Columbia University in the United States (15). Notably, the interviewees were asked, "What do you think of your own level of emergency rescue capability?" and all respondents agreed that their actual emergency first aid skills and first aid knowledge were far from sufficient.

> "Professional knowledge is needed. In my opinion, only with such specialized knowledge can we judge and handle emergencies. Theoretical knowledge is the foundation of all abilities and skills" (P9).

> "Just like the recent COVID-19 outbreak, because we have a clear understanding of the emergency planning and processing processes, we can know exactly what to do next" (P12).

Early warning assessment capability

Rogers and other experts (16) argue that in addition to mastering relevant disease knowledge and clinical skills, professional medical staff also need to be able to apply their skills in areas such as monitoring potential hazards and risk information transmission. They must also be able to analyze the risk factors in the environment to prevent incidents or further deterioration. The views of some of the respondents of this study were consistent with this assertion. Specifically, participants mentioned that professionals should be sensitive to emergencies. That is, they must have a developed early warning assessment capability, which is necessary for professionals to participate in emergency rescue in public health emergencies. In addition, some respondents reported that early identification, judgment of abnormal information that may occur in public health emergencies, and investigation of possible risks can reduce the occurrence of emergencies and their possible harm and loss to a certain extent.

"For example, in our nearby school, several students in the same class came to see the doctor because of diarrhea one after another. In this case, I think as a physician, you should be aware that it could be mass food poisoning, and that requires us to have an early warning and assessment capability" (P3).

"As a professional we should be sensitive and be able to recognize that such events may be public health emergencies…" (P10).

Information reporting capability

Timely information reporting, standardized reporting processes, and accurate reporting content help minimize the damage caused by public health emergencies (17). Respondents reported that medical staff should be able to report, collect, and analyze information, including knowledge of reporting requirements, the registration process for public health emergencies, and the legal reporting time limit for infectious diseases. However, nine respondents indicated that their awareness of reporting was not high, which may increase the risks associated with potential emergencies. The research evidence shows a clear relationship between the reporting ability of medical institutions and employees' sense of responsibility and training (18). Therefore, improved training and education may be an effective way to improve the information reporting capabilities of professionals.

"A standardized reporting process is essential, and only when a health care worker reports such an unforeseen situation does it draw the attention of others to the situation and somehow mitigates its adverse effects…" (P13).

Emergency response capability

All participants mentioned that emergency response capabilities such as emergency rescue, injury classification, transportation of patients, the use of general rescue techniques, and emergency equipment capabilities are necessary for professionals. Patients at the scene of emergencies often have complex injuries, and professionals need to be good at observing changes in the condition of patients and dealing with them in a timely manner. When there is an emergency situation, professionals must respond quickly, make timely

judgements, and take appropriate measures to treat the wounded. Studies have shown that medical staff have a good grasp of fundamental basic first-aid techniques, However, their first-aid capabilities for rare public health emergencies are insufficient (19, 20), which is consistent with the views of some respondents in the current study. Therefore, in addition to mastering general first-aid skills such as cardiopulmonary resuscitation, medical staff also need to master first-aid capabilities for infectious diseases, occupational poisoning, and chemical leaks (21).

"Master the first-aid technology. Like this COVID-19 pneumonia, the risk rate of this disease is much higher than that of normal diseases. We should be ready to give patients tracheal intubation and CPR cardiopulmonary resuscitation at any time…" (P14).

"For critically ill patients, we also need to have knowledge of emergency equipment such as ECMO, artificial livers, and artificial kidneys" (P8).

Self-protection capability

In the "State Nursing Directors Association Opinion" issued for disaster emergency response missions, the U.S. Public Health Preparedness Commission proposed that the capabilities required by medical personnel also include personal protection (22). Self-protection and management of hospital-acquired infections is one of the critical steps in controlling the spread of public health emergencies, especially during major infectious disease outbreaks (23). The on-site environment of an emergency rescue is usually an exceptional environment that is complex and changeable. Rescuers often face problems such as a poor working environment and high work intensity. Emergency rescuers are three times more likely to be injured or killed than ordinary staff (24). All respondents in the current study experienced the COVID-19 epidemic. Thirteen respondents indicated that they needed to do a good job of self-protection during this time, such as strict standardization of the use of personal protective equipment and strictly abiding by the disinfection and isolation protocol so as to prevent self-infection and cross-infection.

"First of all, we should take protective measures for ourselves and adopt standard precautions. All patients should be considered infected and screened in isolation at specific times" (P15).

"Self-protection and prevention of hospital-acquired infections is essential. For example, we must be able to skillfully put on and take off protective clothing and wash our hands. Then, hand hygiene must be maintained before contact with the patient to avoid cross-infection" (P8).

Personal capability

Individual capabilities are seen as the cornerstone of the entire emergency response capability system (25). Participants reported that professionals should respond to public health emergencies with a conscientious and responsible attitude, good mental and physical fitness, and a spirit of saving lives and helping with injuries (26, 27). Medicine is an ever-developing discipline, and professionals need to commit to active learning and regular participation in emergency

drills and courses related to emergency management. In addition, medical staff cannot ignore their own psychological adjustment while continuously improving their core emergency response capability for public health events (28). Notably, in the current study, when asked about their psychological state in the novel COVID-19 epidemic, most respondents reported that they had felt anxious and confused, which is consistent with previous findings (29). Therefore, as the main force behind rescue work, medical staff need to undergo timely adjustment of their psychological state to adapt to the special working environment during public health emergencies and invest in emergency rescue work as soon as possible.

> "Public health emergencies are inherently high-risk. We must be psychologically prepared and dedicated…" (P10).

> "In addition, for individuals, we need to strengthen the relevant learning. Such public health emergencies will not happen often, but we need to participate in as many emergency drills as possible to improve our emergency response capabilities" (P2).

Coordination and cooperation capability

Several studies have shown that good coordination and cooperation can ensure the smooth running of emergency rescues and improve rescue efficiency (30, 31). Communication ability in emergencies not only refers to communication with patients and family members but also includes reporting information to relevant government agencies and communication with news media and the public. In addition, in the process of an emergency rescue, professionals must cooperate with other staff and adhere to the allocation of personnel and materials by each unit. In our survey, respondents agreed that public health emergencies are often sudden, and personnel and materials are often temporarily allocated. Such circumstances requires the relevant personnel to have the good ability to coordinate and cooperate, follow the distribution, and rationally use emergency materials.

> "Epidemics are often unpredictable. Manpower and material resources are very scarce at these times. As a member of the medical profession, we must first and foremost be on call 24 h a day, obey our superiors, and follow orders" (P13).

> "Close cooperation with relevant line ministries, including the Government, or rescue forces" (P15).

Health education capability

Health education is the most effective and economical way to mobilize social forces, raise public health awareness, reduce the risk of infection, and enhance information disclosure (32). Several studies have emphasized the importance of communication in connecting with the public during a public health emergency (33–35). Such views are consistent with the views of some respondents in the current study. Seven respondents reported that educating community residents on how to protect themselves and how to respond to emergencies is also part of emergency rescue work. Additionally, respondents believed that during public health emergencies, the management of the health status of community residents, especially the management of special

populations, such as the older adult with chronic diseases, should not be ignored.

> "For example, in the case of this new type of coronavirus pneumonia, health education will enable residents to know how to protect themselves" (P5).

> "Some people do not know much about respiratory transmission, and health education will let them know what the routes of infection are, so that they can take some precautions in advance" (P10).

Theme 2: influencing factors

Educational background

All respondents expressed that educational background will affect the emergency rescue abilities of professionals, consistent with the results of Yang et al. (36) and Ren et al. (37). The occurrence of public health emergencies is often unpredictable, and the emergency response process involves a complex rescue environment and heavy rescue tasks. Such characteristics require professionals to not only have a comprehensive professional theoretical base and sufficient skills, but also an extensive knowledge base on epidemiology, public health protection, psychological assistance, and other aspects. Compared with medical staff with low educational backgrounds, medical staff with high educational backgrounds may have received more systematic emergency rescue professional training, resulting in better-developed knowledge and mastery. In addition, highly educated professionals have more awareness of and ability to engage in autonomous learning; they accept new things faster, which can contribute to an improved emergency rescue ability in public health emergencies. Accordingly, health management departments should rationally allocate human resources, increase the training of highly educated talents, and meet the needs of community healthcare (38).

> "I think that educational background also affects the ability to respond to emergencies. More educated people are more able to accept new things and have a stronger sense of active learning, so their emergency response capability will be better" (P3).

Region

Participants reported that there would be substantial differences in the level of first aid provided between different regions, and the ability of professionals would certainly be different. Evidence suggests that the higher the level of a medical institution, the stronger its medical staff's health emergency response capacity (39). Ma (40) described several reasons for the weak health emergency management ability of primary medical institutions. First, they lack emergency preparedness; for example, they lack emergency material reserves for the prevention and control of the COVID-19 epidemic. Second, their emergency response capacity is not strong; they lack sufficient information support and modern science and technology. Third, due to economic and human resource constraints, a lack of professional talents and rescue equipment and facilities at the grass-roots level has reduced the emergency rescue capacities of these institutions. Therefore, coordinated emergency management and regional

development should be strengthened by enhancing communication and interaction between provinces and cities.

> "The provincial hospitals in our city have no problem with this, while the lower-level hospitals may not do it well enough. Because our hospitals are often faced with public health emergencies, such as the previous bird flu, H7N9, and SARS, our hospitals are more experienced in emergency care in this area, and lower-level hospitals may not do so well" (P1).

> "There is a great difference in the level of medical care between urban and rural areas, and the competence of professionals is certainly different" (P7).

Experience

Studies have shown that a larger number of emergency response experiences predicts a higher self-evaluation of coping capacity (41, 42). In the current study, thirteen respondents stressed the important role of practical experience in improving emergency response capabilities. They expressed that experience is the best teacher, and experienced medical staff can better combine theoretical knowledge with practice and summarize their own shortcomings and deficiencies during the rescue process, enabling them to strengthen these factors in later work. Such an approach is consistent with the "novice to expert" theory proposed by American scholar Benner. This theory holds that medicine is an applied discipline that requires both theoretical knowledge and practical application. With the gradual accumulation of work experience, knowledge gradually develops from shallow and explicit to deep and implicit, and an individual's professional ability gradually develops and improves (43, 44). With an increase in working years, medical staff obtain richer working experiences, including experience in emergency and disaster management, and this translates to higher emergency rescue abilities (45).

> "I think one's personal clinical experience affects one's rescue ability, and when there is an outbreak, we need to determine if it is likely to be a public health emergency, such as food poisoning" (P6).

> "The more experience you have, the better your overall competence in all areas will be, compared to someone who has just graduated or has not experienced such activities" (P10).

Hospital level

Participants expressed that whether a hospital focuses on training in emergency response capabilities, whether relevant emergency response plans exist, and whether the stockpile of materials is adequate all affect the emergency response capabilities of professionals, which is consistent with other research results (46, 47). The higher the level of the hospital, the more emphasis on the cultivation of core emergency capabilities; accordingly, more training opportunities related to major infectious diseases are provided and this strengthens the ability of professionals to carry out practical exercises. Studies (48, 49) have indicated that the emergency rescue ability of professionals who have participated in emergency drills is generally higher than that

of those who have not participated in relevant drills. In a systematic evaluation of the disaster preparedness of professionals (50), the importance of simulation exercises for improving emergency rescue capabilities was also emphasized. On the other hand, high-level hospitals admit more acute, severe, and complex patients on weekdays, and the medical staff have relatively more treatment experience (47). Such interpretation is consistent with the above findings suggesting that the experience of professionals affects their rescue abilities.

> "The organizational ability and coordination ability of the hospital will have an impact. Our medical personnel are only a small part of the emergency rescue of public health emergencies. Well-organized hospitals and well-coordinated departments can help us to be more effective" (P10).

> "Does the hospital have corresponding systems and processes for various public health emergencies? Any training, any drills? Is there a special agency in charge of this? I think these have a great influence on our professional emergency rescue ability level" (P1).

Insufficient human and financial investment

Factors such as a lack of emergency professionals, low financial investment, and a lack of attention from the relevant authorities will affect the enthusiasm of professionals to a certain extent, and this will, in turn, affect their emergency rescue abilities (51). In particular, when public health emergencies occur in grassroots medical institutions, the rescue capability of the institution is directly related to the quality and timeliness of its emergency response (40). Most respondents in the current study reported that the hospitals they work in invest little in emergency rescue, and professionals' efforts in emergency rescue have not been remunerated accordingly. When a public health event occurs, an emergency team is temporarily established, and often, there are not enough human resources. Several respondents argued that relevant government departments must increase their capital investment and talent pool.

> "In fact, human and financial investment is not enough. Our hospital actually has an emergency team, but each member has much daily work to do, and sometimes they do both. If we encounter a public health emergency, human resources are necessarily not enough" (P4).

Discussion

Carry out emergency continuing education training to cultivate professional talents

Generally, professional emergency personnel with solid theoretical knowledge and rich practical experience capabilities are scarce in China (52). Previous studies have indicated that the emergency rescue abilities of clinical medical workers, community medical workers, rescue team members, and other professionals in public health emergencies in China are average to low (53, 54). Thus, they are often unable to meet the needs of emergency rescue in public health emergencies, and this, to some extent, limits improvements in emergency rescue quality. The results show that most participants in

the study have a high demand for continuing education and training in emergency rescue and management. Emergency rescue in public health emergencies requires not only first aid knowledge and skills but also epidemiological knowledge, risk assessment abilities, and public health response abilities (26, 55).

The more educated a professional is, the more comprehensive their knowledge of the profession, and the more motivated and active they will be at work (56). However, the emergency management personnel involved in public health emergencies are generally not highly educated and have a low professional level. In China, for example, more than half (54%) of the personnel in China's Centers for Disease Control and Prevention have only a college degree, about one-third (37%) have a Bachelor's degree, and only 7% have a Master's degree (57). Such educational levels suggest that relevant departments should carry out continuing education and training on emergency management and rescue for professionals with different levels, educational backgrounds, and positions, based on their different needs, with improved training contents and methods. The training content should not be limited to the theory and skill training of emergency rescue personnel. However, it must also provide training in preventive isolation, epidemiological monitoring, quarantine and disinfection, and psychological assistance. With the rapid development of information technology, applications such as WeChat, networks, and other platforms could be utilized to establish online learning courses so that training time is more mobile (58). Scientific retraining is the basis of relevant emergency skills retention. Such outcomes emphasize the importance of regular provision of continuing education and training for professionals involved in emergency management and rescue (59).

Strengthen emergency drills and improve practical ability

Several participants in this study mentioned that, although they have a certain theoretical understanding of public health emergencies, they do not have much experience in public health emergencies. Therefore, when things do happen, they are still busy with their usual tasks and do not know how to deal with the emergency. One study found that those who regularly participated in emergency drills generally had higher emergency rescue capacities than those who did not participate in relevant drills (60). Through emergency drills, professionals can become familiar with the contents of emergency plans, work processes, and personal responsibilities in an emergency rescue through exposure to real scenes similar to public health emergencies. Such exposure can also increase their theoretical knowledge and build their confidence in participating in real rescue situations (61, 62). Therefore, in the daily training process, hospitals and relevant departments should not only provide theoretical education but must also regularly hold emergency drills for public health emergencies. Such drills would not only deepen the understanding and experience of professionals in dealing with public health emergencies but would also improve their crisis awareness and emergency response abilities. Through emergency drills, shortcomings and loopholes in the relevant emergency plans can be identified and adjustments can be made further to improve the institution's emergency plan and responsibility.

Make emergency plans and establish an emergency team

Emergency plans play a crucial role in responding to public health emergencies (41, 63). Governments and medical institutions at all levels (i.e., provinces, cities, and counties) should formulate corresponding plans and procedures for handling public health emergencies based on relevant emergency plans, laws, and regulations of the state in combination with their actual situation. In addition, as an essential part of emergency capability, an emergency rescue team plays an vital role in emergency rescues. Public health emergencies are often unpredictable, so agencies should immediately deploy emergency response teams who specialize in dealing with public health emergencies and unify their command to ensure timely organization and management of the emergency (64). Public health events are different from other emergencies; they often require a large number of medical professionals. Therefore, it is necessary to further strengthen medical systems, encourage and support medical workers, strengthen the training of rescue workers, simulate the natural environment during exercises, and improve the professionalism of emergency rescue teams.

Increased government investment and improved treatment

Public health services are public welfare provided by the government to the entire population; they play a vital role in the prevention and control of various diseases (65). The findings mentioned above, and interview results suggest that low wages, a lack of attention, and a lack of human resources are dilemmas faced by emergency rescue systems, which is consistent with previous research (66). Some participants mentioned that many public health emergency professionals work part-time. In addition to medical-related work, they also undertake many jobs. Their salaries and treatment are not proportional to their workloads, and thus, their work enthusiasm is reduced. Many respondents felt that emergency rescue work is irrelevant to their work, and they, therefore, ignore learning relevant knowledge, which, in turn, affects their abilities. Therefore, it is suggested that the government should pay attention to the treatment of professional staff, adjust the proportion of personnel, clarify the work responsibilities of professionals, appropriately improve their salaries and treatment, and improve the social status of relevant personnel (67) to promote their enthusiasm and initiative, increase their attention to emergencies, and improve their emergency rescue abilities.

Conclusion

In this study, semi-structured in-depth interviews were conducted with 15 clinical medical workers, community medical workers, and rescue team members to understand the composition and factors influencing the emergency rescue abilities of professionals in dealing with public health emergencies. Professionals require an extensive knowledge reserve as well as

warning and evaluation, information submission, emergency response, self-protection, personal, coordination and cooperation, and health education abilities to participate in emergency rescue. Education, region, experience, hospital level, and insufficient human and financial investment will affect a professional's emergency rescue ability. Therefore, it is necessary further to optimize the provision of emergency education and training and cultivate professional talents. Relevant agencies should formulate emergency plans, establish emergency teams, and strengthen their emergency drills to improve the rescue ability of their agency. In addition, attention should be paid to the construction of an emergency rescue team, the adjustment of the personnel ratio, the improvement of staff treatment, and the promotion of work enthusiasm to improve the emergency rescue abilities of professionals in dealing with public health emergencies. These authors thank the professionals participating in this study who shared their experiences with us.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Ethical Review Board (ERB) of the Zhejiang Chinese Medical University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Sharing lessons learned from COVID-19 vaccine introductions: a global community forum for countries

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To optimize the efficient introduction and deployment of COVID-19 vaccines across the globe during the COVID-19 pandemic, in April 2021 WHO launched a new process and tools for countries to rapidly review the early phase of countries' COVID-19 vaccine introduction. This methodology is called the COVID-19 vaccination intra-action review, also known as mini COVID-19 vaccine post-introduction evaluation (mini-cPIE). As of November 2022, 46 mini-cPIEs had been conducted. In collaboration with Project ECHO, WHO convened and facilitated real-time experience sharing and peer-learning among countries following their mini-cPIEs through a virtual global real-time learning forum. This five-session clinic series was attended by 736 participants from 129 countries. Based on post-session feedback surveys, when asked about the utility of the sessions, half of the participants said that sessions led them to review national guidelines and protocols or make other changes to their health systems. The post-series survey sent following the end of the clinic series showed that at least eight countries subsequently conducted a mini-cPIE after participating in the clinics, and participants from at least nine countries indicated the experience shared by peer countries on the clinic largely benefited their COVID-19 vaccine introduction and deployment. In this article, we highlight the benefits and importance of creating a global experience-sharing forum for countries to connect and share pertinent learnings in real-time during an international public health emergency. Moving forward, it is critical to foster a culture of individual and collective learning within and between countries during public health emergencies, with WHO playing an important convening role.

KEYWORDS

immunization, COVID-19, emergencies, program evaluation, community of practice

Introduction

The World Health Organization (WHO) recommends that countries conduct a post-introduction evaluation (PIE) 6–12 months following the introduction of a new vaccine (1) to help countries evaluate implementation and take corrective actions. A PIE aims to fully assess the progress of vaccine introduction and can be time and resource-intensive requiring

in-person field visits at all levels of the immunization system (2, 3). The COVID-19 pandemic, however, necessitated the rapid vaccination of the entire global population (4). Countries had little time to conduct a full programme evaluation such as a PIE, especially during the early phases of COVID-19 vaccine introduction and deployment (5).

To address this need, WHO developed a new evaluation method by adapting the WHO COVID-19 intra-action review (IAR) for countries to conduct a simpler, shorter and more flexible version of the PIE process, coined as mini-cPIE (6–8). The mini-cPIE was developed in line with the National Deployment and Vaccination Plan for COVID-19 vaccines (NDVP) (9), COVID-19 vaccine post-introduction evaluation (cPIE) and COVID-19 Strategic Preparedness and Response Plan (SPRP) (10). The WHO guidance for conducting a COVID-19 IAR (11) was developed soon after the pandemic onset for key stakeholders to collectively identify practices and lessons learned to course-correct and improve the ongoing response (12). During the IAR, a facilitator guides group discussions, in-person or virtual, over a period of 2–3 days using trigger questions pre-selected to address country needs. Based on the findings, the stakeholders then collectively recommend short-and mid-to long-term follow-up activities.

As countries and partners began using the mini-cPIE, they were eager to learn about ongoing vaccination implementation challenges and emerging best practices to improve their own processes and coverage. With this goal in mind, WHO collaborated with Project ECHO (Extension for Community Healthcare Outcomes) to create a global virtual community of practice (vCoP) called the mini-cPIE clinic, consisting of virtual learning sessions for countries to share and learn from experiences in real-time with immunization peers. These were referred to as "clinics" henceforth. During clinics, countries that had recently conducted a mini-cPIE were invited to present their learnings and best practices to peers that were planning or considering conducting a mini-cPIE. This was followed by Q&A/discussion that allowed for direct connection between countries.

Five clinic sessions were conducted from July to December 2021 (13). Clinic design was informed both by a past WHO-ECHO vCOP series on broader COVID-19 immunization, and by Project ECHO's 20 years of experience implementing the ECHO collaborative-learning model. This model supports low-dose, high-frequency, virtual case-based learning to promote timely peer-to-peer information sharing and collaborative problem solving. This learning approach has proved to be instrumental in improving health outcomes during COVID-19, in other public health emergency responses and as related to general continuing health professional education (14–19).

The objectives of the clinics were threefold: (1) to create a forum for countries having conducted a mini-cPIE to share their experiences and learnings with stakeholders and peer countries; (2) to cultivate a community of learning and collaborative problem solving for COVID-19 vaccine introduction; and (3) to provide opportunities for countries interested in conducting a mini-cPIE to receive practical tips and technical guidance. The intended audience of the clinics were country immunization representatives interested in conducting, planning to conduct, or who had conducted a mini-cPIE, as well as partners technically or financially supporting these activities.

In this article, we describe the clinic design and participants' characteristics, challenges, lessons, and best practices shared by presenting countries, and the perceived value of the clinics among participants.

Methods

Clinic design, content, and promotion

Between July and December 2021, WHO hosted a series of monthly, 90-min clinics on the Zoom videoconferencing platform. Clinics began with two to three country presentations followed by facilitated discussion, presentations from experts on immunization topics of interest, questions and answers, and interactive polls for real-time feedback from participants. The clinics were designed to be interactive, with participating countries able to directly engage with and ask questions to presenting countries. All questions that were not addressed during the clinic due to time constraints were compiled and shared with all participants and posted on the TechNet-21 immunization community collaboration platform (13). To maximize accessibility and promote multilingualism, simultaneous interpretation was provided to and from English, French, Spanish, Russian, Arabic and Portuguese. To further encourage participant engagement, a Telegram instant messaging group was established to offer participants an additional opportunity to continue discussions and experience sharing asynchronously outside the clinics.

Over the course of the six-month series, the Ministries of Health of 10 countries from four WHO regions, the African (AFR), American (AMR), Eastern Mediterranean (EMR) and South-East Asia (SEAR) regions, accepted the invitation to virtually present on their experiences with recently conducted mini-cPIEs (Table 1). The first two clinics addressed the conduct of and general learnings from mini-cPIEs -- including successes, challenges, and lessons learned -- and covered all immunization programme areas defined in the COVID-19 National Deployment Vaccination Plan (NDVP). The format of the clinics evolved through the series based on participant feedback and immunization topics that arose during that period of the pandemic. For the final three clinics, the presenting countries were asked to focus on specific immunization programme themes pertinent to challenges

TABLE 1 Overview of the virtual mini-cPIE clinic series hosted by WHO and ECHO project, July–December 2021.

Session No.	Session date	Session theme
1	28 July 2021	Global Overview and Country Experience Sharing (Bhutan, Gambia, Senegal)
2	21 September, 2021	Mini-cPIE Experience Sharing and Lessons Learned (Ghana, Uganda)
3	12 October 2021	Experience Sharing and Lessons Learned in Fragile States/ Humanitarian Contexts (South Sudan, Somalia)
4	23 November 2021	Promoting Vaccine Uptake - Unique Risk Communication and Community Engagement Approaches (Democratic Republic of Congo, Mozambique, WHO Regional Office for Europe)
5	14 December 2021	Inequities in COVID-19 Vaccination Uptake (Bolivia), Gender and the COVID-19 vaccine roll-out

observed during the COVID-19 vaccine introduction and deployment (Table 1).

Advocacy and outreach efforts were made to ensure the intended target audiences were aware of scheduled clinic sessions. These included engaging with WHO regional and country focal points for both immunization and health emergencies so that they would share information about upcoming clinics with relevant country-level counterparts. Participants were also invited to join the sessions relevant to their interests through email announcements, social media, and Project ECHO and TechNet-21 platforms. Pre-registration was required for attendance and open to the public. After each session, Project ECHO distributed session materials (i.e., recordings, presentations, and Q&A responses) along with announcements for the subsequent session. Session materials were also posted on the TechNet-21 collaboration platform.

Data collection and analysis

Participant demographic data were collected upon registration via a unique Zoom link, including name, email, gender, area(s) of expertise, professional affiliation, geographic level (e.g., multi-country, national, sub-national), and country. Registration and attendance data from Zoom reports were linked by email address. The first session registration data did not include gender, area(s) of expertise, and region of work. That and a few incomplete responses explain discrepancies in the result's profile data totals.

A link to an anonymous online post-session survey (Supplementary Appendix 1) was shared with all participants for the third, fourth and fifth clinics, with digital certificates of participation provided to participants who completed the survey. The survey asked participants about their knowledge of the session's topic before and after; relevance of the session to their current work; balance of lecture and interactivity; and intention to use what was learned in their work. In addition, Project ECHO distributed a post-series survey via email in November 2022 (eleven months after the last session) to all program participants to solicit feedback about the entire clinic series, including qualitative examples of barriers to conducting mini-cPIEs and improvements to vaccine roll-out linked to series learnings (Supplementary Appendix 2). The University of New Mexico Health Sciences Institutional Review Board approved the evaluation (ID 20–469).

Chi-square and Fisher's exact tests were used to compare results across dichotomized geography (multi-country versus single-country) and country income levels. The Wilcoxon signed-rank test was used to compare knowledge before and after sessions. Quantitative analyses were conducted in R version 2022.07.1. Open-ended text responses were coded systematically using NVivo 1.4.1.

Results

Characteristics of participants

From 28 July 2021 until 14 December 2021, 996 attendances were recorded over five clinics. Among these, 736 unique individuals from 129 countries across all six WHO regions participated in at least one clinic session (Table 2 and Supplementary Figure S1). The number of

TABLE 2 Demographics of participants who attended the virtual mini-cPIE clinic series hosted by WHO and ECHO project, July–December 2021.

Demographics	Frequencies		Attended 2+ sessions		
	n	%	*n*	%	*p*-value
Geographic level (*n* = 732)					
Multi-country	296	40.4%	86	29.1%	0.004
Single-country	436	59.6%	87	20.0%	
Gender (*n* = 639)					
Female	306	47.9%	76	24.8%	0.256
Male	333	52.1%	96	28.8%	
Expertise (*n* = 648)					
Immunization	244	37.7%	74	30.3%	0.296
Emergency preparedness and response	149	23.0%	40	26.8%	
Programme management	146	22.5%	36	24.7%	
Other	109	16.8%	23	21.1%	
Country-level income (*n* = 736)					
Low	104	14.1%	101	23.2%	0.793
Low-middle	332	45.1%			
Upper-middle	111	15.1%	72	24.0%	
High	189	25.7%			

participants in each session ranged widely from 88 to 241. Most (*n* = 563; 76.5%) participants attended only one session and 23.5% (*n* = 173) attended two or more. More participants (*n* = 436; 59.6%) described themselves as working in a single country versus multiple countries (*n* = 296; 40.4%) (i.e., working at the regional or global level). More than half (59.2%) of participants were in low or lower-middle income countries. The most common areas of expertise among attendees were immunization (*n* = 244; 37.7%) followed by emergency preparedness (*n* = 149; 23.0%) and program management (*n* = 146; 22.5%) (Table 2). Participants attended an average of 1.4 clinics each. Participants representing a single country were less likely to attend multiple sessions than those working at the regional or global level (Table 2).

Lessons learned and best practices shared by countries

Country case studies were presented by either government representatives or WHO immunization experts from Bhutan, The Plurinational State of Bolivia, Democratic Republic of Congo (DRC), Gambia, Ghana, Mozambique, Senegal, South Sudan, Somalia, and Uganda. Speakers shared the importance of strong political commitment to mobilize national resources, bilateral negotiations for donations to increase access to vaccines, and multi-sector engagement to mobilize human resources. Strong inter-sectoral collaboration contributed to successes in every thematic area. Leading by example, political and community leaders were able to build trust and improve vaccine uptake.

Immunization experts from countries highlighted their successes with key innovations. Bhutan described how the Prime Minister boosted public confidence by receiving the first and second doses of a heterologous regimen. Bhutan achieved 95% vaccine coverage for the first dose and more than 90% vaccine coverage for the second dose following the first national vaccination campaigns. The Gambia described using a "vaccine caravan" to improve vaccine uptake and engage remote communities. Ghana used an innovative yet cost-effective approach for authentication of vaccination status with metallic holograms on vaccination cards, as well as utilizing drones to deliver vaccines to hard-to-reach areas.

Challenges and proposed solutions were shared together, although sometimes these solutions highlighted additional difficulties. For example, Senegal successfully established a COVID-19 Adverse Event Following Immunization (AEFI) committee and investigated all serious AEFIs; however, with this success came the challenge of how the country was addressing the lack of free medical care for those experiencing serious AEFIs. Uganda addressed delays in deployment of funds to the operational level by emphasizing early and transparent communication with health workers to instill confidence and allow continued vaccination services during resolution of administrative problems. Somalia described challenges in the availability and distribution of doses due to short expiry dates and described forecasting tools used to improve vaccine management and distribution. Bolivia worked to address coverage disparities through review of uptake data disaggregated by geographic area, target population, age, and gender. In low uptake populations, Bolivia prioritized single-dose regimens to minimize the risk of drop-out and reduce vaccine access inequity.

Strong risk communication and social listening activities at subnational and local levels were described by several Ministries of Health as essential to successful COVID-19 vaccine deployment. South Sudan dispelled rumors by acting on behavior survey findings through media engagement, high-level advocacy meetings, radio programmes and jingles, especially when new variants of concern emerged and created a loss of public confidence in COVID-19 vaccines. In the session focusing on unique risk communication and community engagement approaches, the DRC described strategies to build confidence among high-risk populations through strong interpersonal communication of health workers, pre-registration and monitoring of vaccination status to allow health worker follow-up and engagement. Mozambique used multiple communication channels to create public demand for vaccines and regularly monitored and managed rumors through a technical working group and digital platform.

Poll responses

During the clinics, polls gathered real-time feedback from attendees. Examples of polling questions used were, "What topics/themes related to COVID-19 vaccine roll-out would you like to see discussed in future mini-cPIE clinics?" and "In a few words, what risk communication and community engagement strategies have you seen that worked well to increase COVID-19 vaccine uptake?." The polls, whose answers were visible to all, were successful in enabling quick sharing of perspectives from multiple country or partner representatives from the audience and stimulated further discussion on new topics (Supplementary Figure S2).

Post-clinic feedback surveys

The response rate for post-session surveys was 11.0% ($n = 117$). In post-session surveys, respondents rated their post-session knowledge significantly higher than before the session (Supplementary Figure S3) ($p < 0.001$). Almost all survey respondents ($n = 110$; 94.0%) reported the "right" balance of didactic and interactive learning. Additionally, most ($n = 110$; 94.0%) would definitely or probably recommend the session to a colleague and 80.2% reported the session was extremely or very relevant to their work. Most respondents would "definitely" ($n = 94$; 80.3%) or "probably" ($n = 17$; 14.5%) use information from the session in their respective work. The most common way participants planned to use the information was to share with colleagues ($n = 81$; 69.2%) followed by general use ($n = 73$; 62.4%), looking up additional information ($n = 63$; 53.8%), and making guidelines, protocols, or other changes to health systems ($n = 60$; 51.3%). Almost one-third ($n = 37$; 31.6%) planned to change how they worked with patients or community members.

Qualitative comments from post-session surveys reinforced the quantitative findings (Table 3). Respondents found the knowledge and information shared in each session useful and noted plans to share

TABLE 3 Feedback from participants to the open-ended questions of the post-session survey following the virtual mini-cPIE clinic sessions hosted by WHO and ECHO project, November 2022.

Theme	Description	Number of responses
Usefulness	**Responses to open-ended survey question "What part of this session was most helpful to your learning?"**	**154**
General	"All" or "everything"	54
Knowledge and information	Knowledge and information gained from sessions, including sharing with colleagues or using to develop communication strategies	45
Other countries' experiences	Specific or general experiences shared from other countries	39
Other	Discussion, interaction, and question and answer components of session; gender and equality topics	16
Recommended improvements	**Responses to open-ended survey question "How could this session be improved to make it a more effective learning experience?"**	90
Topics	COVID-19 specifics such as vaccines, vaccine confidence, reinfection, adherence to preventive measures, specific country experiences, finances, and metrics	54
More time	Requests for longer or more sessions	12
More interaction	Requests for more ways to interact during sessions	11
Other	Clearer slides shared with participants, need for language interpretation	13

($n = 227$).

with colleagues or stakeholders as well as using them to develop communication strategies for advocacy or community outreach. One respondent reported, "*I liked the ideas of evidence-based communication, analysis of community feedback to craft communication products that respond to community inquiries,* etc." while another said, "*The information shared in the session increased my understanding of challenges in other contexts which also apply to the African region.*" Answers from respondents helped inform priority COVID-19 topics for future sessions, including vaccines, booster dose policies, vaccine misinformation and hesitancy, financing, and metrics. Respondents also appreciated peer-sharing: "*It was a great cross learning opportunity. The challenges [encountered] in [fragile, conflict-affected, and vulnerable] settings are similar but the way these are addressed is the key learning.*"

Post-series survey

The response rate for the post-series survey was 5.4% ($n = 40$) (Table 4). Most respondents primarily worked in a single country characterized as low or low-middle income ($n = 19$; 63.3%). Fifteen respondents (37.5%) from eight countries mentioned that their countries began planning or conducting a mini-cPIE due to their participation in the clinic series. For 66.7% of those respondents ($n = 10$), participation in the series significantly helped inform planning, implementation, and follow-up. Planning or implementation of a mini-cPIE was more likely to be reported by low income or

TABLE 4 Characteristics of post-series survey respondents and reported impact of the virtual mini-cPIE clinic series hosted by WHO and ECHO project, November 2022.

	Frequencies	
	n	%
Demographics		
Geographic level ($n = 40$)		
Multi-country	9	22.5%
Single-country	31	77.5%
Country-level income ($n = 30$)		
Low	9	30.0%
Low-middle	10	33.3%
Upper-middle	7	23.3%
High	4	13.3%
Impact of the clinic series		
Country began planning or conducted mini-cPIE due to participation ($n = 40$)		
Yes	15	37.5%
No	10	25.0%
Do not know	15	37.5%
Extent participation improved COVID-19 vaccine rollout ($n = 40$)		
A lot	18	45.0%
Some	11	27.5%
Do not know	8	20.0%
Not at all	3	7.5%

lower-middle income country respondents compared to high income or upper-middle income countries ($p < 0.01$; Supplementary Figure S4).

Nearly three quarters of respondents (72.5%, $n = 29$) affirmed that their participation in the clinic series had improved their countries' COVID-19 vaccine introduction and deployment a lot or some amount (Table 4). The improvements shared by the respondents varied but referred to specific strategies learned during the clinics. For example, "*More vaccination posts were created to support community access and decongest health facilities. In addition, vaccination campaigns to de-stigmatize vaccines were held across the country physically and through media.*" Additionally, respondents mentioned adjustments to their national vaccination plans, new strategies for prioritization of high-risk populations, strengthening vaccination data management, and long-term integration of COVID-19 vaccination efforts within the national immunization and health system. Seven respondents shared barriers to using learnings from the series including immunization decision-making being outside their scope of work or scheduling conflicts to participate in more sessions.

Discussion

WHO, recognizing the importance and urgency of real-time peer-learning, leveraged its global coordinating role to rapidly convene countries and partners in the clinics described in this article. WHO, in collaboration with Project ECHO, created a global virtual learning forum for countries to highlight and share with peer countries their respective challenges, solutions, and innovations experienced during their COVID-19 vaccine introduction and deployment. While Project ECHO had prior experience establishing virtual communities of practice related to clinical medicine topics (16–18), this method for real-time peer-to-peer virtual learning was first used for the global immunization community during the pandemic. At the start of the COVID-19 pandemic prior to the mini-cPIE clinic series, WHO and Project ECHO collaborated on the ACT Accelerator COVID-19 initiatives (19), and a second series that convened partners and practitioners to build global capacity in preparation for COVID-19 vaccination (14). Several studies have shown that virtual training can help equip healthcare professionals with knowledge and skills for effective vaccination deployment during critical times of the COVID-19 pandemic (20, 21). The mini-cPIE clinic series was novel as it not only showcased the use of the intra-action review process recommended by the International Health Regulations Emergency Committee (22) early in the pandemic, but it also leveraged the virtual multi-country platform for case-based learning including country-level case presentations and participation from national public health practitioners.

Use of a virtual platform was essential given pandemic restrictions on in-person convening but also greatly reduced costs for convening large audiences. The establishment of the virtual platform also enabled WHO to continually advocate on behalf of Member States for additional technical and financial support from partners and donors. Participants who responded to post-session surveys found the clinics valuable. Survey responses show the value of clinics for participants in several ways, including a self-reported significant increase in knowledge, a high likelihood of endorsing the clinics, and

plans to use the newly acquired knowledge. Evidence from the post-series survey reinforces this value, particularly for low and middle-income countries, by supporting the planning or conducting a mini-cPIE. Perceived value is also reflected in the suggestions for improvement, including requests for more sessions, more topics, and more time for discussion and interaction. The fact that most attendees attended only one and not multiple sessions suggests that either attendees were interested in a specific country presentation or a vaccination topic, or they were busy and could only select specific sessions to attend. Some participants may have taken advantage of the option to watch recordings of the sessions in addition to attending live.

Participant feedback was used to adapt clinic content to be most relevant and useful. For example, one of the clinics was dedicated to COVID-19 vaccine introduction and deployment in Fragile States/humanitarian contexts (13). The importance of strong risk communication strategies and community engagement was mentioned in multiple clinics, and given common challenges in this area, participants also expressed interest in having a focused session on the topic. This became the theme for session four (13), where presenters and participants shared regional and context-specific challenges and solutions. Global expert and audience contributions touched on key learnings that have since been documented in the literature (23, 24) including the importance of just-in-time risk-communication training and evidence-based community engagement approaches that rely on understanding the behavioral and social drivers to increase uptake and decrease hesitancy (25–28).

During the clinics, Q&A sessions generated considerable interest among participants, especially in the use of innovative approaches to increase vaccine coverage. Although it is encouraging to learn of the many emerging innovations borne of the COVID-19 crisis, best practice still requires that innovations be piloted and evaluated before scale-up, to assure that the innovative initiatives are beneficial, cost-effective, locally appropriate and sustainable. Equally, documentation of the impact of different approaches used by countries has been important to inform and optimize their use in the longer term for COVID-19 vaccine deployment, for other emergency vaccine responses or for routine vaccination programs (29).

In addition to innovation, countries described and discussed how best practice vaccination strategies from established childhood (e.g., polio, measles) and adult (e.g., influenza) immunization programmes were used to improve COVID-19 vaccination uptake. For example, strong outreach or mobile immunization sessions were described as crucial in many settings to reach priority populations. This finding aligns with literature documenting the use of outreach and mobile vaccination units to promote equity and reach underserved populations both prior to (30, 31) and during the pandemic (32–34). Moreover, enhanced engagement with private sector health providers expanded access to non-traditional or new vaccination sites. Strategic private sector engagement has been described elsewhere as an effective strategy for mass health emergency vaccination (35). During the pandemic, working collaboratively with different sectors in a whole-of-society approach was also highlighted in the global analysis of IARs conducted by WHO (36).

Established practice for one country might be innovation for another. Countries shared the mosaic of digital strategies reported

subjectively to improve aspects of their vaccination programs: virtual training platforms; digital data management tools for tracking vaccine supply and distribution; electronic vaccination registries; electronic vaccination cards with sophisticated methods for authentication; digital platforms and social media for social mobilization, monitoring rumors, and infodemic management. Peer-to-peer learning on these practices allowed clinic participants the opportunity to seek support from country representatives or global partners to develop in-country capacity for the real-world implementation of evidenced-based strategies for digital applications across the immunization system from vaccine supply to delivery to monitoring to communications and community engagement. Evidence was beginning to accrue on use of these strategies prior to the pandemic (37, 38) but has expanded greatly with the pressures of the COVID-19 vaccine rollout (39, 40).

The development of this COVID-19 vaccination IAR (mini-cPIE) toolkit and the clinics initiated a new and collaborative process between the Health Security Preparedness Department and the Department of Immunization, Vaccines and Biologicals at WHO. The development process provided opportunities for relevant stakeholders and end-users at all organizational levels (global, regional, country) to provide feedback. WHO's collaboration with Project ECHO's academic team leveraged their global vCOP and interactive webinar production experience and added a new perspective for achieving the right balance of information sharing and peer-to-peer learning on global COVID-19 immunization. WHO often encourages countries to adopt a multi-sectoral, whole-of-government and whole-of-society approach to emergency preparedness and response. In this clinic series, WHO also followed this model from the design to the implementation.

Our analysis is limited by the fact that the response rates to the post-session and the post-series surveys were relatively low and cannot be generalized to all participants. For the post-series survey, this is likely related to the delay of almost a year after the completion of the clinics before the survey was conducted. It is possible that participants most likely to respond were those who experienced the greatest benefit. Regardless, the feedback provided by respondents indicates that the series may have prompted at least eight countries to conduct mini-cPIEs and many more felt the material shared led to positive change in practice.

Conclusion and future directions

The creation of this virtual global real-time learning forum allowed countries to connect and share their COVID-19 vaccine introduction and deployment challenges and successes during an acute global emergency. A similar approach can be used to share pertinent topics beyond vaccination in real-time in future public health emergencies. The mini-cPIE clinics have also served as a springboard for a subsequent community of learning addressing lessons learned on COVID-19 immunization practices beyond the mini-cPIE (41). Moving forward, it is critical to foster a culture of individual and collective learning within and between countries during a public health emergency to help accelerate the sharing of new knowledge, promising practices, and real-world implementation of evidenced based practices, with global health agencies such as WHO playing an important facilitating role.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2024.1376113/full#supplementary-material

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A tabletop exercise approach to global disaster preparedness: insights from Nepal's first international conference on disaster preparedness and management

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Considering recent earthquakes and the COVID-19 pandemic, disaster preparedness has come to the forefront of the public health agenda in Nepal. To strengthen the developing health system, many initiatives are being implemented at different levels of society to build resiliency, one of which is through training and education. The first International Conference on Disaster Preparedness and Management convened in Dhulikhel, Nepal on December 1–3, 2023. It brought together international teaching faculty to help deliver didactic and simulation-based sessions on various topics pertaining to disaster preparedness and management for over 140 Nepali healthcare professionals. This paper focuses on the tabletop exercise-based longitudinal workshop portion of the conference on disaster leadership and communication, delivered by United States-based faculty. It delves into the educational program and curriculum, delivery method, Nepali organizer and US facilitator reflections, and provides recommendations for such future conferences, and adaptation to other settings.

KEYWORDS

disaster resiliency building, disaster medicine, health systems strengthening, interdisciplinary education, disaster preparedness, tabletop exercises, developing health systems

1 Introduction

Disasters are events which stress a community's resources and response capabilities beyond its capacity. One component of the disaster cycle is disaster preparedness, which involves developing operational response plans and conducting trainings, drills, and exercises, to ensure that the people and systems involved are prepared (1). Exercises are frequently used in disaster

preparedness efforts to evaluate and practice response policies and skills (2). The tabletop exercise (TTX) is a specific type of discussion-based exercise where a scenario is presented to the participants and as the scenario develops, the participants must discuss their response actions in the confines of the plans and policies in place and their assigned roles and responsibilities (3). It is used with the intended aims of providing and applying a conceptual understanding of disaster policies and procedures, identifying areas of strength and improvement through discussion, and fostering leadership and communication skills (3). TTXs require low costs and low resources, and can be done in a stress-free informal, classroom, or workshop setting. This makes them useful for preparedness efforts, particularly in low resource settings. Guidelines provided by the United States Department of Homeland Security's Exercise and Evaluation Program (HSEEP) and prior studies have shown that adapting the scenario to the context, characteristics, and settings similar to those that participants are likely to encounter in practice, is crucial for ensuring a meaningful experience for the participants (3–6). Exercises are built around hypothetical or "model" cities or communities, using a technique that is frequently used in emergency management and by the US Federal Emergency Management Agency for training purposes (7, 8).

Nepal, one of the most highly ranked disaster-prone countries globally, adopted the Sendai Framework for Disaster Risk Reduction in 2015 by establishing the National Disaster Risk Reduction Strategic Action Plan (9, 10). This constitutional mandate provided a national disaster management framework, with an incorporated incident command system (ICS) framework, for all levels of the government. However, similar to other developing healthcare systems, the implementation of this national plan is slow to reach the community level (10).

In an effort to fill this implementation gap, a group of Nepali emergency medicine and general practice physicians led by the Nepal-based co-authors of this paper, organized and hosted the First International Conference on Disaster Preparedness and Management in Nepal, at the Dhulikhel Hospital in December 2023. The United States-based faculty group and co-authors of this paper were invited to facilitate the TTX-based longitudinal workshop portion of this conference. Given that this was a major focus of the conference, this paper focuses on its conception and components, and provides a model for adaptation in other developing health systems.

2 Methods

2.1 Conference

Dhulikhel Hospital hosted the World Academic Council of Emergency Medicine's (WACEM) section for Crisis and Disaster Medicine to facilitate a Regional Congress for Tabletop Exercise and Communication in Crisis Disaster Medicine (TOPCOM), during this First International Conference on Disaster Preparedness and Management in Nepal. WACEM is a collaborative international council focused on the academics of emergency sciences. WACEM's section for Crisis and Disaster Medicine has been hosting an annual TOPCOM workshop since 2021, focusing on the use of TTXs to discuss emergency scenarios, test local emergency response plans, and practice communications skills in simulated emergency scenarios (11). Our US-based faculty group was invited to facilitate the TTX workshop under this premise. The conference brought together over 140 Nepali participants and was facilitated by invited international faculty from India, Malaysia, and the United States (US). The mission of the conference was:

To develop technical and non-technical knowledge, skills, and attitudes during disaster response; to improve disaster response utilizing Hospital ICS implementation; and to improve leadership skills during disaster response. To improve patient and healthcare workers' safety during disaster, intra or inter-departmental and interhospital communication and coordination skills; and to improve hub and satellite hospital networking (12).

2.2 Site and participant selection

Conference organizers for this inaugural conference are a group of emergency medicine and general practice physicians. They chose Dhulikhel Hospital as the site because of its disaster-prone location, and for logistical convenience. It is an independent, non-profit, non-governmental Kathmandu University-affiliated hospital located 30 kilometers southeast of the capital, Kathmandu. It has been the site of disaster response for earthquakes including the 7.8 magnitude earthquake in 2015, landslides, road traffic accidents, and recent COVID-19 pandemic. It also serves as a hub hospital and tertiary care referral center for its catchment area of 2.5 million people (13).

The conference organizing committee invited participants through targeted selection. Invitations were sent to healthcare personnel involved in all aspects of disaster response and coordination from all 25 hub hospitals in the country, as well as the 11 Kathmandu University-affiliated medical colleges in the Kathmandu Valley. After recruiting invited participants, registration was kept open for all others who were interested. Any English-speaking healthcare worker, over 18 years of age, with an interest in disaster management was eligible to enroll.

The conference was made possible through financial, logistical, and technical support from national and local governmental and non-government agencies, World Health Organization, Nepal Red Cross Society, Rotary Club, Government of Nepal, Dhulikhel Hospital, WACEM, Kathmandu University Hospital, and other local stakeholder organizations.

2.3 Agenda

The conference was designed to meet the stated objectives which were achieved through a combination of focused half-day workshops, expert panel discussions with local and international leaders in disaster response, plenary sessions, logistics and planning meetings, and the TTX-based longitudinal workshop on disaster leadership and communication (Table 1). The TTX workshop was one component of the overall conference and was delivered in three distinct phases, each of which built on the lessons of the prior sessions but would also be meaningful as a stand-alone exercise.

The curriculum was adapted from previous TTXs conducted by this workgroup in various global contexts over the last decade, including India, Sri Lanka, Malaysia, South Africa, Qatar, and Turkey. The exercises introduced the topics of the incident command system (ICS), communication and leadership during mass casualty incidents (MCIs), developing hospital disaster preparedness protocols, and approach to managing chemical, biological, radiological, and nuclear (CBRN) incidents.

TABLE 1 Conference agenda.

Day 1	Pre-conference workshops (participants had a choice to pick one of these, each had a cap of about 30 participants): Disaster Point of Care Ultrasound, Wilderness Medicine, CBRNE Decontamination, Tabletop Exercise curriculum, Pre-hospital care and hospital disaster preparedness planning
	Nepal leaders disaster response panel discussion
	Opening ceremony
Day 2	Essentials of critical care
	Plenary sessions
	International faculty disaster management experience sharing panel discussion
	Tabletop exercise curriculum
Day 3	Tabletop exercise curriculum
	Closing ceremony

2.4 Curriculum development

The curriculum consisted of didactic lectures paired with a TTX (Table 2). The didactic lecture-based portions served as an introduction to key scientific theories and technical skills related to general disaster management topics. The paired TTXs aimed to teach the soft skills of leadership, communication, teamwork, situational awareness, and decision-making, where conference participants were challenged to troubleshoot locally adapted scenarios and apply the learned concepts. The educational content was delivered in English and participants were encouraged to communicate with each other and the facilitators in English. Exercises were developed based on guidelines provided by the HSEEP, incorporated concepts from the ICS framework, and followed a progressive approach whereby each exercise built on the concepts and objectives learned from prior exercises and increased in complexity (3).

The specific curriculum topics were selected to provide a comprehensive yet general overview of key considerations in managing a disaster, and driven by the conference objectives of providing knowledge and skills for ICS implementation, improving disaster leadership, communication, and coordination skills, and addressing patient and healthcare safety concerns. While the specific scenarios were tailored to the local context, the topics covered were generalizable to any disaster. Focus was given on applying the roles and responsibilities of the ICS posts, developing a hospital response plan, managing mass casualties and fatalities, as well as patient surge, providing support for families and staff, and handling the psychological impacts of providing care during and after a disaster.

2.5 Exercise scenarios

The TTX scenarios were adapted to the local disaster governance framework, country geography, disease and disaster burden, health service capacity, and first responder and emergency medicine workforce structure, in an effort to simulate the existing conditions. This was done largely through review of literature on current national disaster

framework policies in Nepal, as well as input from the faculty member who is Nepali and has extensive work experience in the country (10).

For the half-day workshop on the first day, the US-faculty led a group of participants through the basics of the ICS and management of radiological MCIs. One scenario for this topic was centered around a terrorist attack at two mass gathering sites, given the global impact of terrorism as well as the prevalence of mass gatherings around religious holidays in Nepal (14). A second radiological scenario was selected due to the rarity of radiological events in the country, under the assumption that it would be a topic participants would be least familiar with, and therefore fill a potential knowledge gap.

The second and third days of the conference brought together all the over 140 conference participants in a large auditorium. On the second day, the ICS was introduced again for the entire group to provide a standardized approach for organization. This was followed by lectures on mass fatality and psychological first aid. The lectures were followed by a TTX, where the main objective was to have participants plan their response utilizing ICS roles, coordinate among the different response entities involved, and anticipate health facility needs, including mass triage, patient transport, morgue capacity, and patient tracking. The TTX was based on an intercity bus accident scenario, given the high prevalence and healthcare burden of road traffic incidents in Nepal (13). Participants were broken up into groups representing a local health department, three hospitals with different resources and capacities, a first responder group, and a police group, and within each group assigned themselves ICS roles for the exercise. A specific adaptation was made in this exercise to account for a lack of a centralized pre-hospital ambulance system in the country, a role which private vehicles, taxis, and public transportation vehicles play (15, 16).

2.6 Model cities conception

The third and final day consisted of a culminating multi-city, multi-organizational exercise based on a model cities concept. Facilitators developed sample model cities of varying sizes based on the geography, demographics, and population of actual cities in Nepal. The model cities were based off of Kathmandu, Nepal's capital and largest city, two smaller cities in less populated southern and western locales, and an outlying remote village in the far west of the country. Google Maps was used to estimate the distances between the model locales. While the general location in the country, size, population, demographics, and distances between each other were based on actual locales in Nepal, specific details regarding healthcare resources, physical infrastructure, industries, natural and constructed resources, and recent disasters were all created hypothetically to facilitate the flow of the exercise prompts and delivery of the workshop objectives. These key pieces of information allowed participants to put themselves into the simulation and think critically about how each locale's hazards could affect the vulnerability and response to disasters.

Considering Nepal's seismic activity, and at that time, the recent Jajarkot District earthquake, facilitators chose an earthquake scenario as it seemed like one of the most likely disaster scenarios that participants could face. A large magnitude earthquake would also require a national response in reality - allowing many different groups to be involved and, therefore, accommodating the large number of participants.

Participants were divided into equally-sized groups into the 4 locales, and then within each locale, were further organized into smaller

TABLE 2 Tabletop exercise-based curriculum outline.

Day	Lecture topic	Tabletop exercise scenario	Conference objectives addressed
1	Incident command system	Terrorist threat at 2 mass gathering sites	1. Hospital ICS (HICS) implementation
	Approach to nuclear and radiological mass casualty incidents	Radiation detectors triggered on an arriving flight into the international airport	1. Technical knowledge and skills 2. Non-technical knowledge and skills 3. HICS implementation 4. Leadership skills 5. Patient and healthcare worker safety
2	Incident command system - refresher	Mass fatality incident involving a intercity bus accident	1. Technical knowledge and skills 2. Non-technical knowledge and skills 3. HICS implementation 4. Leadership skills 5. Patient and healthcare worker safety 6. Improve interhospital communication and coordination
	Mass fatality incidents		
	Psychological first aid		
3	Hazard vulnerability assessment	Earthquakes in several regions of the country prompting a national response	1. Technical knowledge and skills 2. Non-technical knowledge and skills 3. HICS implementation 4. Leadership skills 5. Patient and healthcare worker safety 6. Improve interhospital communication and coordination 7. Improve intra-departmental communication and coordination
	Incident response guides		
	Job action sheets		
	Disaster public messaging		

sub-groups representing an appropriately leveled governmental emergency operations center, a hospital or clinic administration group, and hospital or clinic clinical staff group. Each group was provided information for their respective entity, a designed local map, and pertinent details about geography, distance in relation to the other cities, and their local hospital or clinic staffing and capabilities. These included number of beds, available specialty services, and number of operating rooms. An exact list of supplies was not provided. Participants were encouraged to simulate what resources would be available and what would need to be requested. In future simulations, this allows for participants to use their personal knowledge of the country to enhance the drill's applicability. It also makes the plan more generalizable.

Armed with this information, facilitators instructed groups through the preparation phase of disaster response. Participants were guided through conducting a hazard vulnerability analysis for their assigned jurisdiction or facility, creating an incident response guide for an earthquake scenario, and filling out job action sheets for their respective ICS roles within their groups. Participants also had to develop memorandums of agreements with other cities and hospitals during this planning phase.

The following 2-h TTX required participants to apply the aggregate learned concepts from the 3 days to conduct a multi-city, multi-sector national earthquake response using the ICS framework and implementing and utilizing their incident response guides and memorandums of agreement. Prompts were given at certain times throughout the exercise to select groups who then had to respond and communicate the needs of their respective city and/or healthcare facility to the other groups in the room. This required participants to continually reassess and effectively communicate. These prompts let group members experience first-hand the challenges of disaster response. Debriefing sessions were conducted periodically to align all the groups together and learn from each other's experiences. The number of prompts and number of debriefs that are performed during the tabletop can be adjusted to the

needs and time-restraints of the group. Larger groups may need more prompts and debriefs to allow all participants to learn from each other, while smaller groups may be able to focus on a prompt for a longer period. This exercise stimulated participants to employ their leadership and delegation skills within their groups, troubleshoot inter and intra-group communication challenges, and work through addressing patients' and healthcare providers' health and safety needs during a disaster response event.

3 Discussion

3.1 Strengths

The host institute and organizing committee found the exercises particularly useful as knowledge and skill delivery methods. Given that there is limited knowledge on disaster management at the grassroots community level, the material from the exercises helped fill part of the national policy implementation gap for disaster response for healthcare workers.

Most of the participants were early career healthcare workers. In settings of MCIs, they would likely be on the frontlines of clinical care provision and less likely in administrative roles. Disaster resilience frameworks identify redundancy as one of the key components of disaster resilience and health systems strengthening ([17], [18]). A study looking at hospital resiliency at a large university hospital in Kathmandu after the 2015 earthquake revealed that redundancy and task-shifting played a major role in the immediate response ([19]). To this end, through the introduction of concepts and skills critical to managing disasters, the conference material contributed to resiliency building by providing a means of redundancy.

Through the TTX, an emphasis was placed on inter and intra-departmental and organizational communication. Participants were encouraged to troubleshoot patient care, transportation, supply-chain, and logistical issues within their assigned groups and with the other groups, mirroring the reality of the situations that arise in MCIs. As the final exercise progressed, facilitators were also able to teach the importance of communicating up the chain-of-command to effectively manage a disaster, and the fallouts that can occur when communication occurs in silos.

The TTXs used in this program as a training tool were adapted to the local context with the creation of model cities, to ease the participants' understanding of the simulation and facilitate interactivity with the scenarios. The TTXs can be scaled to test disaster protocols at different levels, from the facility level all the way to a national level. The model cities concept that was used for the culminating exercise is especially useful for conducting an exercise aimed at coordinating a multi-agency multi-sector response.

3.2 Limitations

It is important to note that while this paper highlights the experiences and reflections from the perspectives of the organizers and facilitators, one limitation it has is lack of formal feedback from the participants. It would be beneficial to obtain evaluation data to help inform future exercises. Direct observation is one way to evaluate an exercise and requires assigned observers familiar with the exercise development, who observe each group involved and assess whether each group met the objectives, by what means, with how much input or guidance from a facilitator. In addition to director observation, participant feedback on the quality of the training sessions and faculty members, as well as a separate follow-up study to evaluate for content retention and application can help further augment future program organization and delivery. Additionally, while all participants spoke English, we did have Nepali speaking faculty who helped translate some points that were more complex. Using either live translators or having co-facilitators who speak the local language can be useful for capturing a wider audience in appropriate settings.

3.3 Looking ahead

Disaster response requires a multi-sector, multi-disciplinary approach with involvement from professionals and community members at various levels in the healthcare and community hierarchy. This conference hosted clinical staff, including physicians, nurses, and health assistants from around Nepal. Future conference efforts should focus on selectively involving a larger interdisciplinary participant base, including community health workers, medical personnel in supportive roles, police, staff from hospital clerical services and environmental services, public health professionals, and administrative leadership. Involving professionals from all involved sectors in preparedness efforts will only help augment coordination and communication during the response phase of the disaster cycle and set the stage for a unified response effort.

Through national legislation, Nepal has implemented a structure for disaster governance that mandates the establishment of emergency operation centers at the national, provincial, district, and local levels. While the framework provides a structure, studies cited above have found gaps in its implementation, a limited understanding of roles and responsibilities, inadequate training, and no standardized educational structure to deliver the training. This tabletop exercise-based workshop served as one means of filling this grassroots training and education gap. Further efforts must be made locally to sustain the momentum, build on the basic framework provided by such conferences, and expand it to include further protocol and policy development at the hospital level, with a multidisciplinary, multisector, whole community-involved training and education approach.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

JP: Writing – original draft, Writing – review & editing, Conceptualization. RK: Conceptualization, Writing – review & editing. JM: Conceptualization, Writing – review & editing. SB: Writing – review & editing. SS: Conceptualization, Writing – review & editing. BP: Writing – review & editing. BA: Conceptualization, Writing – review & editing, Supervision.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The emergency medical teams initiative in the WHO African region: a review of the development and progress over the past 7 years

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Background: The WHO Emergency Medical Teams (EMT) Initiative coordinates the deployment of qualified medical teams who promptly respond to public health emergencies (PHEs) and provide quality service during emergencies whilst strengthening capacity. Globally, 40 EMTs have been classified between 2016 and the present (as of the writing of this article in December 2023) and are from across all the WHO regions except the WHO Africa Region (AFRO). However, WHO Africa has prioritised the implementation of EMTs in 10 priority countries to address the public health emergencies (PHEs) affecting the region.

Objective: This article describes the development and progress of national EMTs in the WHO African Region over the past 7 years and elucidates the main lessons learned and the complexity and challenges in the process.

Methods: This study employed a case study approach because of its appropriateness in examining a complex social phenomenon in a socio-political context in depth, using multiple lenses simultaneously. Data and information were obtained through document reviews and key informant interviews (KIIs) ($n = 5$) with the members of the EMT Initiative on shared field experiences. Data were systematically analysed using the Stages of Implementation Completion (SIC) framework, and the lessons learnt were presented using components of a framework from Adini et al.

Results: The Initiative commenced in the WHO African Region following its launch in December 2017 in Senegal. The assessments of the concept's engagement (involved learning and deciding), feasibility (reviewing expectation and capacity), and readiness planning (collaborating and preparing) showed that the context-specific (African context) challenges, lessons from different emergency response

actions mainly guided the Initiative's pre-implementation phase in the region and prompted the WHO emergency leadership on the urgency and need for the EMT concept in the region. The assessment of the implementation processes showed progress in key areas, with staff demonstrating improved competency, EMT services maintaining high fidelity, effective consultation launching critical components, and ongoing services providing successful support and monitoring. Creating the N-EMTs and revitalising the EMT concept required an aligned strategy with other regional emergency programmes and a futuristic vision. Proposed sustainability and governance components include creating N-EMT, developing a coordination structure, collaborating with partners, and finalising the N-EMT.

Conclusion: The Initiative is an imperative component that would allow better-targeted management of health emergencies in the region. The continuous refinement of the EMT initiative is crucial. There is a need to work on additional components, such as a context-specific framework for collaborations and partnerships that would enhance deployment and procurement modalities and the complementarity between other regional initiatives to improve the work. Emphasis should be placed on strengthening local health systems, enhancing training and capacity-building programmes, and fostering regional and international collaborations. Additionally, sustainable funding and resource allocation are essential to ensure the resilience of EMTs in the African region and their long-term success.

1 Introduction

Low-income countries (LIC) and low- and middle-income countries (LMIC) are disproportionately burdened by the occurrences of outbreaks, disasters, and other complex emergencies (1). These countries have weak healthcare systems and are substantially strained by a lack of supplies, inadequate infrastructure, and a limited health workforce, which hinders response efforts and the needed quality healthcare when faced with emergencies (2). Furthermore, they are disproportionately affected by poor disaster-preparedness systems and the lack of response resources despite the urgently needed logistical and health requirements during emergencies (3, 4).

The World Health Organisation (WHO) developed the Emergency Medical Teams (EMT) initiative in 2015 (5, 6). The Initiative was built based on the lessons (such as poor coordination of the responses by the medical teams that were largely characterised by an absence of standardised care and accountability and governance) learned from the response experience of the earthquake in Haiti in 2010 (5–7). Subsequently, an expert review was conducted on the Foreign Field Hospitals following the aftermath of sudden-impact disasters (SIDs) by the Pan American Health Organization (PAHO), which, together with the lessons from Haiti, prompted the need for standardisation of response actions and coordination (5, 6). As a result, the WHO launched a series of steps to develop the criteria, principles, and standards for medical teams and the global EMT registry (1, 8). The registry envisaged having EMTs voluntarily apply to undergo a classification process of EMTs to demonstrate that they meet the internationally accorded EMT minimum standards and

agree to provide quality care using accepted guidelines. After the classification, the EMTs would then be deployed to respond to emergencies with the support of WHO and following a request of the host government (1, 8).

The EMT Initiative coordinates the deployment of qualified medical teams who promptly respond to emergencies (such as conflicts, climate-related disasters, and outbreaks) and provide quality service during emergencies whilst strengthening capacity and fortifying overwhelmed health systems (9, 10). Additionally, the Initiative focuses on training for specialised and general emergency disasters and diseases and supports governments in developing policies towards establishing EMTs. Over the last 10 years, there has been an improvement in the standardisation and professionalisation of care for emergency-affected communities, partly because of the changes and initiatives spearheaded by the WHO EMT initiative (4). The Initiative has provided a platform for developing specialist EMTs and strengthening specific emergency health and logistical responses. One critical focus of this Initiative has been building National EMTs (N-EMTs) within the countries in the continent and enhancing and strengthening their capacity. N-EMTs are healthcare professionals organised at the national level to provide rapid medical care during emergencies (such as natural disasters, disease outbreaks, or humanitarian crises) and who are quickly deployable to affected areas, providing critical healthcare services and supporting overwhelmed local health systems. The Initiative emphasises having teams of appropriately skilled personnel who provide care in a coordinated approach that targets the health needs during an emergency whilst meeting the minimum standards of care (4).

Globally, 40 EMTs have been classified between 2016 and the present (as of the writing of this article in December 2023) and are from across all the WHO regions except the WHO Africa Region (AFRO) (11). However, some WHO AFRO countries have begun building capacities and garnering resources to establish their N-EMTs to address the public health emergencies (PHEs) affecting the region. Nonetheless, given the heterogeneity in characteristics in the different countries in the continent and the pre-existing vulnerability of the populations, the context-specific of every emergency (such as their variation based on scale and the capacity of the affected community and country to manage the event) (2), the response strategies needs to be tailored to the specificity.

This article describes the development and progress of EMTs in the WHO African Region over the past 7 years. It further elucidates the lessons learned, including the complexity and challenges, and proposes recommendations for improving EMT work.

2 Methods

2.1 Analytical framework

The implementation processes of interventions are designed to be flexible, capturing potential variations. This adaptability ensures that assessment measures can inform progression through implementation stages, increasing the likelihood of success (12, 13). The process evaluation of interventions in implementation science involves analysing the formulation and implementation (including the role of different actors, processes involved, the fidelity of implementation, and the nature of the contexts) (14, 15). In this study, we systematically document and describe the formulation and implementation (development and progress) of EMTs in the WHO African Region over the past 7 years using the Stages of Implementation Completion (SIC) framework (16). SIC framework outlines three phases: pre-implementation, implementation, and sustainment, further divided into eight implementation activities: engagement, consideration of feasibility, readiness planning, staff hired and trained, adherence monitoring processes in place, services and consultation begin, ongoing services, consultation, fidelity monitoring and feedback, and competency. In our study, we chose the model to fit the distinct lessons, perspectives, and timelines of implemented activities following a standard sequence of steps reminiscent of an implementation cycle, and we summarise the activities necessary to move towards successful programme start-up, competency, and sustainment (see Table 1). On the other hand, the lessons learnt were presented using components of a framework from Adini et al. (17), as summarised in Table 1.

2.2 Design

In this study, we employed a case study approach because of its appropriateness in in-depth examining a complex social phenomenon in a socio-political context, using multiple lenses simultaneously (18–20). In this design, the case described is the EMT initiative in the WHO African Region, whilst the focus or the unit of analysis is the Initiative's formulation and implementation. Furthermore, the temporal boundaries are the past 7 years during which the Initiative

has been implemented, whilst the case parameters are those the Initiative has supported in the context.

2.3 Data collection and analysis approaches

Data and information used in this study were obtained from document reviews and key informant interviews (KIIs). These approaches were based on the methodologies applied in previous studies that focussed on the deployments of international EMTs (I-EMTs) (5, 21–24).

For the KIIs, we considered respondents who were knowledgeable about the EMT initiative and had been involved in the formulation and entirety of the implementation. In this study, we refer to them as insiders. Insider researchers are considered to have a place in a social group being studied (25, 26). They have been described as those who can have a more authentic understanding of the culture and are truthful with the concepts being studied, given their easy access to the context and concept being studied through their first-hand implementation experience (27). However, researchers have shown they can also be inherently biased (28). In this study, they elucidated insights into the dynamics, processes, and approaches employed in the Initiative's implementation in the region and highlighted the lessons learned and challenges from the implementation. As part of their roles in the EMT initiative, they either participated in meetings with the different actors such as government officials, EMT teams, and WHO country/regional/headquarters leaders or led different components of the Initiative at different times, which they used for understanding the dynamics of the stakeholders involved in the implementation of the EMT initiative. Five KIIs were interviewed between October and November 2023, with the guides focussing on the evolution of EMT development in the WHO AFRO and the processes involved.

For the document reviews, we used a rapid review approach to assess the elements already known about the EMTs initiative in the WHO African Region over the past 7 years. The approach used systematic reviews to search for and critically appraise the existing evidence (29). It included documents or studies written in English, French, and Portuguese and related to the EMT work (reported the concepts of formulation of the implementation of EMTs) in the WHO African Region. The documents considered in this study were from (a) secondary data availed by the WHO teams in the African Region and headquarters; (b) pivotal websites of the United Nations Office for the Coordination of Humanitarian Affairs and WHO EMTs; (c) Secondary data provided by different countries that have implemented different elements of EMT work (such as EMTs assessments and surveys, mission reports, bulletins, and meeting minutes of key meetings on the EMTs initiative and networks from the different countries in the continent); (d) Direct contact with the deployed I-EMTs in the continent requesting data on their deployments; and (e) Internet searches (Google scholar and PubMed using the search words "emergency medical team OR Emergency medical teams OR EMT," AND "Africa OR sub-Saharan Africa OR) [all countries in WHO African Region]." The search strategy used for PubMed is detailed in Appendix 1. When searching on Google Scholar, we used the words "emergency medical teams in Africa" and manually reviewed the articles on the first 50 pages. In both sites, we considered articles that met specific criteria, such as language (English, French, and

TABLE 1 Implementation phases, stages, and processes/actions, and lessons learnt.

Phase	Stage	Actions and timelines	Lessons learnt
	Stages of implementation completion (SIC) framework		Framework by Adini et al.
Pre-implementation	1. Engagement 2. Consideration for feasibility 3. Readiness planning	a) **2015–2017**: the regional teams' engagement and feasibility testing of the concept happened based on the continent's challenges and lessons learned from previous responses. b) **2017–early 2019**: the concept's readiness planning (collaborating and preparing) was done through regional sensitisation workshops and country awareness campaigns.	1. Financing and operations supply and logistics (OSL) 2. Initiation and driving desire 3. Planning, regional, and global collaboration 4. Human resource challenges and opportunities 5. Training programmes and exercises and contextualising the concept
Implementation	4. Staff 5. Processes in place 6. Services 7. Fidelity, monitoring, and feedback	c) **2018–2019 and 2022–2023**: launching critical components, such as the development of N-EMTs and deployments, enhanced staff skills, and knowledge transfer. d) **2020–2022**: the COVID-19 pandemic enhanced the EMT implementation aspects of services support and monitoring and staff support, fortifying the development of the N-EMTs in the region. e) **2020–2023**: establishment of the Regional EMT Training Centre and EMT training.	
Sustainability	8. Competency	f) **2022 to date**: developing the WHO strategy and course of action for the future. i. Implementation of N-EMTs in the proposed priority countries. ii. Steps and roadmap for developing N-EMT in the priority countries (10 steps for building N-EMTs) Proposing establishing the regional EMT governance structure. iii. Working on a linkage between the EMT and other regional initiatives.	

Portuguese), relevance to implementing EMTs, and publication date (from 2017 to the present). Our search on PubMed yielded 845 studies, whilst Google Scholar produced 50. After reviewing them for eligibility, we excluded studies irrelevant to EMT work. We screened all titles and abstracts, identified 19 studies that met our criteria, and included them in the final review. To analyse the content, we used thematic analysis guided by Braun and Clarke (30) to address questions about the journey, lessons learned, and challenges.

3 Results

The results are presented in two sections. Section 1 presents the journey and processes the EMT concept has undergone from 2015 to date (as of the writing of this publication in December 2023) using dates and events that happened guided by the stages and actions based on the SIC framework whilst Section 2 presents the lessons learnt using themes based on the framework proposed by Adini et al. (16, 17).

3.1 Pre-implementation (engagement, consideration for feasibility, readiness planning)

The assessments of the concept's engagement (involved learning and deciding), feasibility (reviewing expectation and capacity), and readiness planning (collaborating and preparing) showed that the context-specific (African context) challenges, lessons from different emergency response actions mainly guided the Initiative's pre-implementation phase in the region and prompted the WHO emergency leadership on the urgency and need for the EMT concept in the region. Examples are discussed in detail below.

3.1.1 2015−2017: the regional teams engaged in and conducted feasibility testing of the concept based on the continent's challenges and lessons learned from previous responses

Prior to the commencement of engagement with the EMT concept in the region, the lessons learned from responding to global emergencies had led the global EMT initiative to undergo the standardisation of EMT principles. These principles were then applied to different global emergency responses, especially building on the lessons from the West African Ebola outbreak (2014–2016) that had demonstrated the EMTs' value in outbreak response and other emergencies. The outbreak had the largest deployment of EMTs, involving 58 teams (6). The continent was one of the last to implement EMTs (despite facing numerous emergencies), prompting the need for stronger EMTs in the WHO's African region and, hence, the beginning of testing the Initiative's feasibility in the region.

Before the engagement and feasibility testing of the concept in the region, the developed global principles had emphasised the focus of the EMTs as mainly being on trauma and surgical care in response to sudden-onset disasters (SOD). However, after the lessons, broader definitions and EMTs were expected to care for various conditions, from communicable to non-communicable diseases. Additionally, teams were needed to support populations affected by flood, conflict, and protracted crises such as famine, with a need for clinical surge

capacity in all emergencies with health consequences (6). EMTs also had a role in reestablishing and maintaining essential health services, taking the discussion of EMT implementation in the region to a new level.

At the onset of the engagement process with the regional WHO African team, the global WHO Health Emergencies (WHE) Programme had just been setup (following the lessons learnt from the response to the Ebola outbreak in 2014–2016 in West Africa) with a philosophical approach of having one programme (at the global, regional and country offices with one budget and workforce) managed from the WHO headquarters (HQ) and with one line of communication (31). The aim was to work with the continent's member states to augment their capacity to detect, prepare for, prevent, and respond to health emergencies through streamlined emergency response efforts. There were five pillars: preparedness, infectious hazard management, response, health information, and management and administration.

Subsequently, to support the partnership component of the new WHE programme, the team implemented the WHO Global Partnership networks comprising the Global Outbreak Alert and Response Network (GOARN), health clusters, and EMTs. In 2017, the network leadership, having seen the progress in the other WHO regions, had a desire to introduce the EMT initiative in the WHO African region given the challenges with the emergencies the region was facing at the time and allocated funds to the WHO Regional Office for Africa (AFRO) develop the EMT initiative to test the feasibility of the process and support the readiness planning. One respondent noted:

> …they allocated USD 300,000 to the WHO Regional Office for Africa (AFRO) to implement strategies for bringing partners together and managing emergencies through [the use of] EMTs. (Respondent 01)

3.1.2 2017−early 2019: the readiness planning (collaborating and preparing) of the concept was done through regional sensitisation workshops and country awareness campaigns

The funds allocated to introduce the EMT concept in the region were used for the initial regional sensitisation workshops in Senegal in December 2017, which formed the basis for the readiness planning. It enhanced the collaboration and prepared the continent to implement the concept. All 47 countries in the WHO African Region received an invitation sent through their WHO country offices (WCOs). 11 of the 47 countries (Cameroon, Burkina Faso, Côte d'Ivoire, Kenya, the Democratic Republic of the Congo (DRC), Nigeria, Madagascar, Rwanda, Senegal, South Africa and Uganda) expressed interests and attended the meeting, and mainly guided by their capacities, history with natural disasters, and potential for better development of EMT (32).

Additionally, regional partners such as Save the Children, the West African Health Organization (WAHO), and the International Federation of Red Cross and Red Crescent Societies (IFRC) also joined. In the workshop, a need for cultural awareness of the EMTs was emphasised, leading to cross-country awareness campaigns (33). Following this recommendation, an awareness workshop was organised across different countries, starting with Senegal in April

2018 (32). The awareness campaign galvanised action around boosting countries' preparedness for emergencies, advancing the timely deployment of EMTs during emergencies, and harmonising the EMTs' adherence to minimum standards (34, 35).

A second regional meeting, which laid the foundation for the national implementation plans, was organised in June 2018, jointly with the WAHO in Côte d'Ivoire. It included Burundi and 12 countries of the Economic Community of West African States (ECOWAS): Burkina Faso, Benin, Côte d'Ivoire, Cabo Verde, Ghana, Guinea, The Gambia, Guinea-Bissau, Nigeria, Liberia, Sierra Leone and Togo. More awareness workshops were conducted in 2018 in South Africa (June 2018). The additional ones in Nigeria (October 2018), Guinea (November 2018) and Ghana (November 2018) were jointly undertaken with WAHO. Equally, two independent organisations, Médecins d'Afrique (MDA) and the Alliance for International Medical Action (ALIMA), also participated (32).

From the more awareness workshops, Senegal, South Africa, and ALIMA signed up to undergo the international EMT (I-EMT) classification (recognised international EMT response organisations, whose classification process are carried out annually to discourage unannounced arrivals at emergencies and encourage joining recognised organisations) (35). There was a consensus that countries needed to strengthen their disaster risk management and health emergency capacities urgently. Furthermore, it was resolved that member states needed to adapt EMT's core and technical standards to fit their country's context for better preparations to respond to outbreaks and other PHEs. It resulted in a roadmap for institutionalising N-EMT in the countries. As a result, the countries' capacities were assessed to strengthen them based on the key components of readiness using the EMT Minimum Standards guide (9). In early 2019, an additional EMT national awareness workshop was conducted in Kenya (32).

3.2 Implementation staff (support), fidelity monitoring (feedback), consultation (launching of critical components), and ongoing services (support and monitoring)

The assessments of the implementation processes, including staff (support), fidelity monitoring (feedback), consultation (launching of critical components), and ongoing services (support and monitoring), showed progress in key elements. Specifically, the staff demonstrated improved competency, the fidelity of EMT services was maintained at a high level, the consultation process was effective in launching critical components, and the ongoing services successfully provided support and monitoring. Examples are discussed in detail below.

3.2.1 2018−2019 and 2022−2023: the launching of critical components, such as the development of N-EMTs and deployments, enhanced staff skills, and knowledge transfer

Following the awareness workshops, some participating countries launched the critical components of EMT, such as the development of N-EMTs and deployments to tackle growing regional emergencies. For instance, ALIMA, in a collaborative effort with the MoH of DRC, WHO, IMC, IRC, and other development partners, was deployed to support the Ebola outbreaks in May and August 2018. This partnership

successfully set up an eight-bed Ebola treatment centre (ETC) at the epicentre of Ebola in the Itipo region, Equateur Province, and a 60-bed ETC in the Beni region of North Kivu Province (36). These ETCs served as crucial points for providing clinical care interventions, screening and isolating suspected cases, and reaching out to neighbouring communities and health facilities. This collaborative effort not only facilitated a significant transfer of skills and knowledge but also improved the case management of patients, laying a solid foundation for the future development of the N-EMT (32).

In October 2018, the Senegal EMT, with the support of the country's army, was deployed to manage cases in the DRC after a collision between a bus and an oil tanker resulted in a fire that left over 50 dead and more than 100 with severe burns (32, 36). This was done in partnership with the MoH and the WHO. The team provided patient care and worked with local responders to enhance clinical burn care capacity. Following this successful mission in the DRC fire tragedy, the EMT was deployed to Sierra Leone (under WHO's facilitation) in November 2021 to support the MoH in providing care to the injured after a road traffic accident led to a fire, resulting in over 101 deaths and about 123 injuries (37). The team's efforts resulted in 87 out of 155 patients being discharged home following successful provision of care (including pain management, reconstructive surgery, palliative and wound care, psychosocial counselling, rehabilitation, and physiotherapy) (38). Furthermore, in August and September 2022, the Senegal EMT, in collaboration with the MoH of The Gambia, responded to the Acute Kidney Injury (AKI) event in The Gambia. This followed The Gambia's MoH identification of 82 confirmed AKI cases amongst children who were < 8 years old, which had resulted in 70 deaths, with an estimated case–fatality ratio of 85% (39). The WHO, collaborating with the MoH, issued a medical product alert on four possible contaminated cough syrups suspected to have caused the

emergency, provided the technical and financial support for the deployment, and conducted an epidemiological study on the same (39).

In August 2023, the MoH Malawi, with support from the WHO AFRO, deployed a national 12-member EMT (from different countries) to Chikwawa District, having been trained in April and June of the same year for preparedness for potential PHEs. The deployment was mainly aimed at enhancing the case management of cholera cases that were on the rise across the country's districts. They helped mentor the in-house teams in the Chikwawa cholera units, offered case area-targeted interventions/strategies that included surveillance support, shared behavior change messages (by working closely with communities and officials), and distributed essential WASH resources. The different experts in the team minimised the mortality gap by improving the quality of patient care, documenting the processes, supporting the improvement of the guidelines, and working closely with the local team and the communities (40).

3.2.2 2020−2022: the COVID-19 pandemic enhanced the EMT implementation aspects of services support, monitoring, and staff support, fortifying the development of N-EMTs in the region

The emergence of COVID-19 brought about significant economic and health challenges. Subsequently, through the collaboration of various WCOs and the EMT network, the WHO African Region supported 22 I-EMT deployments in 17 countries, as illustrated in Figure 1 (41). These deployments, initiated in response to requests from the countries for external assistance (based on their diverse needs to address the pandemic at that time), enhanced the EMT implementation aspects of services support and monitoring and staff support, fortifying the development of the N-EMTs in the region. For
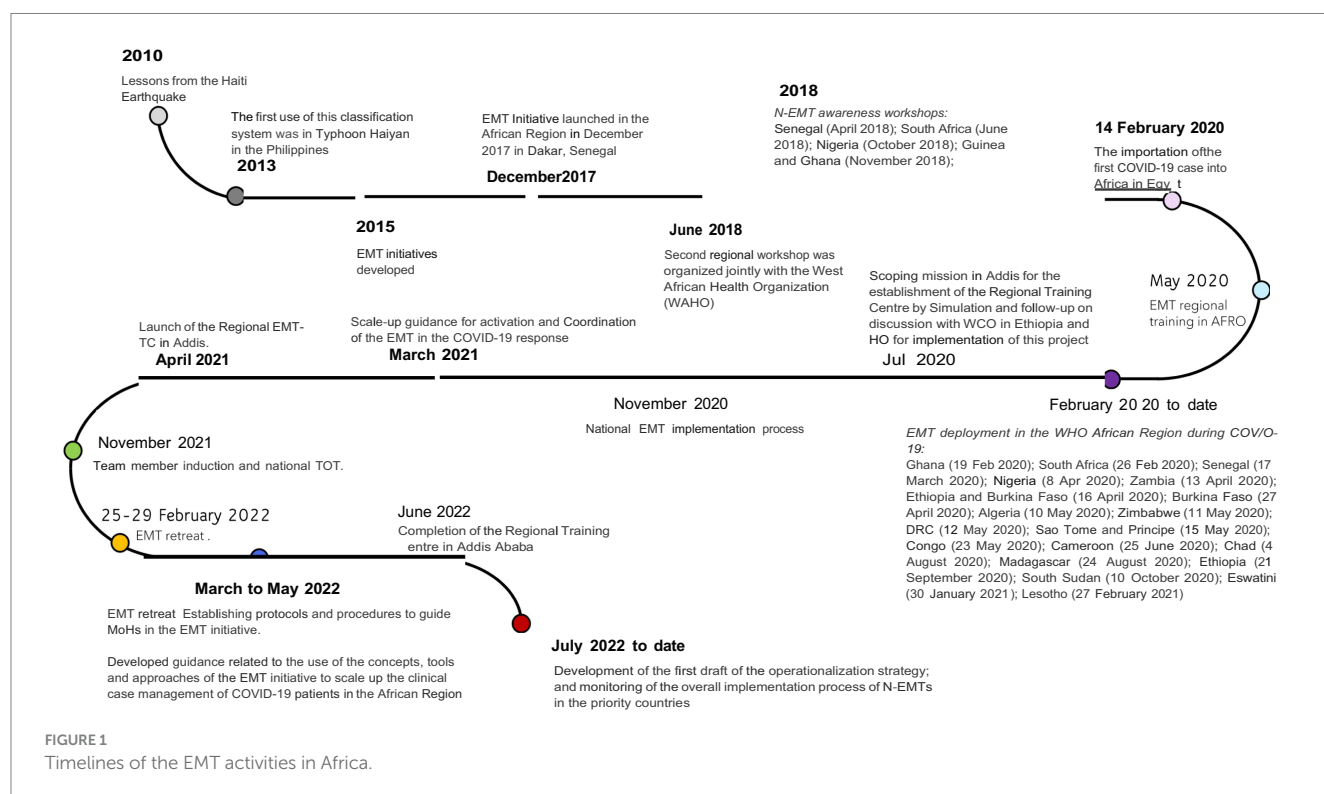
FIGURE 1
Timelines of the EMT activities in Africa.

example, some deployed EMTs stayed longer in certain countries during the peaks of different COVID-19 waves, facilitating coordination and development of guidance on using EMT approaches, concepts, and tools to enhance clinical case management. This also contributed to capacity building for the N-EMTs or teams working to reduce COVID-19 cases.

3.2.3 2020–2023: establishment of the regional EMT training centre and EMT training

Implementing and establishing self-sufficient N-EMTs that adhere to minimum standards, enhance staff capabilities, and ensure service provision has been a priority/vision for the EMT network. As such, the WHO established a regional EMT training centre in Addis Ababa, Ethiopia, which was inaugurated in 2021 and presented a remarkable opportunity to build and enhance in-country capacity and for use for capacity-building activities to complement countries' process towards developing N-EMT and promoted south-to-south cooperation and reverse innovation (42). The centre offers 10-step training for building N-EMTs, EMT induction training, and EMT field deployment training. These trainings have been organised in collaboration with WHO AFRO, WHO HQ EMT secretariat, and partnering I-EMTs. The centre has also been instrumental in drafting a functional chart of the proposed N-EMTs and setting standard operating procedures (SOPs) for the N-EMTs before and during deployments.

All 10 countries identified for prioritisation in the N-EMT programme (discussed in Section 3.3.1 and Figure 2) have completed the proposed training process. Additionally, countries like Malawi and Mali, which had not initially been prioritised to implement the

N-EMT, have also undergone training due to increased response needs (see Table 2). Furthermore, Ethiopia has had four deployments within the country to address issues such as malnutrition, drought, internal conflict, and international response efforts in Turkey and Chad. Senegal has similarly responded to emergencies in other countries, including the burn tragedies in Sierra Leone and the DRC.

3.3 Sustainment (competency): developing the who strategy and course of action for the future (2022 to date)

The creation of the N-EMTs and reinvigoration of the EMT concept in the region required an EMT strategy that would align with the other regional emergency programmes and conceive a futuristic vision for the EMT work in the region. To accomplish this, experts involved in various EMT initiatives, including classification, deployment, management, and research, convened at an EMT retreat in Brazzaville, Congo, in February 2022 to plan for the sustainability and advancement of the WHO strategy and future course of action. The proposed components for sustainability and governance orientations are outlined in Figure 3 and include the steps of creating N-EMT, developing the coordination structure, collaborating with partners, and finalising the N-EMT.

3.3.1 Implementation of N-EMTs in the proposed priority countries

The EMT retreat highlighted the need to establish N-EMTs by collaborating with governments to address emergency challenges, such

FIGURE 2
Priority countries for N-EMTs in Africa.
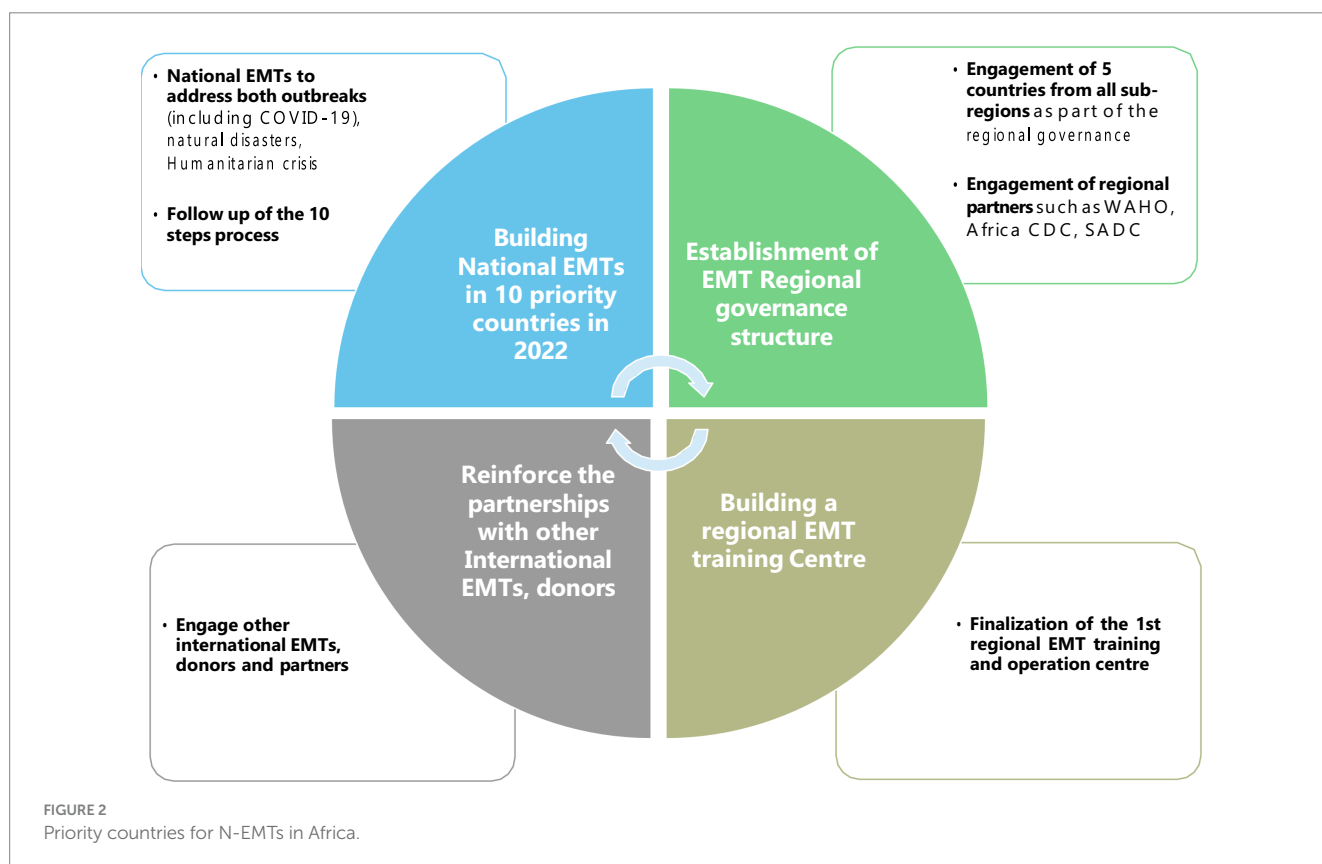
TABLE 2 Training that the countries have undergone.

Year	Month	Location	Course type
2020	May	Ethiopia	Team member induction
2021	December	Uganda	Team member induction
2021	December	Uganda	Training of trainers
2021	December	Namibia	Team member induction
2022	February	Ethiopia	Training of trainers
2022	March	Ethiopia	Team member induction
2022	March	Ethiopia	National EMT implementation workshop
2022	June	Ethiopia	Team member induction
2022	July	Ethiopia	Team member induction
2022	October	Mauritania	Team member induction
2022	November	Ethiopia	Massive afflux burns
2022	November	Togo	Team member induction
2022	December	Democratic Republic of the Congo	Team member induction
2023	January	Namibia	Team member induction
2023	March	Malawi	TM induction/cholera CM
2023	June	Malawi	10-step implementation
2023	January	Namibia	10-step implementation
2023	February	Botswana	Team member induction
2023	July	Uganda	Team member induction
2023	July	Uganda	Team member induction
2023	July	Uganda	Team member induction

as logistical challenges during deployment because different countries have specific differences (43). Ten countries [one in Central Africa (DRC), four in West Africa (Mauritania, Nigeria, Niger, Togo), two in East Africa (Uganda, Ethiopia), and three in Southern Africa (Botswana, Zimbabwe, Namibia)] (Figure 2) were prioritised for developing the N-EMT, and Senegal was chosen for implementing an I-EMT. Ethiopia was proposed as the location for the regional training centre.

3.3.2 Steps and roadmap for the development of N-EMT in the priority countries (10 steps for building N-EMTs)

Based on the consensus of experts at the EMT retreat in Brazzaville, Congo, and a two-step literature review process conducted by the team (44), WHO AFRO developed a roadmap to guide N-EMT development in priority countries. This roadmap was based on a curriculum developed by WHO HQ and lessons learned from African emergency response contexts. The steps included forming a core human resource team, training them, managing logistics, knowledge management, and demobilisation (Figure 4). These activities were piloted during the development of the first N-EMT in Ethiopia in April 2022. It was observed that there was variation amongst countries regarding the public health emergencies they face, their context, and the governance system needed to manage the steps. As a result, each country has been redesigning the steps based on its institutional capacity, support, types of public health emergencies, and implementation priorities.

3.3.3 Proposing the establishment of the regional EMT governance structure

In the abovementioned retreat, the team proposed a regional governance structure envisaged to comprise representatives from countries, partners, and WHO AFRO, as shown in Figure 5 (43). As conceived, it was envisaged that one country would assume a leadership role of ensuring EMT-related information would reach the right people in the countries and participating organisations. Each of the countries would rotate in the position yearly. Five countries (Botswana, Ethiopia, DRC, Mauritania, and Senegal) at an advanced stage in developing their N-EMT at the time volunteered to form the initial governing structure. The EMT representatives from the EMT regional groups were proposed to act as team leaders and the policy and technical focal points of the EMTs in both countries and organisations. It was envisaged and designed that the EMT Regional Group for Africa would facilitate how the countries would participate actively in driving the desire amongst other interested countries and stakeholders and drive the Initiative's implementation. It would act as a forum to discuss and formulate a regional work plan that would adapt the global objectives of the Initiative to the contexts of the region and countries. In addition, it would provide the strategic orientation of the Initiative. Partners (such as PCPM, MSF, ALIMA, IFRC, CADMEF, and WAHO) were proposed to form part of the key working groups. Other partners would be identified based on expertise and interest in the Initiative. The representatives of the partner would enhance the linkage of the partners and proposed regional groups and learn from their knowledge and experiences.

3.3.4 Working on a linkage between the EMT and other regional initiatives

In implementing the N-EMT, there has been a reflection on aligning with other regional strategies. For instance, through the collaborative project of the WHO AFRO and Africa CDC called the Emergency Preparedness and Response Flagship Initiative (45), the collaborative elements aim to work on Transforming African Surveillance Systems (TASS) Flagship Project, Strengthening and Utilising Response Groups for Emergencies (SURGE) and Promoting Resilience of Systems for Emergencies (PROSE) Flagship Project. The Initiative aims to build on existing systems and efforts such as EMTs, Field Epidemiology and Laboratory Training Programs (FELTP), and Public Health Emergency Operation Center (PHOEC) to achieve its overall objectives of timely response to emergencies, thereby mitigating catastrophic loss to infrastructure and resources and saving lives.

EMT initiative strengthens a resilient health system in the same spirit as the SURGE initiative, and integrating it as a component of the SURGE initiative helps to maximise the capacities, thereby bolstering the flexibility and independence of the countries' health system capacity to respond and control emergencies in a coordinated, integrated, effective and efficient approach utilising skilled, trained and equipped workforce. Additionally, the EMT initiative fosters knowledge sharing and strategic partnerships with other networks and partners targeted by the SURGE Flagship. Therefore, the EMT Initiative specialised modules must leverage the capacity of the AVoCH-SURGE core responders, who are provided with an additional and crucial operational arm. Additionally, the complementarity between Emergency Operations Centres (EOCs), Rapid Response Teams (RRTs), and EMTs in response to PHEs in the African context is key in enhancing response action; hence, it is a work in progress (43).

FIGURE 3
Proposed EMT strategic focus for the WHO African region in 2022. Source: adapted from the regional EMT strategic paper (43).
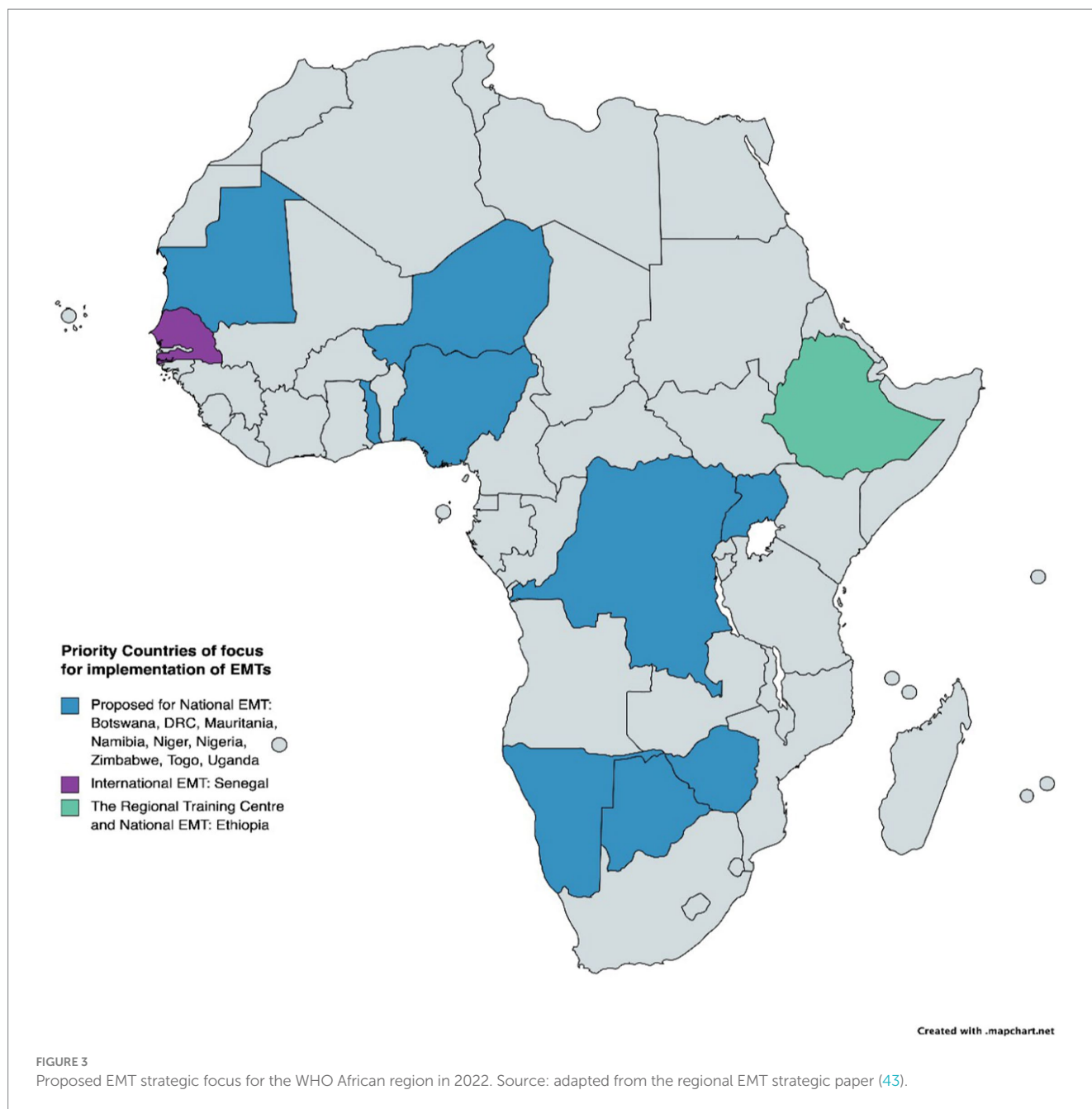
4 Lessons learnt

This section presents the lessons learnt from the journey of the EMT initiative in the WHO African Region. The results have been synthesised from document reviews and interviews and presented using components of a framework from Adini et al. (17).

4.1 Financing and operations supply and logistics (OSL)

EMT concept was perceived as being finance, supplies, and logistics-intensive beyond the capacity of many countries. During the initial workshops with the countries, when the concept was first presented,

most countries highlighted their inability to meet the financial needs of attaining self-sufficiency with the idea, which included purchasing the requisite equipment and maintaining an able team of human resources. Many of the countries, at the onset, suggested that it would have been better to have national teams that were able to respond to an internal emergency for which the governments did not have to spend extra costs as they are already on the government payroll. Despite these challenges, the region's focus has been on building national EMTs, though the need to attain self-sufficiency in technical and logistics capacity remains difficult.

> the countries … suggested … to have national teams … for which the governments did not have to spend on their salaries because they would be considered part of the employee. The concept was
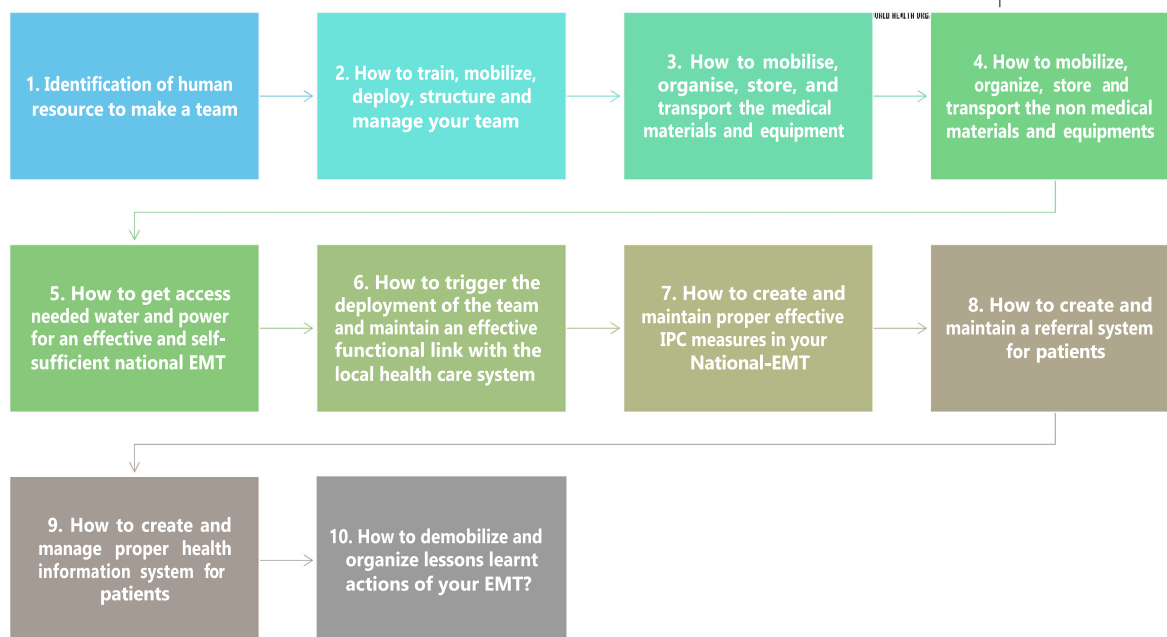
FIGURE 4
Roadmap for building N-EMT in the priority countries in the WHO African region.
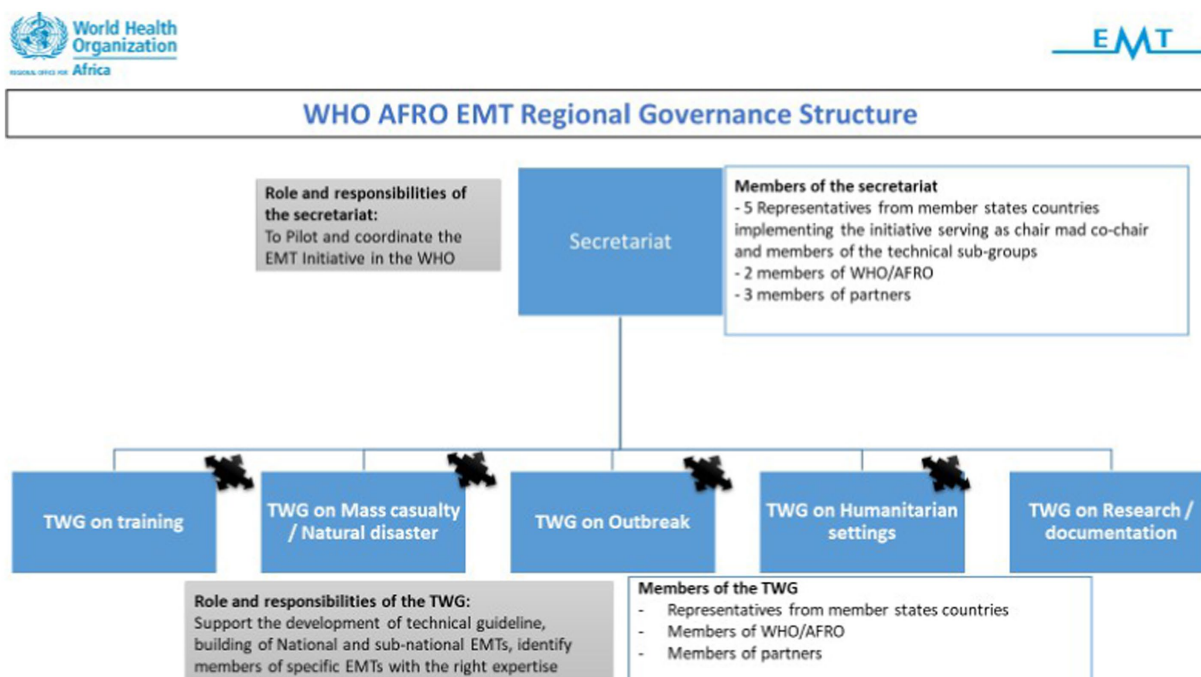
FIGURE 5
Proposed governance structure of the technical working group (TWG) of the WHO AFRO EMT initiative.

supplies and equipment intensive, and many governments could not commit payments to achieve it…. The concept of the EMT is yet to be part of the continent's culture. (Respondent 04)

Despite the perception of financing, the initial financial support (to the WHO AFRO for the concept) was a useful strategy because it provided the ability to work on the concepts, set up systems, and run

programmes with the countries. It brought confidence and autonomy in managing the EMT activities, such as the ability to hire personnel, e.g., a full-time consultant, whose full responsibility was implementing EMT work and ensuring continuity of the work.

4.2 Initiation and driving desire

Before the onset of the workshops, initial global training on EMT injected some desire into the EMT concepts, and countries were eager to join and learn. It brought an understanding of what EMTs are, which was quite useful. The initial concept was on the international classification of EMTs, which brought the idea of identifying two countries that wanted to join the international classification process.

> However, when the concept was initially presented to the countries at its onset, it was perceived as something from the West (i.e., the global north to the global south) akin to colonial medicine. (Respondent 04)

The concept involved an international/external team coming to different African countries to support emergency response and work with the country's counterparts. During the awareness workshops in the countries, the country teams often conflicted with many questions regarding whether they needed those teams to solve their problems.

Countries that took up the concept in the initial awareness workshops were convinced of their usefulness because of their level of preparedness and the desire to be better, but also because of the workforce that was convinced it would be better based on their resources. For instance, the Senegal Military was convinced that the concept would work because of their operational position and assets (such as aeroplanes and boats), making the work easier. Furthermore, at that time, someone was handling the PHEOC who was also quite positive and supported the creation of a good work dynamic. The Senegal army EMT, which was prepositioned at the commencement of the Initiative, picked it up well and has been working to respond to PHEs in the region. The army EMT concept has worked well because they are well equipped and have the government's support.

> In May 2022, Senegal's military emergency medical team carried out a drill, with support from WHO, to bolster its capacity and obtain international certification for high standard of emergency response…. If Senegal is successful, it will become the first African country to obtain international classification. [WHO AFRO Article (46)]

4.3 Planning, regional, and global collaboration

Conflict with other global and regional initiatives that were already or are trying to become well established. In Africa, most of the PHE are linked to outbreaks. From the lessons on the response to Ebola, an idea to develop a kind of outbreak-oriented EMT was brought forth, as the initial concept of the EMT was mainly focussed on handling natural disasters. This suggestion, however, was not as well received.

As the EMT concept/Initiative was being implemented, there was a perceived conflict with the other WHO AFRO initiatives, such as the proposed AVoCH-SURGE project. However, it was proposed that the two needed to be linked as they were perceived to serve the same function but with a different governance.

As the Initiative grows and there is a standardisation of activities, it would be imperative to bring in some of the diplomacy knowledge in the concept and include the support of the country's Ministries of Foreign Affairs because they play a key role in permitting the arrival of I-EMTs. The EMT concept, particularly in the region, is very geopolitical and requires a lot of tactical diplomacy, especially when there is the involvement of I-EMTs being deployed to the continent.

> For instance, because of the language and cultural practices, it is plausible for a country like Mozambique to work well with Angola because of language and shared cultural aspects. However, the deployment experience has shown that this aspect of pairing teams, considering cultural knowledge, may have been missing. For example, as a coordinating person leading the Initiative, it would be easy to tell Angola that they're not EMTs and should not come to Mozambique. However, the governments guided by their shared sanitary diplomacy would enhance the deployment. (Respondent 03)

The EMT values rely on standards and quality, which would be imperative to maintain; they bring uniformity about how responses are made, which is key. Strategically, strong regional leadership and expanded multilateral partnerships (such as with African CDC and African heads of state) will enhance countries' engagement and stronger implementation of the Initiative (47).

> The EMT has good standards … they bring uniformity about how [emergency] response is made … positioning the future of the EMT work may require the team to consider working with the African CDC, which is more independent and closer to the African heads of state, to implement the Initiative. Given that the challenge of the EMT initiative is funding-driven, working with a body closer to the countries will work well to ensure acceptability and the quick implementation of the strategy. (Respondent 05)

4.4 Human resource challenges and opportunities

There was difficulty changing the visions of the EMT to fit the context given the changes in the human resources. There was rigidity that the initial EMT concept, whose description was about the subheading, needed to remain as it was, yet there were challenges.

> For example, we wanted outbreak-oriented changes, but the new staff wanted to have type one, type two, and type three. (Respondent 01)

Consistent leadership is imperative to enhance the EMTs' work in the region. With consistent messaging and the deployment of different steps, today, we have many countries interested in the concept and funding their teams for training and development. These newer

country teams have been deployed regionally for further training in different countries and are even used to respond to local crises. For instance, Ethiopia has enhanced its national team with the government's support, which has even seen it being deployed and partnered with other international groups through intergovernmental support. On the other hand, teams such as Namibia have been used to respond to cholera outbreaks in Malawi.

4.5 Training programmes and exercises and contextualising the concept

Several outbreaks in the WHO African region bolstered the rollout of the EMTs. For example, the measles outbreak, Ebola, explosion, COVID-19. The first deployment was a team from Senegal supported and capacitated under visionary leadership. The Senegal team took up the lessons from the awareness workshop and rolled with it quickly. They developed the SOPs within a very short period and started EMT work. After that, following an explosion in DRC, they were sent to respond and even came with equipment and materials. The Senegalese team provided support for 6–7 weeks and trained the locals on basic management. It was the initial lesson learned that this type of deployment was possible. They also supported the response in Mozambique, Sierra Leone, and the Gambia.

The WHO Regional Office for Africa actively participated in global EMT activities to learn new ways of reshaping the EMT to fit the local context. For instance, amidst the response work, the team contributed to developing work through the blue book and other similar documents.

COVID-19 brought a new way of thinking in the EMT deployments and changed the concept to fit the thinking. With COVID-19 came more money and leadership keen to enhance the focus of EMT work. The outbreak also provided an opportunity to improve the deployments for teams in different countries. It further brought rise to the concept of developing a training centre, helped to advance the 10 steps of creating an EMT, and even supported the clinical and organisational management of the EMTs.

Timeliness is needed over perfection in the EMT work, particularly in the African Continent. Lessons from using the EMTs in the Ebola crisis showed that the I-EMTs would take too long to set up ideal triage settings meeting the standards set (for instance, they would do a working triage process and flow that would take 1 month to build). On the contrary, when the team hired local Africans to make a triage setup, it was set up in half a day using locally available materials, giving them more time to focus on working with the patients. There is a need for flexibility in how things are done.

It will be imperative to contextualise the EMT concept to consider our unique characteristics (language and culture) moving forward. The continent has a lot of capacity for science and medical expertise that can be leveraged to build stronger EMTs.

5 Discussion

This article describes the progress of the WHO African Region in implementing the EMT Initiative from 2015 to December 2023. It discusses significant milestones and challenges, offering valuable insights into the implementation process within the African context. The journey, guided by stages and actions based on the SIC framework, emphasises the importance of considering the specific context and global emergency response lessons.

Our results showed the origin of the global EMT concept and how the continent's challenges shaped the introduction of EMT in the WHO African Region. Furthermore, the results have shown the initiation of regional sensitisation workshops and country awareness campaigns on the concept and how the countries bought in the idea and agenda. There was a need to institute the EMT initiative in the region to enhance the timeliness of response and quality of service provided during emergencies whilst enhancing the national/country capacities to respond. Being a region experiencing more than 100 emergencies at any given time (48), with a lack of classified teams to timely respond to the different, in some cases context-specific challenges of the African countries, the WHO prioritised the African Continent as a prime for the EMT concept. In addition, the continent faces health emergencies yearly emanating from climate-related events (such as protracted droughts, calamitous floods, and cyclones), human–animal–environmental interface, and prolonged humanitarian crises (such as cross-border movements, internal population displacements, and mass refugee migration) (48–52) which the EMT concept was envisioned to help to respond to.

Furthermore, the study has shown that the initial phase (2015–2017) focussed on engagement, feasibility testing, and readiness planning, which highlighted the unique challenges faced by the African region and required a tailored approach to the EMT concept. The initial global EMT principles, which focussed primarily on trauma and surgical care for sudden-onset disasters (SOD), needed to be broadened, and the establishment of the WHO Health Emergencies (WHE) Programme provided a structured framework for the Initiative.

The EMT initiative faced several challenges during its implementation in the African region. The region's unique health system vulnerabilities, resource limitations, and the complexity of coordinating multiple stakeholders posed significant hurdles. In addition, the pandemic exacerbated the existing challenges to the fragile health system, coupled with multiple emergencies happening in most countries, and hampered the continuity of health services in the region (2, 53). However, these challenges also provided valuable lessons for future emergency response planning. The key themes identified from the implementation process include the importance of local context adaptation, capacity building, stakeholder engagement, and sustainable funding mechanisms.

The EMT initiative benefited from several outbreaks, such as Ebola and COVID-19, underscoring the importance of timely and flexible responses. The Initiative has demonstrated that local adaptations, such as using local materials for triage setups, can significantly enhance efficiency. This flexibility and local adaptation are also emphasised in EMT deployments in the Pacific region, where local practices and materials are often utilised to great effect (54). Adapting the EMT concept to fit local contexts whilst maintaining consistent leadership and messaging has been critical (55). Countries like Ethiopia and Namibia have successfully developed national teams with government support and have participated in regional responses. This highlights the importance of context-specific adaptation and

consistent leadership, similar to the experiences in South Asia, where consistent leadership and local adaptation have been key to successful EMT deployment (56).

The global training on EMTs initially injected enthusiasm into the concept, but some perceived it as an external imposition reminiscent of colonial medicine. Nonetheless, countries like Senegal demonstrated the concept's viability, leveraging their operational assets and government support to develop effective EMTs. This mirrors experiences where strong national support and pre-existing military structures facilitated EMT implementation (38, 57–60), and training programmes enhanced it (61). As such, the WHO African Region fortified the elements of the training by developing a training centre that was positioned to enhance and fortify the technical skills of regional EMT members, including the N-EMTs, provide specialised training and clinical care management (such as in managing severely sick and critical patients), initiate healthcare workers to enhance operational hands-on skills and act as an EMT innovation centre in the WHO African Region. At the onset, the initial training curriculum was envisioned to be developed with the support of the other WHO EMT networks, other WHO technical units, associated WHO collaborating centres, and members of academia.

Following the progress of the concept in the region, it has highlighted how the countries use the skills acquired to conduct regional and local deployments, which they use to enhance the development of skills and knowledge transfer. Furthermore, it has highlighted the development of the WHO AFRO strategy and course of action for the future, including establishing and prioritising the development of the N-EMTs, development of the roadmap of implementation, the proposed coordination, and the regional training centre as crucial elements of the EMT strategy in the region. These align with the aims and objectives of the global EMT 2030 strategy, which envisions a globe where every country can respond effectively and timely to national PHEs, leveraging on the regional and sub-regional capacities to help vulnerable communities and others in need but also strengthening information systems, evidence and research (62). The lessons learnt show a need to work on additional components that can improve the work. For instance, there is a need to establish a framework for collaboration with I-EMTs which is context-specific and diplomatically sound for the countries. Such a partnership would enhance the deployment and procurement modalities. In addition, working on the complementarity between other regional initiatives would be imperative.

From the lessons learnt, the EMT concept was perceived as financially and logistically intensive, beyond the capacity of many countries in the region. Initial workshops highlighted countries' inability to meet the financial needs for self-sufficiency, including purchasing equipment and maintaining human resources. Despite this, the initial financial support to WHO AFRO was crucial in setting up systems and running programmes, thereby building confidence and autonomy in managing EMT activities. Similar challenges have been observed in other regions where financial constraints hinder EMTs' sustainability (63, 64).

The EMT initiative faced conflicts with other regional initiatives, such as the AVoCH-SURGE project. Effective integration and collaboration with these initiatives and with bodies like the African CDC are essential for harmonised and efficient emergency response.

This is comparable to the European experience, where integrating EMTs with existing emergency frameworks has been crucial for success (65).

6 Conclusion

The EMT initiative in the African region from 2015 to 2023 has been a flexible and adaptive process shaped by global insights and regional obstacles. The engagement, feasibility testing, and readiness planning phases have highlighted the significance of tailored approaches and collaborative efforts to strengthen emergency preparedness and response capabilities. The journey of the Initiative has provided valuable lessons in financing, initiation, collaboration, human resources, and training. Each area has emphasised the importance of context-specific adjustments, robust regional and national support, and flexible, timely responses. Compared with experiences from other regions, these lessons demonstrate common challenges and strategies, highlighting the global relevance of these insights. As the Initiative moves forward, continuous learning, adaptation, and investment in local capacities will be crucial for establishing resilient health systems capable of effectively addressing future emergencies. Furthermore, the continuous refinement of the EMT initiative is crucial. Emphasis should be placed on strengthening local health systems, enhancing training and capacity-building programmes, and fostering regional and international collaborations. Additionally, sustainable funding and resource allocation are essential to ensure the resilience of EMTs in the African region and their long-term success.

Data availability statement

The original contributions presented in the study are included in the article/supplementary materials, further inquiries can be directed to BO oyugib@who.int and the corresponding author.

Ethics statement

Ethical approval was not required for the study involving humans in accordance with the local legislation and institutional requirements. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was not required from the participants in accordance with the national legislation and the institutional requirements. The participants provided their verbal informed consent to participate in this study.

Author contributions

TB: Funding acquisition, Resources, Supervision, Writing – original draft, Writing – review & editing. BO: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. J-JM: Data curation, Formal analysis, Writing – original draft, Writing

Publisher's note

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Competency in responding to infectious disease outbreaks among nurses in primary healthcare institutions: a quantitative, cross-sectional multicentre study

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Background: Nurses' competencies are crucial for infectious disease prevention and control. We aimed to investigate competencies in responding to infectious disease outbreaks of nurses in primary healthcare institutions and identify their training needs.

Methods: A cross-sectional study was conducted from June to September 2022, recruiting nurses from primary healthcare institutions across Sichuan Province. Their competencies and training needs were assessed using a modified Emergency Response Competency Scale for Infectious Diseases. Additionally, their sociodemographic characteristics and experience in infectious disease outbreak trainings were collected. Univariate analyses were used to compare competencies and training needs by participant characteristics. Multiple linear regression was conducted to identify determinants of their competencies.

Results: A total of 1,439 nurses from 44 primary healthcare institutions participated in this study. The overall competency and training needs had a median of 3.6 (IQR [3.1, 4.0]) and 4.0 (IQR [3.9, 4.7]), respectively. Age ($\beta = -0.074$, $p = 0.005$), experience in higher authority hospitals ($\beta = 0.057$, $p = 0.035$), infectious disease outbreak trainings attended within the last 5 years ($\beta = 0.212$, $p < 0.001$), and regions where the institutions located were determinants of the competencies.

Conclusion: The competencies in responding to infectious disease outbreaks among nurses in primary healthcare institutions were at a moderate level, influenced by varied factors.

1 Introduction

The prevalence of infectious diseases with pandemic potential has been increasing in recent years, which may develop into a global health threat due to the rapid spread of these diseases through cross-border travel and workforce migration (1). Despite significant efforts and considerable progress made in the prevention and control of infectious diseases, they continue to pose significant threats to public health systems and economies globally (1, 2). According to a report from the China Disease Prevention and Control Centre, the incidence of infectious diseases in China was 442.16 per 100,000 individuals, with a mortality rate of 1.57 per 100,000 in 2021 (3, 4). To effectively address the growing threats posed by infectious disease outbreaks to public health systems and economies, it is important to enhance the surveillance and response capacities of not only China but also public health systems worldwide (5).

As the cornerstone of public health systems, primary healthcare institutions usually bear the responsibility of early screening symptomatic patients, providing proper control of infectious diseases, ensuring safe transfers, and minimizing the requirement of hospital services as much as possible (6, 7). The capacities of primary healthcare institutions for response to infectious disease outbreaks become even more important when decentralized infectious disease prevention and treatment strategies are implemented to reduce access disparities in medical services (8). Actually, the capacities of public health systems for response to infectious disease outbreaks do not solely rely on contingency plans or equipment held by institutions. It also encompasses the preparedness of frontline healthcare providers, including their preparedness of skills, knowledge, and attitudes (9–11). Within frontline healthcare providers, nurses are usually the first responders to infectious disease outbreaks (8, 12). Therefore, their competencies in responding to infectious disease outbreaks are vital in preventing further transmission of infectious diseases and ensuring the safety and well-being of patients, healthcare providers, and communities as a whole.

Competency is defined as a combination of complex attributes of skills, knowledge, and attitudes, which enables individuals to perform tasks toward desired outcomes (13). To date, the competencies in responding to infectious disease outbreaks have primarily been discussed in the field of disaster nursing. In the core competencies in disaster nursing version 2.0 prospered by the International Council of Nurses (ICN), nurses are expected to possess eight competencies, including preparation and planning, communication, incident management, safety and security, assessment, intervention, recovery, and law and ethics (14). Previous studies have provided evidence suggesting that nurses' competencies affect nursing effectiveness when responding to disaster events, regardless of the varying levels of competencies observed in these studies (15, 16). Additionally, it has been believed that adequate disaster education and training will enhance nurses' competencies in responding to different disaster events (17). However, our understanding of the competencies in responding to infectious disease outbreaks of nurses in primary healthcare institutions is severely limited. On the one hand, most previous studies have focused on the competencies in disaster nursing for various types of hazards and have only briefly touched upon the competencies related to infectious disease outbreaks. Although these findings in disaster nursing may have some degree of relevance to infectious disease outbreaks, their applicability is generally limited and not clearly defined (10). On the other hand, while several previous studies have examined the competencies in responding to infectious disease outbreaks among

nurses (18, 19), they have not specifically demonstrated the competencies required by nurses in primary healthcare institutions. Additionally, few studies have reported the specific training needs required by nurses to improve the competencies when responding to infectious disease outbreaks. This is a significant gap in the literature because primary healthcare institutions play a crucial role in providing initial and fundamental healthcare services during outbreaks of infectious diseases, especially in resource-limited areas of developing countries.

Therefore, in this study, we aimed to evaluate the competencies in responding to infectious disease outbreaks among nurses in primary healthcare institutions, as well as to identify their training needs. The findings obtained from this study will provide valuable insights to healthcare institutions and policymakers, aiding them in improving the competencies in responding to infectious disease outbreaks among nurses in primary healthcare institutions.

2 Materials and methods

2.1 Study design

This was a quantitative, cross-sectional multicentre study.

2.2 Settings and sample

Participants were recruited using a multi-stage stratified cluster sampling method from June to September 2022 in Sichuan Province, western China. In the first stage, we divided Sichuan Province into five regions (the Chengdu Plain, Northeast, South, and Northwest region) according to the economic and geographic status, then, calculated the ratio of registered nurses in primary healthcare institutions located in these regions. In the second stage, the Probability Proportionate to Size Sampling (PPS) method was proportional to the size of nurses in primary healthcare institutions, which was used to randomly select nine cities from the five regions. In the third stage, the cluster sampling method of PPS was used to randomly select primary healthcare institutions from each city. The exclusion criteria were as follows: (1) engaging in advanced studies in any higher authority institutions during the investigation; and (2) taking maternity leave. According to the latest data from the Health Commission of Sichuan Province, the total number of registered nurses in primary healthcare institutions in Sichuan Province is approximately 74,849 (20).

The sample size was calculated using the following formula: $n = \left(\dfrac{Z_{1-\alpha/2} \times \sigma}{\delta} \right)^2$, where $Z_{1-\alpha/2} = 1.96$. Song et al. (21) previously reported that the competences in responding to infectious disease of nurses in tertiary hospitals were 128.05 ± 22.23. Thus, in this study, we set $\sigma = 22.23$, $\delta = 2$, and $DEFF$ was set as 2 due to the cluster sampling process. Based on these parameters, the initial sample size was determined to be 950. Considering an 80% response rate, the final sample size was adjusted to 1,188.

2.3 Measurement

The competencies in responding to infectious disease outbreaks were assessed using a modified Emergency Response Competency

Scale for Infectious Diseases (ERCS-ID). The ERCS-ID was originally developed by Liu et al. (22) based on the emergency response competency framework for infectious diseases introduced by Kan et al. (23). The original ERCS-ID includes three competencies: prevention, preparedness, and rescue competency. The preparedness competency includes two abilities: emergency planning and legislation. The rescue competency consists of six abilities: monitoring, reporting, medical response, public health response, risk communication, and response to specific circumstances. This original ERCS-ID totally comprises 36 items, with each item scored on a five-point Likert scale (1 represents "totally unknown" and 5 represents "very familiar"). The original ERCS-ID has good content validity and internal consistency with a content validity index of 0.870 and a Cronbach' α coefficient of 0.957. For this study, we removed the item on "Precautions for participating in international emergency rescues" as it was deemed impractical for nurses in primary healthcare institutions. The modified ERCS-ID consists of 35 items (see Supplementary Table S1). According to the criteria proposed by Liu et al. (22), scores below 60% are categorized as non-performance, scores between 60 and 79% indicate moderate performance, scores of 80% or higher denote proficient ranking, and scores of 90% or higher are considered at a distinguished level. In our study, the modified ERCS-ID demonstrated good internal consistency, with a Cronbach's α coefficient of 0.978.

The training needs of competencies in responding to infectious disease outbreaks were also evaluated using the same items of the modified ERCS-ID mentioned above using a five-point Likert scale. A score of "1" indicated "no need" and a score of "5" indicated "urgent need."

2.4 Data collection

Sociodemographic characteristics, including age, gender, marital status, educational years, professional title, monthly income, region, employment type, night work shift, and seniority were collected. Data on individuals' experience in infectious disease outbreak trainings were also collected. All data were collected via an online survey platform.[1] The online survey consisted of two parts: baseline characteristics and the modified scale on competencies in responding to infectious disease outbreaks, as well as training needs for these competencies. The survey commenced with a concise introduction outlining the purpose of the study, and participants were subsequently presented with an electronic written informed consent to review and sign. Upon completion of the consent process, participants were granted access to the survey. To maintain data accuracy, logistic check rules were implemented for each item, and an integrity check was carried out for the entire survey on the online platform.

2.5 Data analysis

Continuous variables were described using the mean ± standard deviation (SD) or median with interquartile range (IQR) depending on their distribution. Categorical variables were

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described using frequency and percentage. The Mann–Whitney U test and Kruskal–Wallis H test were used to compare the differences in the competencies in responding to infectious disease outbreaks and their training needs. Multiple linear regression analysis was conducted to explore the determinants of the competencies in responding to infectious disease outbreaks. The significance level was set at a two-tailed p value of 0.05. All statistical analyses were performed using SPSS v24.0 (Armonk, NY, USA: IBM Corp).

2.6 Ethics approval statement

This study adhered to the Declaration of Helsinki. Written informed consent was delivered to the participants online before investigation. All data were kept anonymous and used in this study only. This study was approved by the Ethical Committee of West China Hospital, Sichuan University (IRB:2020-1256).

3 Results

3.1 Baseline characteristics of the participants

Table 1 presents the baseline characteristics of the participants included in this study. A total of 1,439 nurses working in 44 primary healthcare institutions participated, with a median age of 29.0. The majority of participants were female (97.4%). Most participants were married (68.0%), held a primary professional title (77.2%), and had 10 years or more of working experience in current institutions (44.6%).

3.2 Competencies in responding to infectious disease outbreaks and training needs

Table 2 shows the competencies in responding to infectious disease outbreaks, as well as the training needs of the participants. The overall competency had a median of 3.6, indicating a moderate level of performance (72.0%). The competencies were ranked based on their scores as follows: prevention competency (median = 4.0, IQR [3.0, 4.0]), rescue competency (median = 3.6, IQR [3.1, 4.0]), and preparedness competency (median = 3.5, IQR [3.0, 4.0]) (Figure 1A). In term of abilities, response to specific circumstances (median = 2.5, IQR [3.0, 4.0]) and risk communication (median = 3.0, IQR [3.0, 4.0]) attained the lowest median scores. The median of overall training needs for the competencies was 4.0 (IQR [3.9, 4.7]) (Figure 1B). The training needs for each competency and ability were at a high level, with a median score of 4.0.

3.3 Relationship between competencies and training needs with sociodemographic characteristics

Table 3 presents the competencies in responding to infectious disease outbreaks and training needs stratified by participants'

TABLE 1 Characteristics of nurses in primary healthcare institutions ($N = 1,439$).

Characteristics	N (%)/Median (IQR)
Gender (female)	1,402 (97.4)
Age	29.0 (25.0, 35.0)
Marital status (married)	978 (68.0)
Education years	
≤12	117 (8.1)
12–16	1,320 (91.7)
>16	2 (0.1)
Ethnic minority (yes)	169 (11.7)
Professional title	
Primary	1,111 (77.2)
Intermediate	249 (17.3)
Senior	79 (5.5)
Monthly income (RMB)	
<3,000	426 (29.6)
3,000–5,000	792 (55.0)
5,000–8,000	205 (14.2)
>8,000	16 (1.1)
Region	
Chengdu plain	624 (43.4)
Northeast	329 (22.9)
South	208 (14.5)
Northwest	251 (17.4)
West	27 (1.9)
Employment type	
Contract labor	1,018 (70.7%)
Budgeted post	421 (29.3%)
Night shift (yes)	767 (53.3%)
Seniority	
<5 years	314 (21.8)
5–10 years	483 (33.6)
≥10 years	642 (44.6)
Experience in higher authority hospitals (yes)	740 (51.4%)
Experience in infectious disease emergency rescues (yes)	61 (4.2%)
Experience in other emergency rescues (yes)	88 (6.1%)
Number of emergency rescue training attended in the last 5 years	1.0 (0, 3.0)
Number of infectious disease emergency rescue training attended in the last 5 years	2.0 (0, 5.0)

characteristics. Participants who had experience working in higher authority hospitals scored higher competencies significantly (median = 3.6, IQR [3.2, 4.0] vs. median = 3.5, IQR [3.1, 4.0], $p = 0.002$). There were also statistically significant differences in competency scores among the participants from different regions ($p < 0.001$). In terms of training needs, no statistically significant differences were found among the participants when stratified by their general characteristics.

3.4 Determinants of competencies in responding to infectious disease outbreaks

Multiple linear regression analyses revealed that age had a negative impact on the competencies in responding to infectious disease outbreaks ($\beta = -0.074$, $p = 0.005$). Experience working in higher authority hospitals, on the other hand, had a positive effect on the competencies ($\beta = 0.057$, $p = 0.035$). In addition, the location of

primary healthcare institutions and number of infectious disease outbreak trainings attended within the last 5 years were also found to be significant determinants of the competencies ($\beta = 0.212$, $p < 0.001$) (Table 4).

TABLE 2 Competencies in responding to infectious disease outbreaks and training needs.

Dimensions	Competencies	Training needs
Prevention competency	4.0 (3.0, 4.0)	4.0 (4.0, 4.7)
Preparedness competency	3.5 (3.0, 4.0)	4.0 (4.0, 4.8)
Emergency plan	4.0 (3.0, 4.0)	4.0 (4.0, 5.0)
Legislation	3.5 (3.0, 4.0)	4.0 (4.0, 5.0)
Rescue competency	3.6 (3.1, 4.0)	4.0 (3.9, 4.8)
Monitor	3.3 (3.0, 4.0)	4.0 (4.0, 4.7)
Report	3.3 (3.0, 4.0)	4.0 (4.0, 4.8)
Medical response	3.5 (3.0, 4.0)	4.0 (4.0, 4.8)
Public health response	3.9 (3.4, 4.1)	4.0 (3.9, 4.9)
Risk communication	3.0 (3.0, 4.0)	4.0 (4.0, 5.0)
Response to specific circumstances	2.5 (3.0, 4.0)	4.0 (4.0, 5.0)
Overall	3.6 (3.1, 4.0)	4.0 (3.9, 4.7)

4 Discussion

In this study, we found that nurses in primary healthcare institutions possessed a moderate level of the competencies in responding to infectious disease outbreaks. Our findings indicated that these competencies were influenced by the nurses' geographical regions, as well as their experience working in higher authority hospitals, and the infectious disease outbreak trainings they had attended within the past 5 years. Moreover, this study had identified the pressing needs for further training to enhance the competencies in responding to infectious disease outbreaks.

In this study, we found that the competencies in responding to infectious disease outbreaks were at a moderate level. Compared to the investigation conducted in 2017 (22), there is a slight increase (7.5%) in the competencies in responding to infectious disease outbreaks. Previous literature has extensively documented the positive impact of experience and training related to disasters on nurses' competencies (17, 24, 25). Since the outbreaks of COVID-19, nurses working in primary healthcare institutions have received training in COVID-19 prevention and control, and have provided nursing care for patients with COVID-19 in clinical practice (26, 27). Their experience with the COVID-19 pandemic may help improve the competencies in responding to infectious disease outbreaks. However, within the dimension of rescue competency, abilities of risk communication and response to specific circumstances stayed at a relative low level. The findings indicate that nurses working in primary healthcare institutions struggle to effectively communicate important information about infectious disease outbreaks to the public.

FIGURE 1
Competency and training needs of nurses in primary healthcare institutions. **(1-A)** Score for competency of nurses in primary healthcare institutions; **(1-B)** Score for training needs of nurses in primary healthcare institutions.
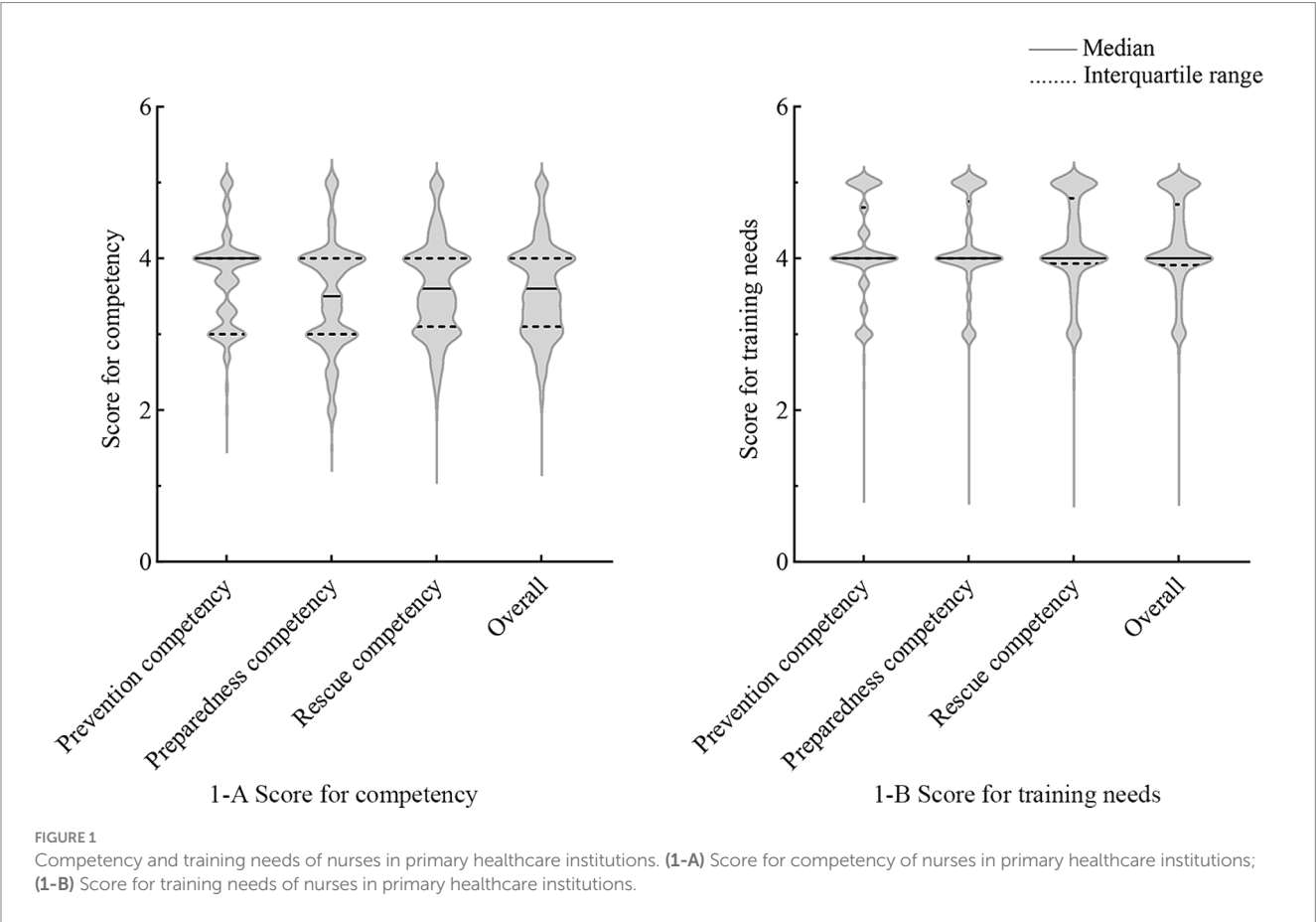
TABLE 3 Competencies in responding to infectious disease outbreaks and training needs stratified by general characteristics.

Variables		Frequency	Competencies	Statistics	*p* valve	Training needs	Statistics	*p* value
Gender	Male	37	3.7 ± 0.6	−0.598[†]	0.55	4.0 (3.7, 4.8)	−0.587[†]	0.626
	Female	1,402	3.6 (3.1, 4.0)			4.0 (3.9, 4.7)		
Age (years)	<30	748	3.6 (3.1, 4.0)	5.147[‡]	0.161	4.0 (3.9, 4.8)	4.163[‡]	0.244
	30–39	474	3.5 (3.1, 4.0)			4.0 (3.9, 4.7)		
	40–49	164	3.5 (3.1, 4.0)			4.0 (3.8, 4.5)		
	≥50	53	3.6 ± 0.5			4.1 (3.8, 4.8)		
Marital statues	Single	461	3.6 (3.1, 4.0)	−1.319[†]	0.187	4.0 (3.9, 4.8)	−1.374[†]	0.169
	Married	978	3.5 (3.1, 4.0)			4.0 (3.9, 4.7)		
Education years	≤12	117	3.7 (3.1, 4.0)	0.924[‡]	0.63	4.0 (4.0, 4.8)	2.021[‡]	0.364
	12–16	1,320	3.5 (3.1, 4.0)			4.0 (3.9, 4.7)		
	>16	2	3.5 (3.0, 3.5)			4.0 (4.0, 4.0)		
Professional title	Primary	1,111	3.6 (3.1, 4.0)	0.603[‡]	0.74	4.0 (3.9, 4.7)	2.587[‡]	0.274
	Intermediate	249	3.5 (3.2, 4.0)			4.0 (4.0, 4.7)		
	Senior	79	3.6 ± 0.5			4.0 (3.6, 4.6)		
Region	Chengdu plain	624	3.5 (3.1, 4.0)	21.502[‡]	<0.001	4.0 (3.9, 4.7)	6.930[‡]	0.14
	Northeast	329	3.5 (3.0, 4.0)			4.0 (3.9, 4.7)		
	South	208	3.7 (3.3, 4.0)			4.1 (3.9, 4.9)		
	Northwest	251	3.7 (3.3, 4.0)			4.0 (3.9, 4.8)		
	West	27	3.6 ± 0.2			3.8 ± 0.7		
Employment type	Contract labor	1,018	3.6 (3.1, 4.0)	2.194[†]	0.139	4.0 (3.9, 4.7)	0.595[†]	0.441
	Budgeted post	421	3.5 (3.1, 4.0)			4.0 (3.9, 4.7)		
Night shift	Yes	767	3.6 (3.1, 4.0)	−1.420[†]	0.156	4.0 (3.9, 4.7)	−0.817[†]	0.414
	No	672	3.5 (3.1, 4.0)			4.0 (3.9, 4.7)		
Seniority	<5 years	314	3.6 (3.1, 4.0)	3.093[‡]	0.213	4.0 (3.9, 4.8)	0.562[‡]	0.755
	5–10 years	483	3.6 (3.1, 4.0)			4.0 (3.9, 4.8)		
	≥10 years	642	3.5 (3.1, 4.0)			4.0 (3.9, 4.7)		
Experience working in higher authority hospitals	Yes	699	3.6 (3.2, 4.0)	−3.038[†]	0.002	4.0 (3.9, 4.7)	−0.244[†]	0.807
	No	740	3.5 (3.1, 4.0)			4.0 (3.9, 4.7)		

[†]Mann–Whitney U test; [‡]Kruskal–Wallis H test.

Additionally, they face challenges in responding to specific circumstances, such as pestilence caused by natural disasters, except for COVID-19. These two ability sets are notably below the benchmarks set by previous studies conducted by Li et al. (18) and Karnjuš et al. (28), who reported that nurses achieved scores surpassing 70% in the abilities of risk communication and response to specific circumstances. The disparity in these results could potentially be attributed to the varying proportions of nurses from tertiary hospitals and educational backgrounds. Therefore, it is imperative to improve the risk communication abilities of nurses working in primary healthcare institutions, enabling them to contribute effectively to the prevention and control of infectious diseases by disseminating key information to the public. Furthermore, this finding underscores the urgency to enhance the nurses' ability in these institutions to

respond promptly and effectively to specific circumstances arising from infectious disease outbreaks. To address this issue, simulation-based learning, which is widely utilized in nursing education (29), can be beneficial. This approach enhances the competencies by simulating specific scenarios of infectious disease outbreaks using virtual reality (VR) or augmented reality (AR). It would be particularly advantageous for nurses who have limited experience in handling infectious disease outbreaks. Moreover, this study found that the training needs for the competencies in responding to infectious disease outbreaks were at a high level, suggesting a long-term impact of the COVID-19 pandemic on nurses' sense of crisis in primary healthcare institutions.

In our study, we discovered that nurses from the South and Northwest regions demonstrated better competencies in responding to infectious disease outbreaks. These regions in Sichuan Province are

TABLE 4 Determinants of competencies in responding to infectious disease outbreaks.

Variables	Std. β	p value	Adj. R^2
Age	−0.074	0.005	
Experience in higher authority hospitals (yes)	0.057	0.035	
Region			
Chengdu plain	Ref	–	
Northeast	−0.003	0.916	0.064
South	0.064	0.024	
Northwest	0.092	0.001	
West	0.002	0.955	
Infectious disease outbreak trainings attended in the last 5 years	0.212	<0.001	

susceptible to natural disasters like earthquakes, debris flows, and landslides (30). Therefore, nurses employed in primary healthcare institutions in these areas may have more experience in disaster nursing, which could explain their enhanced competencies in responding to infectious disease outbreaks, as one aspect of disaster nursing. In this study, we also found that nurses who had experience in higher authority hospitals demonstrated better competencies in responding to infectious disease outbreaks. These results confirm previous findings (17, 24, 25) and suggest the importance of training to improve nurses' competencies in responding to infectious disease outbreaks. In China, training for nurses in primary healthcare institutions is particularly important due to the relatively weak quality of medical human resources in these settings. For example, our study found that only 0.1% of nurses hold a master's degree and 5.5% have a senior professional title, which is lower than national average level (31). No statistically significant differences were observed in the training needs, indicating the training for competencies in responding to infectious disease outbreaks reaches a consensus in all participants.

This study found that the competencies in responding to infectious outbreaks were influenced by several factors. Nurses' experience in higher authority hospitals and infectious disease outbreak trainings attended had positively impacts on the competencies in responding to infectious disease outbreaks. These findings are consistent with previous studies (17, 24). However, this study found that age was negatively associated with the competencies in responding to infectious disease outbreaks. In China, higher nursing education has gradually developed in the last two decades, resulting in younger nurses usually having longer education years and less clinical experience. This may explain the negative association between educational years and the competencies in responding to infectious disease outbreaks. However, the age of nurses is not strictly associated with the number of educational years due to the availability of continuous education programs. Further research is required to clarify the associations between age and the competencies in responding to infectious disease outbreaks. Furthermore, the present

study revealed that the South and Northwest regions exhibit favorable effects on the competencies in responding to infectious disease outbreaks, likely due to the nurses' extensive experience in disaster nursing within these regions. Consequently, it is imperative for managers and policy makers to acknowledge this regional disparity in competencies pertaining to infectious disease response. They should prioritize the implementation of evidence-based, competency-driven, and high-quality training programs for nurses employed in primary healthcare institutions situated in regions with lower competencies, with the aim of enhancing their competencies to a comparable level (32, 33).

This study has some limitations. First, due to feasibility concerns, the sample only included nurses from primary healthcare institutions in cities and towns. This may limit the findings' generalizability. Second, because this online survey does not allow for face-to-face communication to explain the meaning of each item, the content may be misunderstood. Third, the participants self-assessed their competencies so we have no way of knowing to what extent their self-assessment matched with actual competencies. In addition, this study was conducted following the COVID-19 pandemic. Due to the lack of prior knowledge about the virus, nurses had to rapidly learn and enhance their skills to respond to this novel infectious disease. In this process, nurses' competencies changed over time and may have been influenced by various factors, such as the quality of training, role assignments, and local conditions, which may introduce bias. Despite these limitations, the study found moderate competencies in responding to infectious disease outbreaks and identified factors that influence these competencies, and demonstrated the high training needs for the competencies in responding to infectious disease outbreaks in nurses working in primary healthcare institutions. In the future, studies adopting an explanatory mixed methods approach may be beneficial for further exploration of the experiences, competencies, and training needs of nurses in primary healthcare institutions when responding to infectious disease outbreaks.

5 Conclusion

This study discovered that the competencies of nurses in primary healthcare institutions in responding to infectious disease outbreaks were at a moderate level, which were influenced by varied factors. To enhance their competencies, professions could strengthen nursing education tailored specifically to infectious disease response and implementing simulation-based training. Furthermore, it is of paramount importance to consider regional differences in nurses' competencies when allocating educational and training resources in order to achieve overall improvement in the competencies of nurses across all primary healthcare institutions.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Ethical Committee of West China Hospital, Sichuan University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

WZ: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. JZ: Data curation, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. LY: Data curation, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. JL: Conceptualization, Formal analysis, Methodology, Resources, Supervision, Writing – review & editing. HG: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Resources, Supervision, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2024.1406400/full#supplementary-material

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Organisational learning from the public health response to the COVID-19 pandemic: findings from a qualitative interview study

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System learning from major incidents is essential for enhancing preparedness for responding to future adverse events. Sharing learning not only stimulates further improvements, preventing the repetition of mistakes, but may also promote collaboration and the adoption of evidenced-based best practises. As part of a qualitative interview study designed to explore lessons learned, this paper describes the experiences and perspectives of 30 staff from the public health agency responsible for the national COVID-19 response in the United Kingdom. The focus of the interviews was on enabling factors and practises that worked well, as well as those that were more challenging, and which, if addressed, could improve responses to future infectious disease incidents. The interviews elicited valuable insights across various thematic areas that could inform emergency preparedness activities for future infectious disease outbreaks. The outcomes of this study, while integral for the UK agency responsible for public health, extend beyond organisational boundaries and contribute to a broader spectrum of activities aimed at facilitating global learning from the COVID-19 response.

KEYWORDS

Organisational learning, learning from COVID-19, COVID-19 lessons, public health learning, qualitative phenomenological study, COVID-19, public health, major incidence

Introduction

In the realm of emergency preparedness, dissemination of learning is an integral part of knowledge management practises. It is widely assumed that learning from the experience of previous incidents can help to improve practise and minimise avoidable negative impacts in future emergencies (1–3). Given that the relative rarity of major emergencies provides few opportunities to learn from direct experience, it is particularly important to ensure that learning from real life major incidents is documented and disseminated to others (4, 5). Sharing limitations and practises that did or did not work well can stimulate further improvements, which may in turn prevent duplicating previous mistakes; likewise, sharing successful practises promotes global collaboration and the adoption of best methods for successful outcomes (2, 6–8). It is also widely acknowledged that true organisational learning from emergencies is not easily accomplished: similar recurring problems are often reported across multiple incidents and timespans (2, 4, 9, 10).

After being first identified and reported in December 2019, the novel SARS-CoV-2 virus spread globally, and the disease COVID-19 was declared a pandemic by the WHO on 11

March 2020. Many countries were not prepared to deal with a highly infectious respiratory pathogen, including those with health systems largely regarded as robust (11). The pandemic caused massive public health, economic and social disruptions across the globe, thus highlighting the importance of investing in pandemic preparedness.

According to the World Health Organisation (WHO) COVID-19 dashboard [WHO coronavirus (COVID-19) Dashboard] globally, there have been over 767 million confirmed cases of COVID-19 infection, resulting in nearly 7 million deaths. Worldwide, over 13 billion vaccine doses have been administered. In the United Kingdom (UK), from 3 January 2020, there have been over 24 million confirmed cases of COVID-19, resulting in over 227,000 deaths, as reported to WHO (12). Over 151 million vaccine doses have been administered to the UK's nearly 70 million residents (12).

During the height of the pandemic, like most health systems, the United Kingdom's National Health Service (NHS) was under extreme pressure: staff where exhausted, wards were overflowing, and waiting times for routine and emergency care rose by over 10 times, with most procedures being cancelled or postponed due to the systemwide focus on pandemic-related care (13). Patients reported waiting more than 12 h to be seen in Accident and Emergency (A&E) departments, the highest since records began.

As a Category 1 responder, Public Health England (PHE), the governmental agency responsible for public health preparedness and response, had legal responsibility to respond to emergencies under the (14, 15). As such, the agency was one of the key partners in the UK pandemic preparedness programme, and played a central role in the response to the COVID-19 pandemic.

Both the WHO and European Centre for Disease Prevention and Control (ECDC) have encouraged the sharing of learning and experiences from the COVID-19 response (11, 16, 17). An emerging literature base has published learning outcomes from intra- and after-action reviews (IARs/AARs) of COVID-19 responses from a variety of nations (18–20) and from localised settings including hospitals, refugee camps and cruise ships [e.g., (8, 21, 22)]. Gathering the experiences of the public health response to COVID-19 from a range of perspectives and contexts helps identify common challenges and factors that enabled successful responses, which, in turn, may help to strengthen global emergency preparedness and health response in the future.

The primary aim of this study was to understand processes that could help facilitate learning from Public Health England's (PHE) response in a major incident (MI). Two major objectives were set up to achieve this aim: first, to identify learning from PHE's COVID-19 response, and secondly, to explore how to facilitate the implementation of learning from the MI response in a public health organisation. The first of these two objectives is reported here: this study explores the experiences of staff from inside a UK national public health agency

(PHE) who were involved in the COVID-19 response, including their perspectives on enabling actors and practises that worked well (and thus should be maintained and enhanced), as well as challenges in the response and areas from which to learn for future responses.

Public Health England's (PHE) role in the COVID-19 response

Public Health England (PHE), an executive agency of the United Kingdom's Department of Health and Social Care (DHSC), was established on 1 April 2013 to provide leadership for health protection and improvement, including emergency preparedness and response. The formation of PHE came as a result of the National Health Service (NHS) reorganisation in England as outlined in the Health and Social Care Act (23). PHE absorbed the role of the Health Protection Agency (HPA), the National Treatment Agency for Substance Misuse and several other agencies (23). The agency was explicitly responsible for coordination of the response to public health emergencies, including an "integrated surveillance system" and "investigation and management of outbreaks of infectious diseases" (24).

During the COVID-19 outbreak, PHE played a crucial role in the UK's response to the pandemic. Key activities included: surveillance and monitoring the spread of the virus, including infection rates, hospitalisation and death rates; providing advice and guidance to healthcare professionals, policymakers and public on infection prevention, control, social distancing, testing and vaccination; setting up and managing testing and contact tracing facilities and the NHS Test and Trace System; working with local health teams to manage outbreaks in various settings, including care homes, schools and workplaces; and communicating vital information to the public about the virus and health protection measures. PHE was responsible for publishing weekly COVID-19 epidemiology surveillance summaries, which combined virology and mortality data from community, primary and secondary care to support national and regional planning in response to the pandemic. From April 2020, PHE collated daily reporting of the number of deaths in England where a positive COVID-19 test had been recorded (25).

In August 2020, the UK government announced the reorganisation of public health protection in England, leading to the abolition of PHE in March 2021. In October 2021, PHE's health protection functions were formally transferred into the United Kingdom Health Security Agency (UKHSA), while its health improvement functions were transferred to a number of other government agencies, including the Office for Health Improvement and Disparities (DHSEC), NHS England, and NHS Digital (26). The decision to replace PHE was reportedly due to the organisation's performance early in the pandemic, and challenges implementing measures to test, track, and trace the disease (27). This led initially to the establishment of NHS Test and Trace and the Joint Biosecurity Centre, which ran contemporaneously with PHE, until amalgamated into the UK Health Security Agency in October 2021.

Method

This phenomenological study design consisted of semi-structured interviews with a purposive sample from among Public Health England (PHE) staff involved in the COVID-19 response.

Ethical approval for the study was provided by PHE Research Ethics and Governance Group (PHE REGG R&D 427). Informed consent was obtained from all participants prior to the interview. Participants were informed of confidentiality, anonymity, and their right to withdraw from the study.

Participants

A purposive sampling method, with snowball sampling, was used to recruit study participants. This included PHE staff who were (a) involved in the COVID-19 response, and (b) in a position to participate in, or influence the implementation of, organisational learning identified from the response. Individual invitations to take part in the research included information about the purpose and procedure of the interviews. Individuals who were willing to participate then liaised with the research team to answer any further questions about the study and to schedule a suitable time for the interview.

Initially, 28 individuals (14 senior leads, 14 tactical leads) were identified based on their expertise and invited to take part in the study. A second wave of recruitment involved approaching additional key informants recommended by these initial participants because of their relevant experience and potential to contribute valuable insights. Out of 51 potential participants invited, only 30 were able to take part in the interviews. This number of participants satisfied the theoretical requirements for reaching data saturation in the phenomenological study (28). No further recruitment was conducted beyond this point.

Interviews

Semi-structured conversational interviews were conducted based on a topical guide and sought to explore the experiences and perspectives of participants. This approach is appropriate for a phenomenological study (29), which seeks to encourage participants to articulate their experiences openly and to avoid introducing too many prior assumptions or biases from the research team.

The interview topic guide (see Supplementary material 1) was developed by the research team and piloted with two agency colleagues to ensure that it was comprehensive, relevant, easy to follow, and clear. The guide included some potential questions to gather participants' background data, and some proposed open-ended questions separated into two main parts. In the first part, participants were invited to discuss their perceptions of the agency's COVID-19 response, including what they thought had and had not gone well, what they believed had impeded the most effective response, and what could have been improved or done differently. In the second part, participants were invited to discuss how they believed organisational learning from a major response could be facilitated. The topical guide for this second part was based on Kitson's model of organisational learning (30), which considers factors such as evidence gathering, actioning and facilitation of implementing lessons, and organisational context factors as central features of organisational learning (please see Supplementary material; Supplementary material 3 for additional information on Kitson's framework). At the beginning of the interview, participants were asked to describe their professional background, their usual role in PHE, and their role in the COVID-19 response. All

interviewees were directly involved in the COVID-19 response through their roles, with five holding various strategic roles and 17 in tactical roles. Eight colleagues had Emergency Preparedness Resilience and Response (EPRR) positions as their primary roles. The average length of their experience within their roles was 4 years, ranging between 0.5 and 15 years. All participants were in a position to contribute to the identification and implementation of learning from the COVID-19 pandemic.

All participants were provided with a Participant Information Sheet that explained the purpose of the study and the intention of the interview. They were also invited to reach out to the research team if they had any questions or concerns. Written consent was obtained from all participants before the interviews were conducted. No additional contact with interviewees took place before the interview.

Interviews, scheduled for approximately an hour, were conducted remotely using a videoconferencing meeting platform (Microsoft Teams) between July and November 2021, by a trained and experienced interviewer (DC), who was employed by the agency for this purpose as an independent researcher who had not been involved in the pandemic response. Thirteen participants completed the interview within the one-hour initial session, whilst 16 participants completed the interview across two hourly sessions. One interview was only partially completed, as the participant was unable to schedule a second session to complete it, however, the partial data was still included in the analysis. The mean interview length was 82 min (range 23–130 min). Interviews were audio recorded and transcribed verbatim. Due to technical problems, two interviews were only partially recorded and transcribed; these were included for analysis.

Data analysis

The transcribed interview data were thematically analysed using the following approach: (1) becoming familiar with the data; (2) generating initial codes; (3) searching for themes; (4) reviewing themes and (5) defining and naming themes (31). Analysis was conducted in the context of a sensitizing framework consisting of two pre-determined major themes: (i) enabling factors contributing to the organisational COVID-19 response, and (ii) challenges and barriers to an effective response. Within these two major categories, themes and sub-themes were generated inductively using open coding, allowing for as many codes as necessary to characterize the data.

To generate initial codes, three members of the research team were each randomly assigned three interview transcripts. Each researcher familiarised themselves with their assigned interviews and generated a list of codes to support the data analysis. The researchers then discussed identified codes together and generated an initial framework of themes and codes.

Full coding of interview data was then conducted using NVIVO V.11 software by FS, who is trained in qualitative data analysis. Coding was conducted inductively, using the explicit or surface meaning of the data, and allowing for codes to be adapted or added throughout the process as necessary to characterize the data. Once initial coding was complete, themes were explored and discussed with researcher ES. Codes were then reviewed and refined by FS to simplify the coding framework and identify emerging themes. Two researches (FS & ES) worked collaboratively to group the codes into descriptive themes and agree on appropriate theme names that accurately reflected the

content of each theme. FS identified relevant interview quotes to support each theme.

Coding reliability and validity were checked by an independent experienced researcher who independently applied the generated codes to three randomly selected interview transcripts. Excellent coding agreement was achieved for all codes across all three transcripts, with a mean Kappa of 0.997 (range 0.75–1.00), indicating a high level of agreement and consistency.

Major themes identified from the data are described below, and supported by relevant quotes from participants.

Results

The sensitizing framework for data analysis consisted of two main concepts: (i) enabling factors and (ii) challenges and barriers. Major themes within each of these concepts are described below in order of their prominence in the data and supported by participants' quotes. (Table 1, Supplementary material, Supplementary material 2 provides a summary of the major themes, along with the number of sources and references for each theme).

Enabling factors

Many themes within the 'enabling factors' concept had parallel themes within the 'challenges and barriers concept (see Table 1, Supplementary material; Supplementary material 2). Two key themes, however, were predominantly described as enabling factors: 'staff commitment' and 'scientific and technical expertise'. These themes are described in the sections that follow. Other key themes within the 'enabling factors' concept ('response co-ordination,' 'identifying and learning lessons,' 'communication and collaboration,' 'wellbeing and staff support,' and 'leadership') are described and contrasted alongside their parallel counterparts in the 'Challenges and Barriers' concept.

Staff & organisational commitment

Many participants praised the dedication and commitment of staff involved in the response. They highlighted their willingness to work hard, and to go above and beyond what might be expected of them, including working exceptionally long hours. Participants identified a significant presence of goodwill amongst their colleagues across the organisation, and noted that colleagues were committed to doing their best. This commitment also enabled resources to be redirected to the response (e.g., releasing staff and office space, and covering 'business as usual' roles).

> "…it's shown how many dedicated staff we have who are just willing to go above and beyond and work themselves tirelessly, …to support this" – Tactical Lead

Participants highlighted that the organisation was responding under difficult circumstances – both in terms of the unprecedented scale of the pandemic, and against a background of under-resourcing, political and social criticism, and wide-ranging uncertainty. Participants gave examples of how the organisation, and individuals within it, had risen to these challenges and demands, doing the best it could with what it had available. The fact that the organisation was

able to deliver the response despite these challenges was seen as a success.

> "I do believe that PHE was committed to doing the very best it could at that time, with all the challenges that we were presented with" – Senior Lead

Scientific & technical expertise

Participants noted the high-quality, globally recognised scientific expertise present in the organisation. Participants highlighted particularly important scientific work conducted by the agency, including serological studies, sequencing work to identify variants of the virus, and vaccine effectiveness studies. Some also praised the organisation's ability to provide high quality scientific and clinical advice, which informed policy and government guidance, which was valued and respected by policymakers and decision-makers. They also highlighted the contributions of data scientists and statistics experts, particularly in the development of new data sharing technologies (i.e., data dashboard) and contact tracing.

> "This has demonstrated our ability to provide the scientific advice and support which is required to inform national policy making in the pandemic. And that ability to synthesise data, produce guidelines, work with politicians has been phenomenal" – Senior Lead

Participants attributed these scientific and technical successes to the breadth of internal skills and expertise in the organisation. In addition, the organisation's pre-existing global scientific reputation enabled it to work with international collaborators to support its scientific work.

> "So, what I think has gone well is our ability to mine all the public health skills within PHE, whether those are data, epidemiological, negotiating and influencing, analysts, evidence, behaviour… because those skills were there, and those capacities and capabilities were there, I think we have made incredibly good use of them" – Senior Lead

Challenges and barriers

Human resource

Participants highlighted issues with staff capacity and under-resourcing in multiple functions and teams, as staff worked to provide the surge capacity needed to meet the demands of the response.

> "I think in terms of what's impeded the most effective PHE response in this outbreak has to be—one hundred percent—capacity, and the fact that we just do not have the staff" – Tactical Lead

> "…Years of just slashings in the public health budget meant that the capacity to do what needed to be done… it just wasn't there" – Senior Lead

Participants also highlighted the importance of ensuring the right mix of skills in the organisation, emphasising quality as well as

quantity. Some participants noted challenges in areas where there was a scarcity of skills and expertise, particularly specialist roles such as emergency planners, incident directors, and experts in areas like infectious diseases and genomics. There is frequently a national shortage of these highly specialised staff, making training and recruitment challenging. Participants emphasised the need for long-term investment in developing these skills to ensure that qualified staff are available when needed.

> "You cannot just pluck them off a tree and say, right, we are going to put some money for this purpose now, let us go and grab all these people. They're not there, because we have not developed them" – Tactical Lead

Others suggested that resourcing issues could have been improved by the organisation mobilising its existing skills and capacity more effectively. Better strategic awareness of the availability of skills, along with better awareness of where skills and resources were most needed, could have improved the response.

Resourcing challenges were also exacerbated by difficulties with staff recruitment and onboarding needed to meet the increased demands of the pandemic response. Participants noted that internal organisational delays in recruitment were a major barrier to scaling up the response, along with difficulties attracting candidates to roles with short-term contracts and unfavourable terms and conditions.

> "At every stage of the response we have been working on a short-term plan […] never had time to bring people in on longer term contracts so they have got stability, so we can attract better people to the roles" – Tactical Lead

Planning & preparedness

Many participants highlighted issues associated with planning, both before and during the pandemic. While preparedness plans were focused on influenza and high consequence infectious diseases (HCIDs), the specific details of the COVID-19 pandemic meant that these plans were not as applicable as they could have been. Participants identified the need for more generic, flexible pandemic plans which could be adapted to a wider range of potential pathogens, and which included the ability to respond to the unknown. Some participants suggested that more detail was needed in plans (e.g., standard operating procedures, governance arrangements, lesson reports from previous incidents), and highlighted the importance of not diverging from plans once they were set, changing strategically only when necessary.

> "We had a process in place for something which was called a high consequence infectious disease response developed as a result of Ebola, but I was concerned at the time, and I remain [concerned], thinking that that did not work as well as it should have done because it was very focused on the NHS care for a small number of highly ill people. […] and the flu pandemic clearly wasn't fit for the purpose of following […] so I think we had a sort of fundamental gap in planning strategy" – Senior Lead

> "We did not have a plan, other than our incident response plan […]. But a lot of the other stuff that we needed to have in place, like the

> community testing, these are all stuff that should be commissioned probably anyway, but have not been, historically. And so, they were having to start at a point of having very little or nothing in place" – EPRR

> "When we came to set up cells at the beginning of the response, there was a paucity of supporting information. It was a blueprint for the structures and some top line information on what different bits the response do, and the governance structures. But there was nothing beneath that" – Tactical Lead

Many participants also highlighted a particular gap in surge capacity planning that would be needed to meet the excess demand of the response (as discussed previously under the theme of "Human Resource"). Participants identified the need for greater reserve capacity, along with clear plans for how to effectively mobilise staff resources and urgently bring in additional capacity. They also emphasised the need for better workforce preparedness, ensuring that staff had sufficient skills and training to enable the organisation to respond effectively, including familiarisation with pandemic response plans. Some participants suggested that in the future, more staff in the organisation needed to be trained as Category 1 responders and Incident Directors.

> "We did not have staff trained, we do not have any mandatory training for Category 1 responders, despite the fact that we are all Category 1 responders, and could at any moment be asked to stand up and support any kind of response" – Tactical Lead

Other areas for improved preparedness raised by participants included network building (i.e., developing internal and external collaborative partnerships in advance), improved infrastructure (i.e., facilities, equipment, and technology), and plans for business continuity (i.e., arrangements for ensuring essential functions are maintained). Finally, participants suggested there was a need for greater commitment to future pandemic planning and preparedness, to ensure that the organisation could be better equipped to respond to future incidents.

Leadership & strategic response

Participants highlighted the significance of the overall strategic approach, direction, and high-level incident coordination, especially during the early stages of a pandemic. However, they noted that there were areas for improvement. Participants reported that they saw organisational leaders engaged in reactive and operational-level work, leaving less capacity to establish and maintain a higher-level strategic view. Others highlighted the importance of defined command and control structures, with clear lines of responsibility for various aspects of the response.

> "Certainly, for some time at the beginning […] I think everybody was, sort of, running around and being very busy. But that's my point, that you do need people to take a strategic view, and not everybody to be fully bogged down in operational issues." – Senior Lead

> "Allowing seniors to be freer to conduct some of that high level planning […]. I think that we needed a bit more of a structured objective and direction" – EPRR

Participants also highlighted the importance of transparency and accountability in decision-making, and clarity on how decisions are made and by whom, which was not as clearly present as they would have liked. Others felt that due process in decision making was important and should be followed, and that it seemed as if some individuals had undue influence on decision-making. Some participants noted that unsuitable directives resulted from instances where all relevant individuals were not involved in decision-making processes.

"I think […] there has been from the outset a lack of clarity about how decisions were being made. And it does feel that a lot of decisions were not made, [or] were made informally" – Senior Lead

"… expertise as regional directors [was initially not] really used as effectively as they could be, as part of the central coordinating core to help to shape policies that would be locally acceptable and locally relevant. So many times, it felt as though things were being designed … And then we were asked to implement, and then we said we cannot, because this does not make sense, it's not going to land well" – Senior Lead

Some participants also highlighted how important it was that leaders were aware of organisational operational activities and available resource capabilities, so that they could support strategic decision-making. Senior leadership engagement with front-line staff, both in terms of listening to staff needs and views, and explaining requests and decisions, was also highlighted as being important.

"I do not think even within the organisation there was sufficient understanding of what our capabilities were, what our capacity was […]. I do not think they, themselves, even knew what we could do, or we could not do" – Senior Lead

"So many times, when the decisions that are made, there's no concept of the operational implementation of that. And our teams have so often been left like, floundering and going, well, we have not got, what about this question, then? We're getting these questions. All the very predictable questions that you are gonna get with a policy change, and no one national has considered them" – EPRR

Participants also suggested that strong leadership was needed to manage the expectations of government and ministers, particularly concerning the organisational remit and resourcing. Good representation, both in terms of political and public visibility, was seen as important to ensuring the organisation could play its role as a nationally respected voice for public health.

"should have been the people that could turn around to the secretary of state and say, well not actually, PHE is completely under resourced for doing this […] If you want this, you are gonna need to be able to either pour some more resources into PHE or do something else about it" – Tactical Lead

Some participants provided examples of successful leadership and praised stand-out individual leaders. These leaders were noted as being engaged with staff, having a comprehensive understanding of

the response, and enabling effective strategic direction and response management.

Communication & collaboration

Communication and collaboration emerged as a prominent theme, reflecting challenges experienced both internally and externally, including with relevant partners and stakeholders (such as the NHS and other government departments). Participants suggested that there was a need for better connections between different functions and specialities within the organisation, to facilitate joined up working and ensure that different parts of the organisation communicated effectively with each other. Participants particularly highlighted a divide between regional and national functions, suggesting a need for better engagement with and between regions to help shape policies that were locally relevant, whilst also maintaining sufficient alignment and consistency between regions. Some participants also mentioned that different parts of the organisation did not have a shared understanding of priorities, leading to difficulties with cohesive working and suggesting a need for more effective top-down communication. Similarly, many suggested a need for stronger relationships and lines of communication with external partners, to ensure the public health voice was heard across the board, along with better shared understanding around where responsibilities for different aspects of the response lie.

"I think that the relationship with the regions was not strong enough, in the beginning of the response. In fact, well into the response. Again, I would say late summer 2020 is when that started to be focused on and, really, people concentrated on the working between the regions and the center and that's when that got better" – Senior Lead

"I think there is an issue around the internal communications. How we have communicated to our staff participating in the response. You know, what our priorities were, what we needed them to do" – Senior Lead

"There was very little good understanding of what, you know, what the entirety of Test and Trace were doing, and where the interactions and the interfaces were between PHE and Test and Trace. And whose responsibility was what, for certain things" – Tactical Lead

Where successful communication was noted, it was attributed to positive relationships, whether pre-existing or built during the response. These relationships enabled open communication and better understanding between collaborating partners. Strong command and control structures, along with clear roles and responsibilities, were also seen as facilitators of effective collaborative working.

Participants also highlighted the need for better information sharing, both internally and externally, and improving access to data and information. Participants highlighted the need for improved information flows, coordinated through a centralised, easily accessible system. Whilst the dashboard was mentioned as a useful information resource, and its development was seen as an aspect of the response that had gone well, it was noted that this was not available from the start of the incident and would have helped the initial response. In addition, there was a need for targeted and efficient information dissemination, with participants noting the burden involved in compiling and reporting information.

Coordinated information sharing could have reduced duplication and stopped routine information sharing when it was no longer necessary.

> *"I think certainly information flows, particularly at the beginning, were really, really difficult. Information wasn't necessarily coming through […] and also there was a lot of conflicting information, and information not necessarily making sense"* – Tactical Lead

Participants also highlighted the need for improved public communications and community engagement, which would have helped to develop public trust and ensure that guidance and recommendations are understood and accepted by the public. In addition, some participants highlighted how public-facing staff should have advance notice of any changes to guidance and should be equipped to handle queries from the public.

> *"Thinking about how we were engaging with communities […] the initial response was so biomedical, and so focused on testing and tracing rather than understanding and supporting communities to be part of the response."* – Senior Lead

Working conditions & welfare

Many challenges identified in this theme were due to under-resourcing (as earlier reported in the "Human Resource" theme). Many participants raised issues with staff being burdened with excessive workloads, regularly working excessively long hours. Significant concerns were raised about the impact of these pressures on wellbeing (e.g., high levels of stress, exhaustion), along with the impact on the quality of work when staff are overstretched, including the increased risks of mistakes being made or tasks being overlooked.

> *"I think the intensity of what people were working on and the hours that people were working was something that was a concern"* – Tactical Lead

> *"We end up going from one year to the next with senior people being desperately over-stretched. Working conditions that we would normally say would be very unhealthy and unthinkable"* – Tactical Lead

Other wellbeing challenges included the potential for traumatic exposure for some staff involved in the response (e.g., hearing about and giving advice on upsetting topics), and the impacts of the pandemic on life outside of work (e.g., relatives and friends who were shielding or seriously unwell from the virus, social isolation due to lockdowns). There were also reduced opportunities for face-to-face support due to working from home, and some staff faced challenges with working in a home environment (e.g., lack of space, childcare).

> *"The way in which we were all living and working presented many challenges to people on a personal basis […]. I mean it was a very, very stressful time"* – Tactical Lead

Due to these various welfare challenges, participants highlighted the importance of robust wellbeing support for staff. Many participants acknowledged the organisation's efforts to support the wellbeing of staff during the pandemic, particularly through encouraging a culture of peer support, and a good level of support provided by line managers and leadership. Participants also highlighted the important role of the wellbeing survey to monitor staff wellbeing, along with constructive messaging, signposting, and provision of wellbeing services. However, participants also suggested that there was a need to further improve support for staff, including both stronger wellbeing messaging and making formal welfare provisions available.

> *"I think one of the things that I feel that we have not done as well as we could is the mental health support to staff. I think staff have really, really struggled"* – Tactical Lead

Learning lessons

Participants raised areas where they felt the organisation could have better addressed lessons that had previously been identified, either from exercises or previous major incidents. Many noted that previously identified issues around staff capacity, deployment of skills, and training (e.g., from Ebola response) did not appear to have been implemented by the organisation as lessons learned. Several participants also suggested that easier access to lessons reports from the Ebola incident could have made setting up incident response structures and processes (e.g., response cells, SOPs, governance arrangements) more efficient.

> *"We should have taken on board learning from previous incident responses where we did have shortages of staff and we did have real challenges around resourcing […]. And that learning came out over and over again out of every incident response but was never really addressed"* – Tactical Lead

Many participants also thought that the organisation needed to do better at learning and implementing lessons throughout the COVID-19 response, although others believed that the organisation had learned and improved throughout the response. In particular, there was frustration that lessons were being raised and not acted upon in a timely manner, along with complaints about lessons not being shared or communicated across the organisation. Overall, participants generally felt that learning was inconsistent across the organisation, happening in some places but not others.

> *"We're gathering all of these lessons, but I do not know if we are waiting until the end with a massive list, or whether it might've been better to have regular small chunks that could be actioned now. And where are we getting updates? Where can we see that these have been taken forward, considered and put into action, and who's monitoring it?"* – Tactical Lead

The establishment of the lessons identified team in the early stages of the pandemic response was seen as a positive step forward to support organisational learning from the pandemic, and the lessons identified survey, mailbox, and debriefs were viewed as useful methods of capturing learning. However, the absence of pre-existing mechanisms to enable learning right from the start of the incident was viewed as a limiting factor. Others felt that there was insufficient resourcing of lessons identified team, which limited the capacity to deliver organisational learning objectives. Some participants also suggested a need for more engagement from senior leadership in the

lessons identified process and more buy-in from senior leaders to promote learning across the organisation.

"I think if we had anticipated the need for a live lessons process before, rather than trying to build it in flight, that would've made a huge difference" – Tactical Lead

"My personal opinion is that the needs of a successful lessons identified program were not fully appreciated. So, the resourcing of the team was not adequate to deliver what you would hope to deliver, or what we were being asked to deliver" – EPRR

Governance

Participants highlighted the need to improve incident-related governance structures and processes in the organisation, including: record keeping and decision logging; ensuring accuracy and consistency in information; and sign-off on guidance and communications. It was suggested there was a need for better oversight and accountability, with more clarity about who was responsible for governance: indeed, some participants suggested that governance arrangements of the response were too complex or opaque. Participants also felt that the organisation needed to improve its governance culture in general, with better commitment to good quality governance and understanding of governance issues.

"I think probably more understanding from the beginning about good governance …, and quality within one's own cell. But I think you can only really have that if people have a good understanding of governance and quality in their day-to-day job" – Tactical Lead

One particularly prominent area of concern was governance relating to risk management: participants raised concerns about staff needing to keep risk registers up-to-date, even during the response, as well as concerns about consistently recording adverse incidents and near misses.

Remit of roles & expectations

Multiple participants reported that key stakeholders and partners did not understand the purpose and role of the organisation within the national public health system. As result, participants reported that they were sometimes asked to do things that seemed not to be within the organisation's remit, whilst at the same time new government organisations were being established for activities which participants thought should have been within the agency's existing remit. In addition, some participants felt there was often a mismatch between the organisation's capacity and some expectations that stakeholders or policymakers had (e.g., testing capacity), resulting in reputational damage when expectations were not met. Participants suggested that the organisation needed to be more proactive and clear in articulating and communicating its purpose and capabilities, to ensure that its role in the response was understood by members of the public and others in government and the health system.

"There was a point where new organisations and teams were being established to do the work that we were supposed to do. And a converse was true, that because people did not know what we did,

they ascribed responsibility to PHE when it wasn't our responsibility" – Senior Lead

Incident coordination

Participants reported mixed views about incident coordination. Many participants felt that the response had been well-coordinated, and noted that the establishment of the National COVID-19 Response Centre (NCRC) and the formation of response cells played a vital role in coordinating the response. However, many other participants described challenges with response coordination. They reported that different parts of the response did not fully align with each other, resulting in lost efficiency, duplicated effort, lack of focus, and misunderstanding between functional teams. Participants suggested that improved planning and simple response structures, along with clearer command and control, would improve response efficiency and help maintain a consistent response structure throughout the incident. Where response coordination was seen as having gone well, participants emphasised the importance of having existing tried-and-tested plans and arrangements which could be implemented, whilst also highlighting the importance of flexibility and agility in adapting plans to meet unique or unexpected challenges.

"I would have wanted us, in retrospect, to just switch, an operational switch, and go, this is a really top-level response. Every part of PHE, this is now how it works" – Senior Lead

"One of the key things we need to learn is that arrangements for the response to outbreaks and incidents, however complex those outbreaks and incidents are, the arrangements for leading and coordinating the response should be as simple as possible. And I think the complexity of the response led to confusion, to duplication, led to misunderstandings, and also, in itself, sucked a lot of resources" – Senior Lead

UK government

Some participants felt that there was insufficient understanding across government of what was required for an effective response from a public health organisation, resulting in challenging decision making in some areas and accountability issues in other areas. These misunderstandings were seen as impeding an effective response, both for organisational operation decisions (e.g., resourcing, decision to re-arrange response structure) and for the broader pandemic response (e.g., delays to implementing lockdowns, border controls).

"I do not think you can dissociate [it] from the relationships that the response has had to have with central government and decision-making […]. So I think that's impeded… not so much the way PHE has done its work, but the sense of it being asked to do the right things. Or make sure that what its done is being used most effectively" – Tactical Lead

Some participants also reported the challenges of feeling unfairly blamed or scapegoated in the pandemic response. It was also felt that organisational demands were sometimes unrealistic, because organisational capacity was not sufficient to meet expectations. This

sense of unjustified blame had a negative impact on staff morale and caused reputational damage to the organisation.

UKHSA transition

Various participants noted that the transition from Public Health England (PHE) to United Kingdom Health Security Agency (UKHSA) was a disruptive challenge, adding to existing work pressures, because preparing for the transition generated additional work in an already resource-stretched environment. In addition, the transition generated uncertainty for staff, including concerns about job security, which further reduced staff morale and engagement, and led to concerns about staff recruitment and retention. Many participants thought the decision to transition from PHE to UKHSA during an ongoing major incident response was particularly challenging.

> *"I think the transition, the improvements that we are going to get out of the transition, and there are some, I think they could have been done without winding up an organisation and starting a new one. So, I think that's a major mistake. It's weakened our position; it's going to lead to a staffing crisis if we are not very careful"* – Tactical Lead

Discussion

The purpose of this interview study was to understand experiences of staff members from a national public health agency who took part in the COVID-19 response. The intention was to identify practises that worked well, and thus should be maintained and enhanced, as well as challenges that should be addressed to improve future infectious disease incident responses. Prominent enabling factors identified included staff commitment and scientific and technical expertise. Areas where challenges were reported included human resource capacity; planning and preparedness; leadership and strategic response; communication and collaboration; working conditions and welfare; learning lessons; governance; organisational remit; incident coordination; UK government; and the transition from PHE to UK Health Security Agency during the pandemic response.

The most prominent enabling factor was the dedication and commitment of staff, which allowed the organisation to rise to the challenges presented by the pandemic. This echoes previous findings from a mass casualty terrorist incident response, which reported similar attitudes and commitment from the National Health Service (NHS) staff who participated in the response (32). Thus, dedicated and committed staff appear to be an important asset to public health organisations and are an important enabler of a successful major incident response, and must be supported and encouraged accordingly. However, significant concerns were also raised in the present study regarding excessive workloads and staff being over-stretched during the pandemic, which has a potentially negative impact on staff wellbeing and on the quality of work. A recent study by Anchour et al. (33) conducted with NHS staff found a risk of losing significant staff capacity during extreme events if staff needs are not considered. While goodwill and dedication are central to the efforts of any public health system, public health organisations should be careful not to over-rely on the dedication and goodwill of staff, and should not consider these as a substitute for adequate resourcing.

Indeed, the most prominent challenge reported in the present study was limited staff capacity, due to chronic under-resourcing and a lack of surge capacity to meet the increased resource demands of the pandemic. Previous research has identified difficulties with surge capacity as a recurrent problem in responses to infectious disease outbreaks (6), and this issue has also been reported in other published literature on lessons from the COVID-19 pandemic (18, 19). In contrast, where adequate surge capacity was available at the start of the pandemic, this has been reported as a key factor in enabling an effective response (20). Given that the scale of the COVID-19 pandemic has required a greater public health resource commitment over a more sustained period than any previous major health incident, the COVID-19 response appears to have exposed a previously under-recognised weakness in the UKs pandemic preparedness. A priority recommendation, based on this research, is to strengthen surge capacity planning in the UK for pandemic and infectious disease responses. Other authors have suggested that public health responses should be reconceived as if they were a defensive combat response, meaning that public health organisations retain significant reserve capacity during 'peacetime' to allow for rapid expansion during an emergency (6). Our findings support this proposal.

Allied with this, another prominent challenge reported here was gaps in planning and preparedness, indicating a need for greater investment in pandemic preparedness. Previous research has also highlighted robust planning and preparedness, including comprehensive major incident plans and training, as a key factor in determining successful incident response and coordination (2, 7, 9, 19, 22, 34). Recommended areas for improvement in pandemic planning and preparedness based on this research include surge capacity planning, workforce training, and incident coordination structures, including appropriate governance arrangements. These findings also suggest that pandemic plans need to be able to be adapted for a wider range of potential public health scenarios. Addressing these issues with planning and preparedness should help to improve several other areas where challenges were reported, including mobilization of resources, strategic response, incident coordination and internal clarity of roles and responsibilities.

Various challenges were also reported regarding communication and collaboration, including internal collaboration; engagement with external partners and stakeholders; information sharing; and public communications. Challenges with communication are a common theme in the literature on lessons learned from a variety of different types of major incidents (2, 6, 8, 9, 18, 19, 21, 32). The recurrence of this problem points to the importance of effective communication in a MI response and suggests a general need for further research on optimising communication and collaboration in emergency responses.

Previous research has also identified leadership challenges as a common cause of difficulties in major incident responses, including: the need for clear direction from leaders; the need for clarity in leadership roles; and the need for clear command systems (6, 9). Examples of successful leadership were provided by participants in the present study. However, participants reported that strategic response leadership was a challenge to an effective response. This indicates a need for further development in these areas, and for more clear command-and-control structures. It is important to identify what characteristics a strategic leader needs: Davies and Davies (35) reported that strategic leaders have the ability to strategically orient themselves and their teams, are able to translate strategy into action, are able to align employees and the organisation to the strategy, are able to determine when an effective intervention would be deemed useful, and are able to help develop these same competencies in others.

Similarly, highlighting the significance of good strategic leadership within an emergency response environment, fundamental lessons identified from the work by Parker et al. (36) show that acting and responding swiftly is paramount, and that effective major incident (MI) leaders should be good communicators who are practical, adaptable, and who practise daily reflection. Whilst leadership challenges may be partly addressed by improvements in resourcing and planning, these findings also highlight the importance of leadership being transparent and accountable, engaging with staff, having robust organisational knowledge, and managing expectations.

In addition, the present findings highlighted the importance of effective governance structures and processes, along with a culture of governance to ensure that processes and procedures are followed. Previous research has also highlighted strong governance as crucial for supporting effective emergency response, and inadequate implementation of governance processes such as monitoring and auditing have been found to cause failure in incident response (8, 9, 19). There is a need for more commitment to good quality governance, along with training to ensure an adequate understanding of governance issues, particularly in risk management. Governance processes and culture should be strengthened outside of major incidents, to ensure that good governance becomes routine.

Consistent with findings from previous incidents, this study also emphasizes the importance of psychological wellbeing support for staff during major incidents (32, 37). Our findings indicate that some helpful support was available, particularly in the form of peer support, which has been previously identified as an important supporting mechanism to ease the negative impacts on staff emotional health and wellbeing, that can result from participating in a MI (37–39). Further reinforcement of psychosocial wellbeing provision for health organisation staff during MIs, including through improved access to appropriate training, resources and services, could improve the situation.

The present study reported mixed findings with regards to learning lessons from the pandemic response. Whilst there were some reports of organisational learning and improvement throughout the response, there were also challenges with implementation of lessons in a timely manner. Participants identified that inconsistent organisational learning was likely due to the pressures of the ongoing pandemic response, lessons not being shared across the organisation, and lessons identified from previous incidents and exercises having not being addressed. The establishment of a lessons identified programme from the early stages of the response was viewed as a positive step in enabling learning from the pandemic, and this initiative should be maintained and enhanced for future MIs. The translation of 'lessons identified' into 'lessons learned' is a widely recognised global problem, with recurring problems often being reported across multiple incidents. This demonstrates that learning from major incidents is not easily accomplished (2, 4, 9, 10). Furthermore, many of the challenges identified here, such as resourcing, communication, leadership, and governance, have also been identified as crucial factors for facilitating organisational learning from a MI response (4, 40–43). Based on the outcomes of this study, we suggest that addressing these challenges will not only strengthen organisational emergency preparedness to respond to future major incidents, but will also help reinforce appropriate context, structures, and mechanisms necessary for effective organisational learning.

The various challenges and enabling factors described in this study add to an emerging international literature base on learning from the COVID-19 response, by contributing the perspectives of staff from the UK's public health agency who were central to the national response. Much of the currently published literature on learning from the COVID-19 pandemic involves reporting outcomes from intra-and after-action reviews (IARs/AARs) following the WHO methodology (8, 17–22), whereas the present study involved one-to-one interviews with staff involved in the ongoing response. By taking a different approach, this study can supplement outcomes from IARs and AARs of the COVID-19 pandemic, and aid in triangulation of findings.

Strengths & limitations

In this phenomenological study exploring the perceptions and experiences of staff participating in a national COVID-19 response, the research team took steps to ensure that the research was conducted with a high level of rigour, especially since study aimed to explore the organisation within which they were employed. The research team also included experienced researchers from outside the organisation, for instance, and a researcher independent to the team helped add additional rigour to the coding process. The study had a relatively large sample size for qualitative research ($N = 30$), which provided sufficient data for the team to be confident in the analysis and results. The study captured the views of staff working directly on the pandemic response, and did so whilst the response was still active, hopefully reducing the risk of recall bias. The data reflected the apparent willingness of participants to provide thoughtful and critical responses, including their perspectives on their own missteps and problems in the response, showing that confidentiality and anonymity arrangements allowed staff to share their views openly and honestly.

As a phenomenological study, the present study relied on the self-reported experiences and views of staff involved in a national COVID-19 pandemic response. The study did not seek to include participants from other agencies or bodies included in the response who were external to PHE, and who may have different perspectives on the national response. The study researchers were also employees of or collaborators with PHE, and whilst steps were taken to ensure that the data collection and analysis were rigorous and thorough, and the interpretation and conclusions sound, this is a potential limitation of the study. A combination of purposive and snowball sampling was used to recruit the study participants. While this recruitment method allows for the selection of knowledgeable informants, it may potentially introduce selection bias. This study focuses on the UK national public health agency, which offers a specific organisational context. Applicability of the findings to other contexts and settings should be done thoughtfully and carefully.

Conclusion

Our paper reports experiences by the leading UK public health agency during the response to the COVID-19 pandemic, through a rigorously designed research study. The study identified unique challenges for PHE responders, as well as highlighting those identified during previous public health responses. The latter indicates that more work is needed to apply lessons previously identified, and this is reinforced by new data from the pandemic response. In addition, this paper provides a valuable perspective from the UK, contributing to an evidence base which is currently dominated by research from North America.

National capacity and capability to respond to infectious disease outbreaks is essential for the protection of public health. The present study portrays enabling factors and challenges in the public health

COVID-19 response based on the views and experiences of public health agency staff involved in the response. This study highlighted the importance of understanding staff experiences during a pandemic response, to address critical issues and facilitate a thorough post-incident analysis. Participants emphasised the importance of strengthening surge staff and planning capacity for pandemic and infectious disease responses, which will help meet the potential demands of future incidents, and the necessity of investing resources in timely learning from the response as well as the implementation of learning.

Sharing identified lessons is an essential element of learning from emergency responses and strengthening global preparedness for the future. However, given how challenging it is for organisations to truly learn lessons from emergencies, further work is required to explore how best to ensure that learning from the COVID-19 pandemic is translated into practise. In an accompanying paper (Southworth et al., Submitted) we continue to develop this dataset to identify strategies for facilitating the implementation of learning from the COVID-19 response. Learning identified and reported in this study can be used as first-hand evidence by a broader audience, including policymakers and public health practitioners, to inform global public health emergency preparedness efforts.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by the Public Health England's Research Ethics and Governance Group (PHE REGG R&D 427). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

FS: Formal analysis, Investigation, Visualization, Writing – original draft, Writing – review & editing. DC: Data curation, Investigation, Writing – original draft, Writing – review & editing. GR: Methodology, Resources, Writing – review & editing. RA: Conceptualization, Methodology, Supervision, Writing – review & editing. ES: Conceptualization, Data curation, Investigation,

Methodology, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2024.1411346/full#supplementary-material

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A Knowledge Management System for health emergencies: facilitating knowledge continuity and timely decision-making for frontline responders using experiential knowledge captured during action reviews

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1 Introduction

1.1 Knowledge failures during past public health emergencies

The COVID-19 global pandemic has further exposed a volatile, uncertain, complex, and ambiguous world (1). The pandemic heightened the importance of accessing, processing, and disseminating available critical knowledge to guide emergency response actions to events in dynamic and uncertain times. At the center of the COVID-19 pandemic crisis has been the crisis of knowledge failure which countries have been maneuvering to remedy (2). Knowledge failures are not unique to the COVID-19 pandemic; they have also been evident during responses to past public health emergencies including previous coronavirus epidemics [i.e., the 2003 coronavirus causing severe acute respiratory syndrome, SARS-CoV, the 2012 Middle East respiratory syndrome coronavirus (MERS-CoV)] (3) and the 2018 Ebola virus disease (EVD) outbreak in the Democratic Republic of Congo (DRC) (4).

1.2 Learning from past public health emergencies

Nonetheless, knowledge from past emergencies and epidemics facilitated a rapid response to the COVID-19 pandemic, especially in its early phases, in some countries. Countries adjusted their policies based on past crises, such as the EVD outbreak in West Africa, the cholera outbreak in Haiti, the MERS and SARS outbreaks, and the H1N1 pandemic (5). Countries used any available knowledge to adapt their responses to programmatic and operational considerations brought about by the COVID-19 pandemic. For example, the pandemic influenza preparedness and response plan, developed and implemented before the COVID-19 crisis, was decisive in early country-level responses (6).

Similarly, following a previous Ebola virus disease (EVD) epidemic in Guinea, the country relied on lessons learned and capacities developed during the previous outbreak in a subsequent EVD epidemic (7). In this article, we describe current learning practices from health emergencies, their shortfalls and propose a knowledge management system (KMS) to facilitate effective knowledge management (KM) and KM continuity for public health emergencies management.

2 Current knowledge management practices

2.1 Information management systems used in public health emergency management

Information management systems (IMS), which have been in use for several decades (8), are data collection platforms that generate information to "*support strategic decisions, monitor changes, prioritize action and allocate resources, manage programs, scale up or scale down operations, advocate and formulate concerns in relation to an emergency context*" (9). IMS can either facilitate or hamper health emergencies' management. During the COVID-19 pandemic, IT-based systems facilitated prediction, diagnosis, treatment, infection prevention and health services management without which the pandemic would be difficult to control (10). During the 2014–2016 West Africa EVD outbreak, the existing clinical case record form was too research-focused, aggregate outbreak data collection tools could not be used for individual patients and siloed and fragmented data systems could not integrate all IMS elements hampering EVD control efforts (11).

2.2 Learning tools used during public health emergencies: action reviews

The World Health Organization (WHO) supports Member States to conduct Action Reviews (AR) including early-action reviews (EARs) (12), intra-action reviews (IARs) (13), and after-action reviews (AARs) (14, 15) to learn from on-going or past public health events. An EAR is conducted soon after an outbreak's onset to find system bottlenecks and fix them to prevent escalation of the outbreak (12). An IAR is periodically conducted during a protracted emergency to review and revise where appropriate, response actions taken to control the on-going emergency (13). An AAR is a post-outbreak assessment of response actions to identify gaps and best practices associated with unfavorable and

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Abbreviations: AAR, after action review; COVID-19, Coronavirus disease 2019; DON, Disease Outbreak News; DRC, Democratic Republic of Congo; EAR, early action review; EVD, Ebola virus disease; EWARS, Early Warning, Alert and Response System; IAR, Intra-action Review; IHR, International Health Regulations; KMS, Knowledge Management System; MERS, CoV-Middle East respiratory syndrome coronavirus; NoK, "Nugget" of Knowledge; NoKs, "Nuggets" of Knowledge; SARS-CoV, severe acute respiratory syndrome coronavirus; VUCA, volatile, uncertain, complex, ambiguous; WHO, World Health Organization; 2009 H1N1, a type of Influenza A virus.

favorable health emergency outcomes, respectively, to inform future preparedness and response actions. An AAR, which usually includes all relevant stakeholders and potential funders to finance the implementation of high-impact easy to implement AAR recommendations, formulates practical recommendations that are integrated into national annual or multiyear strategies to improve preparedness for and responses to future public health emergencies (15, 16). During action review and tabletop exercises (DARTs) retrospectively review past actions during emergency response and prospectively analyze future scenarios of concern in a table top exercise that is informed by the retrospective review to assess readiness and resilience (17). There are documented reports of EARs informing emergency responses in Cambodia and South Sudan (18), IARs leading to actionable items that resulted in better emergency outcomes in the USA and Kenya (19, 20), AARs enhancing the performance of public health emergency preparedness systems in the USA and other settings (21, 22), and DART in Bangladesh identifying opportunities for further transdisciplinary expert collaboration in its one health approach to COVID-19 (23). A review of 46 studies on AARs that had only quantifiable impacts done by teams or individuals over a wide variety of settings showed that action reports/debriefs improved effectiveness of individual and team performance and potentially public health emergency preparedness systems performance over a control group by ∼25% (21).

2.3 Failure to capture tacit knowledge gained from past emergencies

Most countries conduct an AAR following a public health event and emergency (15). Inconsistent and unstandardized reporting systems limit the systematization of information gathered from AAR reports (24). AAR reports during the 2009 H1N1 pandemic, among other events, did not contain reflective root cause analyses of public health emergencies (24). Similar observations have been made by Becerra-Fernandez et al., who state that "...*action reports may not cover every issue that needs to be dealt with during an emergency, as frequently unique and unanticipated events arise during each emergency. Furthermore, people may leave the organization, due to attrition or retirement, and some of the informal rules that serve as the "glue" that affords the very ability to function may be lost*" (25).

The quest for documenting contextual and experiential knowledge from the response to emergencies was highlighted during the 2021 WHO-supported AAR of four EVD outbreaks in the Democratic Republic of Congo. Health officials present at the AAR expressed a desire to systematically collect knowledge from many of the 2,000 responders during the outbreaks between 2018 and 2020 who had already left the country and were not present at the AAR. One official succinctly reflected that: "*The knowledge they [responders] gained from the response would be valuable only if made easily accessible for the country to use and support national efforts to better prepare for and respond to future Ebola outbreaks and other emergencies, and to build overall capacities for emergency management in the country before it is 'lost' forever*" (26). Such knowledge is termed tacit knowledge. Tacit

knowledge includes mental models, perspectives, intuitions, know-how and experiences and is difficult to formalize or communicate. Conversely, explicit knowledge is conveyed in formal systematic formats that are easy to communicate such as databases, procedures etc. (27). Tacit knowledge, which is dependent on socialization and externalization (i.e., the number of meetings or discussions that could encourage knowledge flow), rapidly diminishes in situations (or organizations) that experience rapid changes in roles or positions related to a specific workflow process (28). The high turnover of responders during emergencies erodes institutional memory and limits countries' ability to maintain momentum in their response (29).

The lack of systems for the timely capture of knowledge, including knowledge gained through the lived experiences of responders, may lead to knowledge discontinuity and a vacuum where the knowledge is most needed, both within and between responses. However, knowledge continuity, together with the right personnel, can help an organization to rapidly adapt to external conditions beyond its control such as public health emergencies. Individual level factors like willingness to share knowledge influence knowledge continuity (30). While there are in-country efforts to facilitate knowledge continuity, global mechanisms for cross border knowledge sharing are yet to be established (15, 31). Should countries be viewed as an "organization" with the World Health Organization serving as a secretariat, and organizational factors such as organizational culture influencing knowledge continuity (32), the World Health Organization can support knowledge continuity via its knowledge culture (33–35). Although knowledge losses may occur when members of an organization are disconnected (28), the World Health Organization can use its convening power (32) to harness this experiential knowledge of emergency response personnel in globally accessible platforms.

3 A Knowledge Management System (KMS) to address knowledge discontinuity in health emergency preparedness

A knowledge management system facilitates organizational learning, retrieval and reuse of knowledge assets by instituting "*initiatives, processes, strategies, and systems that sustain and enhance the storage, assessment, sharing, refinement, and creation of knowledge*" (36). The World Health Organization is developing a KMS to facilitate knowledge continuity and timely decision-making using experiential knowledge emerging from action reviews (12–14). The proposed KMS will capture contextual tacit knowledge from front-line responders involved in a specific public health event and summarize them as "nuggets" or "digestible" content (small pieces of information). "Nuggets" of knowledge (NoKs) will be stored on a searchable platform powered by taxonomy and anthology, and other content management technologies to maximize its accessibility, retrievability, and reusability in other contexts to inform emergency responses. The KMS will complement existing incident command and management systems (37) or any response or knowledge management systems (38) being used by countries.

The KMS will have the following essential components listed below (39):

- People: the KMS secretariat (and other stakeholders) will work with all emergency responders who have been involved responding to past public health events who will be contributors and users of the knowledge harnessed. The KM platform will be initially managed by a WHO secretariat with plans to expand its management to multiple stakeholders who will also act as administrators with WHO retaining its secretariat role.
- Processes: Knowledge curation, codification and diffusion activities will be conducted to obtain NoKs. Moreover, process monitoring and evaluation activities will help measure knowledge flows.
- Content/technological resources: the NoK platform will be an open-source digital platform that will avail the right knowledge at the right time to emergency responders to support planning, decision-making and knowledge continuity. The platform will be an abridged version of lessons learned from past and protracted health emergencies. The NoK platform will facilitate learning from EAR reports (12, 40), IAR reports (13), and AAR reports (14, 15) among other knowledge resources. Knowledge captured will be garnered as "digestible" content (NoKs) within an accessible collaborative and interactive platform for countries and key responders.

  - NoKs generation will be tied to the World Health Organization's Disease Outbreak News (WHO DON) where WHO publicizes information public on acute public health events or potential events of concern (41). For non-infectious disease events, the activation of the Early Warning, Alert and Response Systems (EWARs) will trigger the plan to capture and generate some NoKs (42). Member States are advised (not required) to report all Action Reviews conducted under the IHR (2005) (43). Therefore, the plan to conduct an Action Review (EAR/IAR and AAR) will trigger the timely development of NoKs.
  - The WHO secretariat will either receive contributions from emergency responders working at operational or policy level, or interview subject matter experts to tap into their memories of past events, or invite voluntary contributions, or coordinate activities to generate NoKs like knowledge jams, or generate NoKs from action review reports and published literature. All submitted NoKs will be validated by reviewers who are in-country subject matter experts and emergency response personnel to address authenticity and liability concerns, respectively, prior to publication. All published NoKs will be reviewed on a regular basis prior to retiring them from the platform to accommodate for the volatile nature of knowledge if necessary.
  - The NoK platform will incorporate text, audio and visual NoKs which will all be open to the public who can anonymously access the client-facing platform to read published NoKs. However, users would need to register to

submit NoKs. Since this is an open-source platform, data will belong to Member States who can access it as often as needed.

- Knowledge management culture: the World Health Organization echoes the value of knowledge in attaining its mission (33–35) by supporting countries to conduct EARs (12, 40), IARs (44), and AARs (14) among other activities.
- Strategic vision: the strategic vision of the KMS that includes the NoK Platform aligns with the World Health Organization's vision, mission, objectives, strategy and approach in developing a KMS for public health emergency preparedness.

The proposed KMS, illustrated in the KM Action wheel (45) shown in Figure 1, encompasses the creation of NoKs, the capturing of NoKs on the platform, the validation and enhancement of NoKs, the management of Noks on the platform, and the retrieval and reuse of NoKs.

4 Discussion

4.1 A Knowledge Management System as a critical incident registry for public health emergency preparedness

Piltch-Loeb et al. (24) proposed the use of a Critical Incident Registry for Public Health Emergency Preparedness to address the ongoing knowledge losses in public health emergency management. Critical incident registries could help facilitate learning from public health emergencies by disseminating lessons learned from previous (and possibly ongoing) public health emergencies and translating these lessons to new incidents or new settings (24). The proposed KMS for health emergencies will build on the concept of critical incident registries proposed by Piltch-Loeb et al. (24) (Figure 2) to address existing knowledge losses in public health emergency management in a country from one outbreak to another.

The KMS will focus on public health emergencies which the World Health Organization defines as situations that have an immense impact on the health and lives of many people which require extensive intervention by multiple sectors (46) (**Element 1**). The KMS will employ a predominantly qualitative approach to probe how and why things happened, including knowledge "jams," key informant interviews and action reviews (EARs, IARs, and AARs) (47) (**Element 2.1** and **3.1**). The KMS will harness NoKs from action review reports that have been prepared by health emergency front-line responders who were involved in a specific emergency response (**Element 3.2**) and structure them "digestible" content ("nuggets", i.e., small pieces of information; **Element 2.1 and 2.2**) in a searchable platform using various categories (**Element 2.3**). The "nuggets" will be categorized based on IHR core capacities and technical areas in the recently published WHO Benchmarks for strengthening health emergency capacities (31) (and other taxonomy, including the emerging pillars highlighted in the COVID-19 pandemic pillars as key priorities by the WHO to control COVID-19, a.k.a.,

the COVID-19 pillars (48), as well as taxonomy covering the time, space, and persons/populations affected by an emergency) which are "meaningful" for the identification, evaluation, and notification of events and for responding to public health risks and emergencies (**Element 3.1**) (49). The categorization of NoKs will facilitate the identification, retrieval, evaluation, and linkages amongst events to provide insights for responding to public health risks and emergencies based on life-saving decisions taken in different contexts. Information will be listed on the NoK platform only after rigorous scrutiny and validation to ensure that it is specific enough (in terms of people's mix, e.g., multisectoral and multidisciplinary collaborations; purposes, e.g., repurposed or downcycled; and processes, e.g., unconventional, or innovative processes, places, or contexts), to elicit specific responses (**Element 3.3**).

4.2 Prospects of the Knowledge Management System

The evidence-based KMS will serve a learning hub for public health practitioners, policymakers, and the broader community by providing "bite-size chunks" of information to limit the information overload experienced by emergency response personnel during crises when they need to make "*accurate decisions, under time-pressured and intense situations*" (50). The KMS will allow countries to access and turn knowledge from past public health events into assets that they can harness at any time.

Additionally, the Nok platform has significant potential to leverage technologies such as artificial intelligence (AI) in resolving knowledge discontinuity and maintaining "living" memory and knowledge in emergency management (51). AI can be used in different KM processes. AI can be used for predictive analytics and natural language processing when obtaining knowledge from different sources during knowledge creation, to structure knowledge using various ontologies and present knowledge in various formats during knowledge classification, organization, storage and retrieval, and to integrate siloed systems and permit real-time smart-sharing of knowledge and interactive feedback during knowledge sharing. Furthermore, AI could facilitate knowledge application by using context-tracking mechanisms to detail intermediate processes through which information moves from data mining to knowledge discovery to business rules with a view to avail situated (contextual) knowledge to the right person at the right time (52, 53). All data generated using automated algorithms will be moderated prior to dissemination on the NoK platform (54).

Given cultural, political and other different dynamics within countries and the potential reluctance in information sharing between countries, countries should first strive to develop in-country knowledge management and knowledge continuity practices to maximize in-country contextual learning (30). For instance, information collected in after action review reports could be gathered in a database of reports, to connect past experiences to future improvements (22). Secondly, countries could share permissible knowledge across countries to facilitate peer-to-peer learning (15, 31).

FIGURE 1
A knowledge management action wheel for the NoK Platform for health emergencies. The WHO echoes the value of knowledge in attaining its mission by supporting countries to conduct action reviews to learn from responses to real-life emergencies. Walh (45) propose a knowledge action wheel to ensure KMS enable specific actions and results. The proposed KMS, will build on routine learning processes to facilitate learning the reuse of experiential knowledge from health emergencies based on processes in the KM action wheel proposed by Walh (45). Adapted from: Walh (45).

1. Scope of critical incidents should include public health emergencies regardless of their nature, size, and duration.
2. Characteristics of the registry
   2.1. Format of the incident report: summary, context, incident description, and an analysis of the emergency preparedness system's response to the incident.
   2.2. Brevity: includes only pertinent details.
   2.3. Searchability: should be searchable by type of event, contextual factors, and emergency response capability.
3. Analytical framework and approach
   3.1. Uses tools that can produce meaningful and actionable insights after investigating interactions between contextual factors and the mechanisms employed to respond to an incident and the roles these interactions played, for instance a mixed-methods approach.
   3.2. Draws on the experience of frontline practitioners with ''insider'' knowledge of how a specific public health emergency preparedness system functions helps to provide insights about mechanisms.
   3.3. Addresses specific public health preparedness capabilities as well the relationship between capabilities.

FIGURE 2
Elements of a critical incident registry. Piltch-Loeb et al. (24) propose the use of a Critical Incident Registry for Public Health Emergency Preparedness, that has been used in the aviation industry, to address the ongoing knowledge loss in public health emergency management. The proposed KM aims to allow countries to access and turn knowledge from past public health events into assets that they can harness at any time. The proposed KMS will employ elements of a critical incident registry proposed by Piltch-Loeb et al. (24) to address existing knowledge losses in public health emergency management in a country from one outbreak to another. Adapted from Piltch-Loeb et al. (24).

5 Conclusion

A growing body of literature acknowledges that learning health systems are robust health systems (55). Stoto et al. refer to AARs without learning as "box-checking" exercises (21). Therefore, as health systems recover from COVID-19 and other health emergencies, it is imperative that aggregated findings and lessons learned from EARs, IARs and AARs of COVID-19, or other public health events, are captured and used as the foundation for active learning practices to avoid the "panic-then-forget" cycle of emergency response (56). Such knowledge will prevent emergency responders from "re-inventing the wheel" during each subsequent emergency and support countries to build sustainable capabilities for emergency management. Ultimately, the proposed KMS platform seeks to have a far-reaching impact on the emergency management cycle by supporting knowledge continuity in countries for broader global health security.

Author contributions

LM: Writing – review & editing, Conceptualization, Writing – original draft. BB: Visualization, Writing – review & editing. AM: Writing – review & editing. EB: Writing – review & editing. CV: Writing – review & editing. LV: Writing – review & editing. SC: Conceptualization, Writing – original draft, Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Training experience is an important factor affecting willingness for bystander CPR and awareness of AED: a survey of residents from a province in Central China in 2023

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Background: Bystander cardiopulmonary resuscitation (CPR) and the use of automated external defibrillators (AEDs) may improve survival in patients with out-of-hospital cardiac arrest (OHCA). The purpose of this study was to investigate the effect of CPR training experience and sociodemographic characteristics on bystander CPR willingness and AED awareness.

Methods: In this study, a questionnaire survey was conducted among 3,569 residents in central China. Descriptive statistics, multiple linear regression and multivariate logistic regression modeling were used to investigate the effect of training experience and sociodemographic characteristics on knowledge of cardiac arrest first aid, awareness of AEDs, and willingness for bystander CPR.

Results: Of the 3,569 participants, nearly 52% were female, 69.6% were < 23 years old, 23.5% had CPR training and 22.1% had witnessed OHCA. Characteristics of increasing bystander CPR willingness included CPR training experience, male, witnessed OHCA but not acting, knowing whether family members have cardiac disease, older age (>40 years) and lower level of education. Farmers were the subgroup with the least awareness of AED and knowledge of first aid.

Conclusion: In China, CPR training experience was an important factor in improving bystanders' CPR willingness, AED awareness and knowledge of cardiac arrest first aid. Additionally, having witnessed OHCA also had a positive effect on bystander CPR willingness.

KEYWORDS

out-of-hospital cardiac arrest, cardiopulmonary resuscitation, automated external defibrillators, training experience, questionnaire survey

Introduction

Cardiac arrest (CA) is a sudden loss of blood flow caused by a sudden stop in the heart, which often leads to death if left untreated within minutes (1). Out-of-hospital cardiac arrest (OHCA) is a common time-critical disease that occurs in the out-of-hospital environment (2) and is also a major public health problem that causes a large number of

deaths worldwide (3). The most common OHCA occurs in the patient's home, and the patient's family members often witness the occurrence of the event (4). According to observational studies, 5 million people worldwide suffer from OHCA every year, and only 7% of them survive (5, 6). Therefore, an increasing number of scholars have begun to focus on how to improve the survival rate of patients with OHCA.

Bystander cardiopulmonary resuscitation (CPR) is one of the key links in the survival chain of OHCA patients, nearly doubling the chances of survival (1, 7–9). Moreover, studies have shown that bystander CPR not only increases the survival chances of OHCA patients (7–10) but also has a positive impact on the prognosis of patients with good neurological status (11, 12). Therefore, many organizations that focus on improving survival advocate the use of extensive community education and training initiatives to increase bystander CPR rates and OHCA survival rates (3, 13). In addition, the use of automated external defibrillators (AED) also has a positive impact on the survival of patients in OHCA (14–16).

However, the initiation of CPR and AED is not optimal (14, 17, 18). In Europe, medical students need to not only improve their knowledge about CA and CPR but also incorporate AED training into mandatory courses (19). In addition, Asians have lower AED usage than white participants (20). Therefore, scholars from various countries have begun to explore how to improve the CPR rate and AED utilization rate in various countries through more effective training (14, 21).

To increase the prevalence of bystander CPR, intervention targets need to be identified (22). However, limited research has been done on the relationship between the type of bystander witness and bystander CPR initiation (22). A recent study in Singapore (22) and Japan (23) demonstrated that the witness type was associated with CPR initiation and OHCA outcomes. In China, little is known about the characteristics of those trained or willing to act when witnessing an OHCA. However, such information is useful to training providers, policy makers, and researchers for identifying coverage of training campaigns (14).

Therefore, the purpose of this study was to investigate the impact of sociodemographic characteristics, CPR training and witnessed OHCA on willingness for bystander CPR, first aid knowledge scores for CA, and awareness of AEDs. Based on this, the characteristics of bystanders' CPR willingness were explored to further effectively improve the survival rate of OHCA patients.

Methods

Study design

This is a cross-sectional study on the willingness for bystander CPR, AED awareness and CA first aid knowledge among residents in a province in central China. This study was conducted from May to July 2023 and approved by the Biomedical Research Ethics Subcommittee of Henan University (HUSOM2023-457). Informed consent was obtained from the respondents. In this study, 3,800 online questionnaires were randomly distributed to residents of a central province by using social media, and 3,569 qualified questionnaires were finally collected.

Data collection and variables

The inclusion criteria of the respondents were as follows: (1) residents of a province in central China and (2) independently completed the questionnaire. The exclusion criteria were as follows: (1) medical staff and (2) incomplete content. The content of the questionnaire was from the mature questionnaire-*Investigation on public knowledge and attitude toward first aid for cardiac arrest* (24), and the author's consent was obtained. The questionnaire consisted of three parts: social demographic characteristics, cardiac arrest first aid knowledge, first aid attitude and training needs. Questionnaires were distributed and recovered to the respondents through the Questionnaire Star platform. After collecting the questionnaire, the data were exported in Excel form, collated and analyzed by two people after checking and confirming that the content was correct.

Bystander CPR was defined as CPR attempted by a bystander prior to arrival of the emergency medical services team, which included both telephone dispatcher-assisted CPR and bystander-initiated CPR (22). Bystander CPR willingness was defined as the respondents' self-reported willingness to perform CPR when witnessing an OHCA. In addition, the CA first aid basic knowledge included identifying the most common place of cardiac arrest and the recognition of cardiac arrest. The CA first aid operational knowledge included five questions: phone 120 when CA occurs, chest compressions position, chest compressions frequency, chest compressions depth, and chest compressions importance. The questions of cardiac arrest first aid knowledge were multiple choice questions, with only one correct option, and the other three were all wrong options. For each correct answer, one point was scored, and the wrong answer was not scored. Therefore, the CA first aid basic knowledge was full of 2, the CA first aid operational knowledge was full of 5, and the total CA first aid knowledge was full of 7. The basic mastery of cardiac arrest emergency operational knowledge was defined as the score of CA first aid operational knowledge ≥ 3 and basic mastery of first aid knowledge of cardiac arrest was defined as the total score of CA first aid knowledge ≥ 5 (24).

Sociodemographic characteristics included sex, age, level of education, occupation, whether they were family members of cardiac patients and whether they had witnessed OHCA. 'Yes, and acting' was defined as having participated in bystander CPR when witnessing OHCA; 'yes, but not acting' was defined as not participating in bystander CPR when witnessing OHCA. The sex of the respondents was categorically defined as male and female. Age was grouped into one of three categories: below 23 years old, 23–40 years old, and over 40 years old. The educational level was classified as high school or below, universities (including junior colleges), and graduate degree or above. Occupation was classified as school students, employees of enterprises and institutions, workers, farmers, and others (self-employment and retirement).

Statistical analysis

Descriptive analysis was conducted to examine the distribution of categorical and continuous variables. The categorical variables were presented as numbers and percentages. Normality of the continuous variables was assessed using the Shapiro–Wilk test, and variables that conformed to a normal

distribution were presented as mean and standard deviation, while non-normally distributed variables were presented as median and interquartile range. In this study, the continuous variables that conform to the normal distribution were presented as mean and standard deviation. For 11 categorical variables, Pearson's chi-square test was used to assess the frequency of sociodemographic characteristics. For the three quantitative data points of the CA first aid basic knowledge score, CA first aid operational knowledge score and CA first aid knowledge total score, ANOVA was used to assess the concentration trend of sociodemographic characteristics. In addition, multiple linear regression was used to analyze the association between the CA first aid knowledge score and sociodemographic characteristics. Moreover, logistic regression analysis was used to evaluate the association between AED awareness, bystander CPR willingness and sociodemographic characteristics. SPSS 25.0 software was used for statistical analysis, and a p value <0.05 was used to determine statistical significance.

Results

Table 1 presents the characteristics of 3,569 participants. The response rate of this study was 93.9%, and 231 questionnaires were excluded due to incomplete content. More than half were female (51.9%), nearly 70% of the participants were < 23 years old (69.6%), and most were school students (67.6%). Most had education at the university level (75.4%). A total of 17.5% of the participants indicated that they were family members of cardiac patients, 6.3% had witnessed OHCA and acting, and 15.8% had witnessed OHCA but not acting. In addition, the table also shows the demographic characteristics of participants (23.5%) who had experienced CPR training. Significantly more male, participants who witnessed OHCA and acting, those aged 23–40, graduate students and above, and family members of cardiac patients reported that they had participated in CPR training. There was no significant difference by occupation.

Most participants knew that cardiac arrest most often occurred outside the hospital, at home (39.0%) and in public places (39.6%). Among them, subjects aged 23–40 (41.4%, $p < 0.001$), employees of enterprises and institutions (45.1%, $p < 0.001$), and family members of cardiac patients (52.6%, $p < 0.001$) were more likely to find that the most common place of cardiac arrest was at home. More than half of the participants correctly recognized cardiac arrest (54.9%), and those with university education (including junior college) were more likely to correctly recognize cardiac arrest (57.0%, $p < 0.001$; Supplementary Table S1).

Among the five questions of phone, position, frequency, depth and importance, the subgroups with the highest accuracy rates were > 40 years of age, who witnessed CA but not acting, who trained in CPR, who witnessed CA and acting, and who trained in CPR ($p < 0.05$ for all; Supplementary Table S2).

Figure 1 shows that the highest accuracy rate is for phone 120 and start chest compressions (Figure 1C), followed by CA recognition (Figure 1B) and chest compression importance (Figure 1G; average above 50%). The accuracy of identifying the most common place of CA at home (Figure 1A), the chest compression location (Figure 1D), the chest compression frequency (Figure 1E), and the chest compression depth (Figure 1F) ranged from 25 to 50%.

Overall, the average score of basic knowledge score and operational knowledge score is less than half, the subgroup with the highest basic knowledge score is 0.99 points (out of 2.00) for employees of enterprises and institutions, and the subgroup with the highest operational knowledge score and total score is 2.73 points (out of 5.00) and 3.67 points (out of 7.00) for personnel who have trained in CPR. The three lowest subgroups were all farmers, with knowledge scores of 0.81, 1.76 and 2.56 ($p < 0.05$ for all; Table 2). Figure 2 shows the scores of each group under the occupational category, with farmers showing significantly low scores.

Most people had heard of AEDs (68.3%), but only a small number had seen AEDs (28.4%). The subgroup with the least heard of and seen AED remained farmers (36.6, 11.5%, $p < 0.001$), the subgroup with the most heard of AED was those who had participated in CPR training (76.8%, $p < 0.001$), and the subgroup with the most seen AED was those who had witnessed CA but did not participate in first aid (57.3%, $p < 0.001$; Supplementary Table S3; Figure 3).

Only a small number of people were willing to participate in first aid (22.6%), and the main reason for reluctance to participate in first aid was fear of imperfect operational skills (53.5%). The subgroup with the strongest desire for first aid was those who had been trained in CPR (44.9%, $p < 0.001$; Supplementary Table S4).

Among the basic factors, education level and family members of cardiac patients were significant predictors. Regarding operational knowledge, education level, family members of cardiac patients, and CPR training experience were significant predictors. Among the total knowledge, sex, education level, family members of cardiac patients, and CPR training experience were significant predictors (Supplementary Table S5).

Those who had experienced CPR training were more likely to have heard of (OR: 1.755) and seen (OR: 2.374) AEDs. Those who had seen OHCA were more likely to have seen AEDs (OR: 3.819). Families of cardiac patients were more likely to have heard of (OR: 2.063) and seen (OR: 1.483) AEDs. Compared to self-employed and retirees, school students were more likely to have heard of AEDs (OR: 1.479), and farmers were less likely to have heard of (OR: 0.422) and seen (OR: 0.489) AEDs. Male were less likely to have heard of AEDs (OR: 0.641) than female but were more likely to have seen AEDs (OR: 1.291; $p < 0.05$ for all; Supplementary Tables S6, S7).

A multivariate logistic regression equation was constructed by including CPR training experience, sex, age, and education level. The results showed that the willingness of participants who participated in CPR training to participate in first aid when witnessing OHCA increased by approximately 3 times (OR: 4.348), which was the most important factor. In addition, male (OR: 1.438), having witnessed OHCA (OR: 1.516), being a family member of cardiac patients (OR: 1.463), and education level of high school and below (OR: 1.612) also had a positive effect on increasing bystander CPR willingness. ($p < 0.05$ for all; Table 3).

Discussion

The main findings of this study were as follows. First, the influencing factors of bystander's CPR willingness included CPR training experience, bystander sex, age, education level, family members of heart patients and witnessed OHCA. Second, training experience was an important factor in improving bystanders' CPR

TABLE 1 Sociodemographic characteristics (*N* = 3,569).

Variables	Total, N(%)	Trained in cardiopulmonary resuscitation, N(%)	
		Yes	No
Total, N(%)	3,569(100.0)	838(23.5)	2,731(76.5)
Sex			
Male	1715(48.1)	456(26.6)	1,259(73.4)
Female	1854(51.9)	382(20.6)	1,472(79.4)
χ^2 (*P value*)		17.761(<0.001)	
Age group, years			
<23	2,484(69.6)	604(24.3)	1880(75.7)
23–40	645(18.1)	169(26.2)	476(73.8)
>40	440(12.3)	65(14.8)	375(85.2)
χ^2 (*P value*)		22.191(<0.001)	
Educational level			
High school or below	708(19.8)	135(19.1)	573(80.9)
Universities (including junior colleges)	2,691(75.4)	653(24.3)	2038(75.7)
Graduate degree or above	170(4.8)	50(29.4)	120(70.6)
χ^2 (*P value*)		11.926(0.003)	
Occupation			
School students	2,414(67.6)	582(24.1)	1832(75.9)
Enterprises	384(10.8)	89(23.2)	295(76.8)
Workers	142(4.0)	34(23.9)	108(76.1)
Farmers	131(3.7)	23(17.6)	108(82.4)
Others (Self-employment and retirement)	498(13.9)	110(22.1)	388(77.9)
χ^2 (*P value*)		3.663(0.453)	
Family members of cardiac patients			
Yes	625(17.5)	193(30.9)	432(69.1)
No	2,630(73.7)	579(22.0)	2051(78.0)
Do not sure	314(8.8)	66(21.0)	248(79.0)
χ^2 (*P value*)		23.248(<0.001)	
Witnessed out-of-hospital cardiac arrest			
Yes, and acting	225(6.3)	114(50.7)	111(49.3)
Yes, but no acting	565(15.8)	266(47.1)	299(52.9)
No	2,779(77.9)	458(16.5)	2,321(83.5)
χ^2 (*P value*)		343.474(<0.001)	

willingness, AED awareness and CA first aid knowledge. Third, farmers were a subgroup with the lowest AED awareness and cardiac arrest first aid knowledge.

Bystander CPR programs are not common in mainland China (25, 26), but this study found that CPR training can increase the willingness of bystanders to perform CPR. The survey results showed that the main reason for the unwillingness to perform bystander CPR when witnessing OHCA was the lack of confidence, and the improvement of CPR knowledge increased the confidence of bystanders to provide CPR (3). This was also consistent with the results of a study in South Korea (27). Additionally, this study found

that males were more willing to perform bystander CPR than females, which was consistent with a study showing that male bystanders in the United States (28) and South Korea (29) were more willing to provide CPR. Furthermore, this study found that factors promoting the willingness of bystander CPR included older age (> 40 years), as is the case in the United Kingdom (14); the level of education in high school and below may be related to the fact that China began to popularize nine-year compulsory education at the beginning of the 21st century (30); knowing whether there were family members of patients with heart disease at home, and investigators who may care about their families have a stronger sense
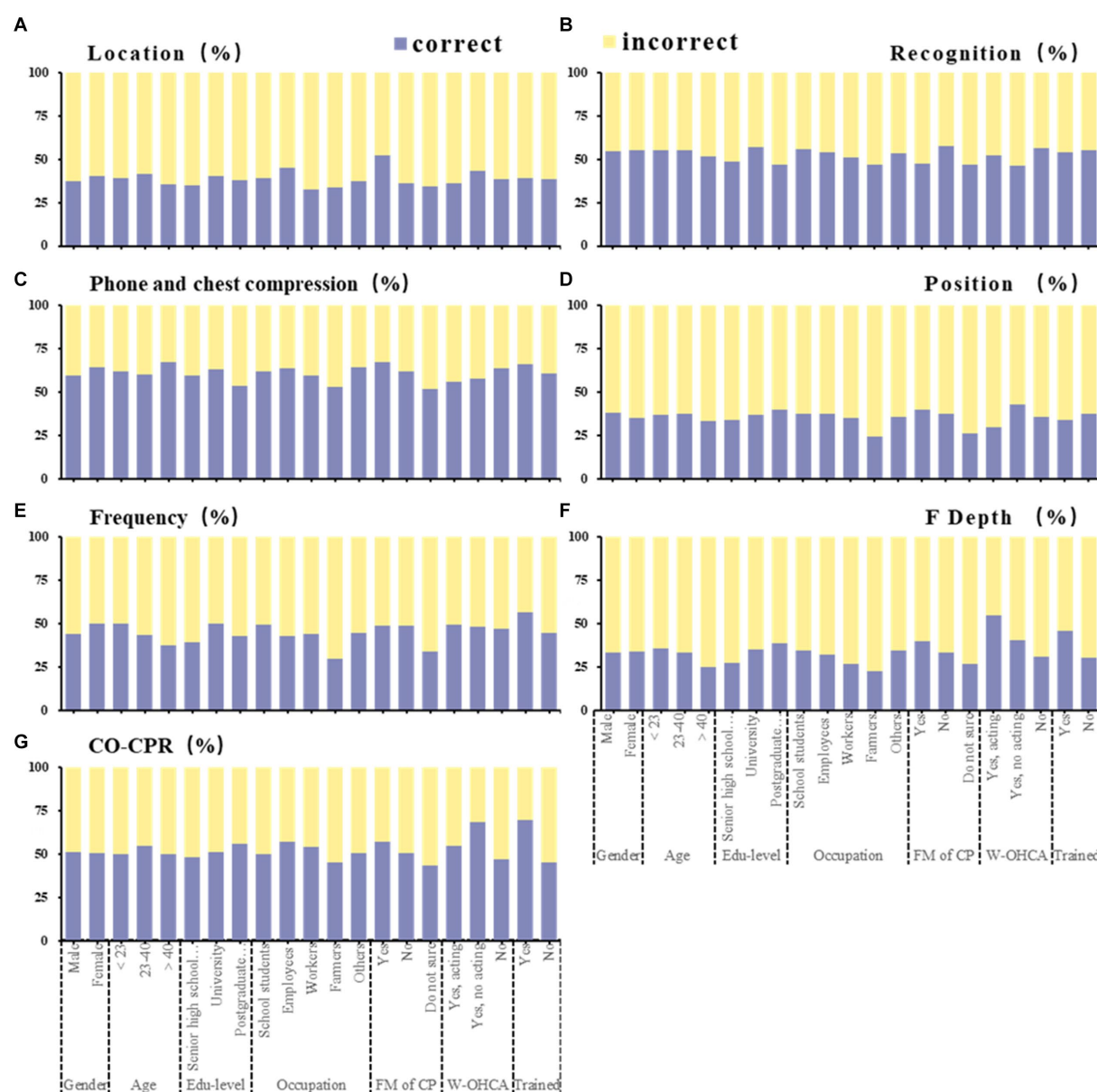
FIGURE 1
Seven categories of knowledge questions among participants (*N* = 3,569). This figure shows the proportion of correct and incorrect counts by sociodemographic characteristics in each question. Association of sociodemographic characteristics with proportion of the cardiac arrest most common location **(A)**, cardiac arrest recognition **(B)**, phone 120 and chest compression when cardiac arrest occurs **(C)**, position of chest compressions **(D)**, frequency of chest compressions **(E)**, depth of chest compressions **(F)**, importance of chest compression **(G)**. Correct location: At home; Correct recognition: Found that someone suddenly fainted, no response to his/her shouting; Correct phone: Phone 120 and chest compression; Correct position: Left chest; Correct frequency: 100–120 times/min; Correct depth: 5–6 cm; Correct importance: Only chest compressions can save lives. CO-CPR, only chest compressions; FM of CP, family member of cardiac patient; W-OHCA, witnessed out-of-hospital cardiac arrest.

of social responsibility; and having witnessed OHCA, as is the case in the United Kingdom (14).

This study showed that nearly half of the people had never heard of AEDs, and less than 1/3 of the people had seen AEDs, especially farmers, who had the lowest awareness of AEDs in all occupations. Previous studies have also shown that AED configuration and use in China were rare (31), and compared with densely populated cities, rural AEDs were less configured. Even 52.3% of people with CPR training experience had not seen AEDs,

indicating that China's CPR training also needed to supplement AED use training tutorials. Meanwhile, Japan's research on the outcome of OHCA patients showed that the effectiveness of nonprofessional defibrillation, only chest compression CPR and conventional CPR was weakened in turn (32). Therefore, it is very important for bystanders to immediately use AEDs and perform CPR when witnessing OHCA (14–23).

Although CPR training could significantly improve the total score of CA first aid knowledge, it had no obvious effect on the score of CA

TABLE 2 Cardiac arrest first aid knowledge score.

Variables	CA first aid basic knowledge score (2.00)		CA first aid operation knowledge score (5.00)		Total score for first aid knowledge of CA (7.00)	
	Mean ± SD	P value	Mean ± SD	P value	Mean ± SD	P value
Total	0.94 ± 0.70		2.31 ± 1.28		3.25 ± 1.56	
Sex		0.142		0.057		0.027
Male	0.92 ± 0.70		2.27 ± 1.27		3.19 ± 1.58	
Female	0.96 ± 0.70		2.35 ± 1.29		3.31 ± 1.55	
Age group, years		0.082		0.006		0.002
<23	0.94 ± 0.70		2.35 ± 1.29		3.29 ± 1.57	
23–40	0.97 ± 0.69		2.30 ± 1.28		3.27 ± 1.53	
>40	0.87 ± 0.72		2.14 ± 1.24		3.01 ± 1.58	
Educational level		<0.001		<0.001		<0.001
High school or below	0.83 ± 0.71		2.09 ± 1.22		2.93 ± 1.53	
Universities (including junior colleges)	0.97 ± 0.70		2.37 ± 1.28		3.34 ± 1.55	
Graduate degree or above	0.85 ± 0.66		2.31 ± 1.43		3.16 ± 1.67	
Occupation		0.028		<0.001		<0.001
School students	0.95 ± 0.70		2.35 ± 1.29		3.30 ± 1.57	
Enterprises	0.99 ± 0.68		2.35 ± 1.28		3.34 ± 1.52	
Workers	0.84 ± 0.67		2.20 ± 1.17		3.04 ± 1.46	
Farmers	0.81 ± 0.78		1.76 ± 1.28		2.56 ± 1.72	
Others	0.91 ± 0.70		2.30 ± 1.25		3.21 ± 1.51	
Family members of cardiac patients		0.001		<0.001		<0.001
Yes	1.00 ± 0.71		2.53 ± 1.17		3.54 ± 1.43	
No	0.94 ± 0.69		2.32 ± 1.29		3.26 ± 1.56	
Do not sure	0.82 ± 0.73		1.82 ± 1.30		2.64 ± 1.69	
Witnessed out-of-hospital cardiac arrest		0.153		<0.001		<0.001
Yes, and acting	0.89 ± 0.70		2.45 ± 1.20		3.34 ± 1.46	
Yes, but no acting	0.90 ± 0.72		2.59 ± 1.12		3.49 ± 1.37	
No	0.95 ± 0.70		2.25 ± 1.31		3.20 ± 1.60	
Trained in cardiopulmonary resuscitation		0.820		<0.001		<0.001
Yes	0.93 ± 0.68		2.73 ± 1.17		3.67 ± 1.41	
No	0.94 ± 0.71		2.19 ± 1.29		3.13 ± 1.58	

first aid basic knowledge. Most of the OHCAs in many countries (4), including China, occurred at home or residence (76.85%) (26), but the survival rate at home (7.8%) was less than half of that in public places (19%) (33). However, based on a survey of residents in central China, this study found that only the families of patients with heart disease could better understand that home was the most common place for OHCA. In contrast, those who had experienced CPR training or witnessed and acting on OHCA were more likely to believe that public places were the most common places for OHCA. British research suggests that first aid training is linked to increased knowledge of CPR (34). Therefore, Chinese residents need to improve their understanding of OHCA occurrence at home through first aid

training. In terms of OHCA recognition, the training in this study did not show an obvious effect. Perhaps with the help of science and technology such as biosensors, the OHCA correct recognition rate could be improved more effectively (35). Therefore, in China, CPR training should pay more attention to supplementing CA first aid basic knowledge.

The influence of training experience on CA first aid operational knowledge was significant. It was crucial to witness OHCA patients making calls for the first time (36), and the shorter the response time of the emergency department was, the more effective the bystander CPR (1). In mainland China, prehospital emergency services were activated by only 120 calls (37). According to the survey, more than half of the

subjects will call 120 for the first time, indicating that residents in central China had a strong sense of calling when witnessing OHCA. However, the position, frequency and depth of chest compressions also need to be trained and educated. The results of this study showed that bystanders who witnessed OHCA but did not act were more likely to correctly understand the location of chest compressions, which indicated that due attention should be given to increasing the chance of witnessing others performing chest compressions in CPR training. Meanwhile, people who received training were more aware of the chest compressions frequency, which confirmed the effectiveness of the training. In

addition, the survey showed that bystanders who witnessed OHCA and acting could better remember the depth of chest compressions, which indicated that the depth of chest compressions in CPR training may be more impressed by the hands of the trainees. This survey showed that nearly half (50.9%) of the subjects had realized the importance of chest compressions alone, and studies had shown that chest compressions alone CPR training could help the public improve CPR skills more than conventional CPR training (32, 38).

From the perspective of the CA first aid knowledge correct rate, the knowledge of farmers was low, but the knowledge of family members of patients with heart disease and those who had participated in training was high (Figure 1). Specifically, there was almost no difference in basic knowledge, while operational knowledge was affected by family members of patients, witnessing OHCA, and training experience. Combined with the results of multiple linear regression analysis, education level and cardiac patient family members were significant influencing factors of first aid knowledge. However, in rural China, there is a lack of access to CPR-related knowledge, and more training is needed for CPR. A retrospective cohort study in Sweden also showed that there is still much room for training in OHCA first aid in rural areas (39).

FIGURE 2
The scores of each group under the occupational category.

Limitations

First, due to the limitations of objective factors such as economy and epidemic situation, this study only conducts an online nonprobability random sampling survey on residents of a province in central China, so the research cannot be completely randomized stratified sampling. Second, because young college students in their 20s are more willing to

FIGURE 3
Awareness of automated external defibrillator among participants (N = 3,569). This figure shows the proportion of yes and no counts by sociodemographic characteristics in AED awareness. Association of sociodemographic characteristics with proportion of whether or not heard of AED (A), whether or not seen AED (B). AED, automated external defibrillator; FM of CP, family member of cardiac patient; W-OHCA, witnessed out-of-hospital cardiac arrest.
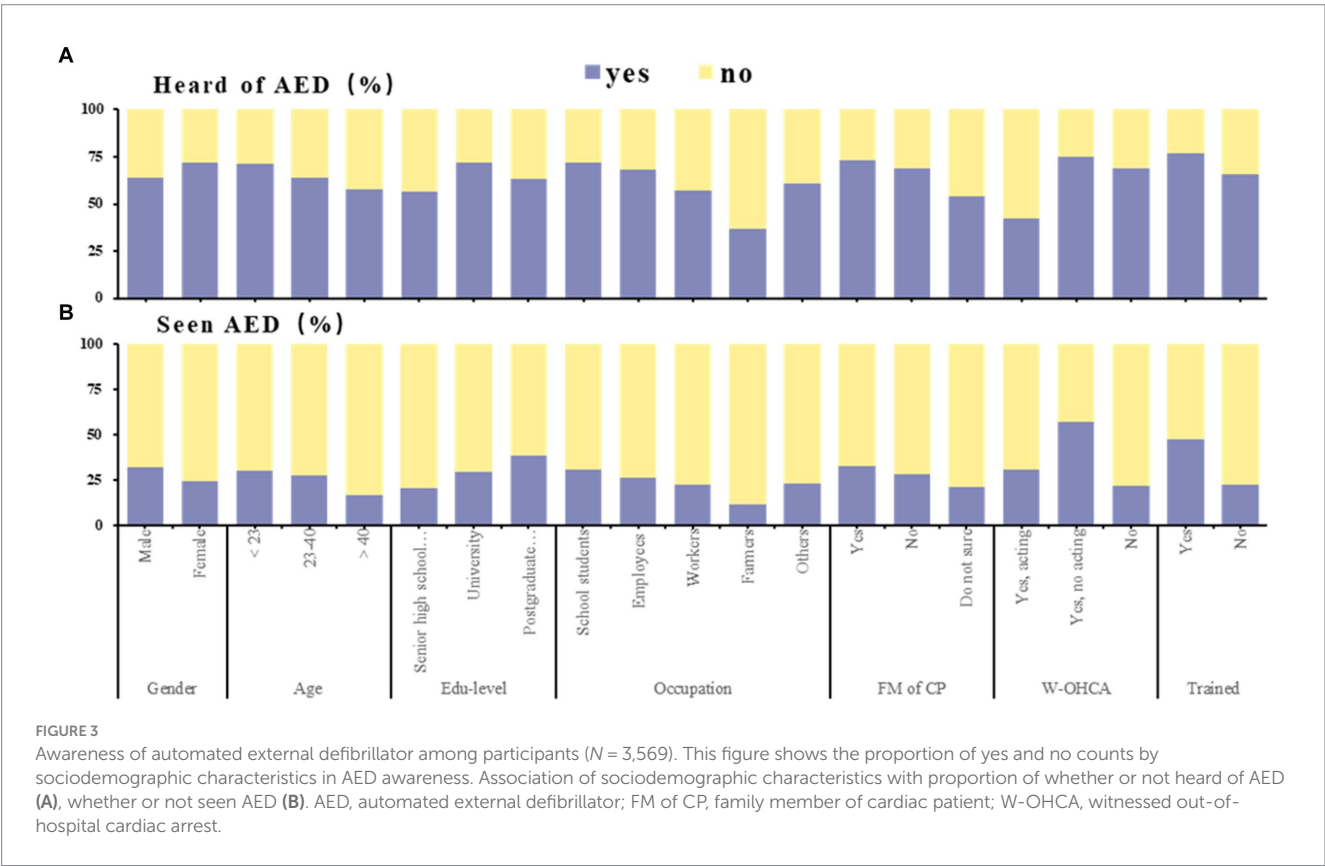
TABLE 3 Multivariable logistic regression analysis between bystander CPR willingness and sociodemographic characteristics.

Variables	Bystander CPR willingness when witnessing out-of-hospital cardiac arrest		
	Wald χ^2	OR	*95%*CI
Sex			
Male	17.692**	1.438	1.214–1.702
Female		1(ref)	
Age group, years	13.690*		
<23	11.476*	0.528	0.364–0.764
23–40	9.666*	0.627	0.468–0.842
>40		1(ref)	
Educational level	4.574		
High school or below	4.433*	1.612	1.034–2.514
Universities (including junior colleges)	2.412	1.391	0.917–2.109
Graduate degree or above		1(ref)	
Occupation	13.698*		
School students	8.237*	0.606	0.431–0.853
Enterprises	2.919	0.753	0.543–1.043
Workers	1.703	0.752	0.491–1.154
Farmers	7.231*	0.513	0.315–0.834
Others		1(ref)	
Family members of cardiac patients	5.872		
Yes	4.257*	1.463	1.019–2.100
No	5.827*	1.487	1.078–2.053
Do not sure		1(ref)	
Witnessed out-of-hospital cardiac arrest	16.338**		
Yes, and acting	0.553	0.879	0.626–1.234
Yes, but no acting	13.950**	1.516	1.219–1.886
No		1(ref)	
Trained in cardiopulmonary resuscitation			
Yes	239.137**	4.348	3.609–5.238
No		1(ref)	

*$p < 0.05$, **$p < 0.001$. OR, odds ratio; CI, confidential intervals; CPR, cardiopulmonary resuscitation.

participate in online surveys, the population ratio is imbalanced, and the research results have certain population limitations. Finally, considering that too much content of the questionnaire will affect the enthusiasm of the respondents to answer, the independent variables involved in this study are limited, and perhaps more positive factors affecting the willingness of bystanders to implement CPR have not been found. In the future, we will use a completely random stratified probability sampling method for face-to-face comprehensive in-depth investigation.

Conclusion

In CA first aid knowledge, residents in central China had a higher awareness of recognition, call links and the importance of only chest compressions; the awareness of the OHCA most common location,

location, frequency and depth of chest compressions was low. The AED allocation rate in a central province was low; furthermore, rural areas not only lacked AED allocation but also lacked first aid knowledge, so it was necessary to strengthen CPR training in rural areas. Training, witnessing OHCA experience and cardiac patient family members had a positive effect on bystander CPR willingness. Summarizing the characteristics of bystanders who were willing to first aid when witnessing OHCA was conducive to targeted CPR training, thereby improving the bystander CPR rate in mainland China.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Author contributions

XT: Investigation, Writing – original draft, Validation, Visualization. YZ: Writing – review & editing. DD: Writing – review & editing.

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Expanding trauma education during war: pediatric trauma fundamentals training in Ukraine

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Introduction: On 24 February 2022, Russia launched a large-scale offensive in Ukraine, resulting in significant casualties to civilians, including children. As part of a seven-stream trauma education initiative, a novel pediatric trauma fundamentals course (PTF) was developed to provide standalone pediatric trauma education by our academic/NGO partnership. The objective of the program was to develop, implement, and evaluate a novel PTF educational course in the active armed conflict zone of Ukraine.

Methods: A novel two-day PTF course was internally developed, translated into Ukrainian, and implemented across eight Oblasts (regions) in Ukraine from November 2022 to December 2023. Participants completed pre-and post-assessments in knowledge and self-confidence, and critical skills were assessed against objective skill checklists. Change in knowledge and self-confidence were analyzed, respectively, with the nonparametric Wilcoxon matched-pairs signed-rank test and McNemar's test for paired data. Anonymous course evaluations were solicited after each course. Six to eight-week follow-up surveys were conducted to assess skill utilization and stewardship.

Results: Four hundred and forty-six Ukrainian health care providers were trained during 30 courses across 8 Oblasts in Ukraine during the intervention period. Aggregated knowledge and self-confidence significantly improved across all measures. Ukrainian instructors of courses received higher raw scores across all evaluation points on instructor feedback surveys as compared to international instructors. Six to eight-week follow-up surveys demonstrated participants had positive views of the training, have used the training on patients, and have taught the material to other health care providers.

Discussion: Our novel PTF intervention demonstrates a successful partnership-based model for implementing pediatric trauma education in an active conflict zone in Ukraine. Challenges to implementing such programs can be mitigated through strategic partnership-based models between academic institutions and organizations with local knowledge and expertise. Ukrainian instructors provide course experiences similar or superior to international instructors, likely due to multiple factors related to language, culture, and context.

Background

On 24 February 2022, Russia expanded its war in Ukraine by launching a large-scale offensive across the country. Over the past 2 years, the conflict has devastated communities in Ukraine, leading to over 10,500 civilian deaths and almost 20,000 injured (1). This includes over 600 children killed and 1,350 injured (2). The ongoing conflict has caused immediate casualties while also leading to a significant and profound impact on public health and hospital infrastructure. Over 1,700 attacks on Ukraine's health system have led to numerous medical facilities being damaged or destroyed, hundreds of health care workers killed (3), and significant disruptions of critical utilities supporting hospital functionality, including energy and water supply systems (4, 5). The prolonged nature of the conflict has also led to a critical shortage in health and medical supplies, overburdened health care workers, public health emergencies, and a significant mental health burden on the Ukrainian civilian population.

The escalation of the conflict has increased the need for trauma and emergency care throughout Ukraine, which has seen an exponential increase in war-related injuries from mechanisms such as penetrating trauma, burns, crush and blast injuries (6). The health consequence of these mechanisms of injury include complex traumatic injuries requiring immediate stabilization, advanced surgical interventions, rehabilitation, and comprehensive long-term care (6). In addition to the profound effect on hospitals, clinics, and medical supply chains, medical providers have faced unprecedented challenges to providing care, including the disruption of medical education and the transition of currently practicing providers toward trauma-based care and education.

The Harvard Humanitarian Initiative (HHI), a university-based interfaculty initiative, has partnered with organizations, agencies, and ministries of health to support humanitarian responses around the world (7). Building from prior relationships delivering Basic Emergency Care and Chemical, Biological, Radiological, Nuclear, and Explosives (CBRNE) courses in Ukraine after Russia's annexation of Crimea in 2014 (8–10), HHI undertook a rapid needs assessment shortly after the 2022 Russian invasion to understand the trauma-related education required to meet the acute care needs across the country. HHI, in partnership with the International Medical Corps, developed a multi-stream trauma training initiative to provide Ukrainian health care workers, public safety officials, and civilians with training in trauma management (11). After a successful preliminary implementation of the multi-stream intervention and in response to feedback, a stand-alone pediatrics trauma course was developed to implement both at the country's freestanding childrens' hospitals and in general hospitals that receive pediatric patients.

Given that the participants of the course would either have a strong background in pediatrics or basic knowledge in adult trauma care with minimal pediatrics knowledge, we undertook the development of a Pediatric Trauma Fundamentals (PTF) course. We developed this course to fill the gap in pediatric-focused trauma education in wartime or conflict settings, while also ensuring a highly contextually appropriate curriculum tailored to the Ukrainian context. The two-day trauma training curriculum was planned and developed with input and feedback from Ukrainian partners. The overall objectives of the program included: (1) the development and implementation of a pediatric trauma fundamentals course to provide immediate training for health care providers in Ukraine and (2) the sustainable integration of the program into Ukrainian educational initiatives. The team sought to assess the effectiveness of the PTF educational implementation program on trauma theoretical knowledge, skills, and practical implementation during an active armed conflict in Ukraine.

Methods

In the Summer of 2022, prior to the conclusion of the first phase of an overarching multi-stream trauma program in Ukraine, a general consensus between partner organizations (International Medical Corps and HHI) was made that a pediatric-specific trauma fundamentals course should be added as a stand-alone trauma education stream. A majority of pediatric trauma care takes place in a network of Ministry of Health-run freestanding childrens hospitals not previously targeted in the first phase of the multi-stream trauma program. Additionally, frontline regions with general hospitals that receive pediatric patients, in cities such as Mykolaiv, were included in the PTF trauma initiative.

Course curriculum

A novel two-day course entitled 'Pediatric Trauma Fundamentals' was conceptualized and developed internally by a core group of seven pediatric emergency medicine physicians and nurses. The core team had previous experience in curriculum development and had extensive experience in the humanitarian sector through engagement with various academic and international agencies and organizations. Content was sourced from several international resources including the World Health Organization (WHO) and the International Committee of the Red Cross Basic Emergency Care, Advanced Trauma Life Support, UpToDate, Fleisher and Ludwig's Textbook of Pediatric Emergency Medicine, and the Boston Children's Global Health Program pediatric resuscitation course (12). Curriculum topics & modules are listed in Table 1.

Educational delivery modalities included didactic frontal lectures, hands-on skills stations, interactive case discussions, and team-based simulation scenarios. All materials were translated into Ukrainian and

TABLE 1 PTF curriculum modules.

Pediatric trauma fundamentals: curriculum modules
Introduction to pediatric trauma
Airway and breathing
Circulation
Head trauma
Thoracic trauma
Abdominal and pelvic trauma
Spine/spinal cord trauma
Burns
Blast injuries
Chemical injuries
Principles of teamwork

reviewed by International Medical Corps interpreters based in Ukraine for language, context and culturally specific considerations. The two-day schedule was adapted as needed for safety/security considerations, which included tailoring course start and end times based on travel requirements and daily safety/security briefs providing real time information about impending attacks. Supplementary PTF videos were developed for high-yield topics in pediatric trauma. Links were provided for students during the course and made publicly available on YouTube (13).

A second curriculum was developed for the "training of trainers" (ToT) component of the course. In addition to the two-day PTF course, three additional days for a five-day course included one day on adult learning and teaching theory and two days on flipped classroom, student-driven didactic, skills and simulation practice.

Course delivery

Courses were delivered in person by international English-speaking instructors and Ukrainian instructors in Ukrainian language, both with live Ukrainian/English bi-directional translation for the duration of all courses. The PTF course was implemented in a three-part approach: (1) international instructor led PTF courses, (2) ToT courses which developed a cohort of Ukrainian instructors to teach PTF to Ukrainian participants, and (3) Ukrainian instructor-led courses with international mentorship. During the initial implementation of the PTF intervention (November 2022 to April 2023), English speaking international instructors provided in person instruction to Ukrainian participants. International instructors were recruited by HHI and International Medical Corps. Given the safety and security considerations in an active conflict zone, and to limit the number of unique providers teaching courses, international instructors were obligated to dedicate two-week blocks of course delivery during the PTF intervention. Recruitment for Ukrainian learner participants was undertaken by International Medical Corps and sought out the following priority medical providers as course participants: pediatricians, pediatric surgeons (all specialties), general practitioners, general surgeons, and any other provider who cares for traumatically injured children. During part two of the PTF implementation (August 2023 to December 2023), Ukrainian participants were identified to attend a five-day ToT course to become instructors. Ukrainian instructors were identified by recommendation

from Ukrainian host universities. ToT courses were taught by in person international instructors. PTF courses thereafter were led by Ukrainian instructors with international instructors onsite to provide active mentorship, content expertise and educational delivery feedback.

Training sites

Training sites were identified by International Medical Corps and based on the identified needs of Ukrainian providers who care for pediatric patients. Figure 1 (14) provides a map of locations of all 11 cities where PTF courses were delivered during the program. Course delivery was undertaken at Universities, hotels and hospitals.

Program evaluation

In alignment with the overarching multi-stream trauma program, the effectiveness of the intervention was assessed through several means. In-person course participation and video access statistics were tracked. Changes in knowledge and self-efficacy were measured individually through pre-and post-course written assessments and self-confidence surveys. Participants completed written evaluations immediately after finishing the course. This information was gathered on paper, transcribed into Kobo Toolbox,[1] and analyzed with the R Studio statistical package (15). Follow-up evaluations conducted six to eight-weeks post-course measured skill adoption, implementation, and maintenance using participants' preferred messaging platforms (Telegram, Signal, WhatsApp, or Viber). Knowledge changes were analyzed using paired t-tests, while pre-and post-course self-efficacy surveys were analyzed with McNemar's test for paired data. Course evaluations included standardized questions about instruction quality, teaching relevance, knowledge gained, and post-course confidence in skills. Handwritten feedback was deidentified, collected in Ukrainian, and translated into English for analysis.

Results

PTF courses ran from November 2022 to December 2023. A total of 30 PTF courses were taught in the following 11 cities in 8 Oblasts over the total implementation period: Kyiv ($n = 3$), Fastiv ($n = 1$), Dnipro ($n = 5$), Kharkiv ($n = 3$), Chernihiv ($n = 2$), Mykolaiv ($n = 4$), Vinnytsia ($n = 3$), Lviv ($n = 1$), Stryi ($n = 1$), Izmail ($n = 2$), and Odesa ($n = 5$). Overall, a total of 17 unique international instructors were deployed to teach PTF in Ukraine. All instructors underwent a pre-deployment orientation to the PTF course, logistics and safety/security briefing. A total of 446 Ukrainian participants were trained in PTF by international and Ukrainian instructors (85 trained by Ukrainian instructors and 361 by international instructors) and 63 Ukrainian participants completed the ToT course. Demographics of the PTF participants can be found in Table 2.

A 25-question knowledge assessment pre-and post-test was developed to align with overarching PTF course objectives. Participant

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1 https://www.kobotoolbox.org/
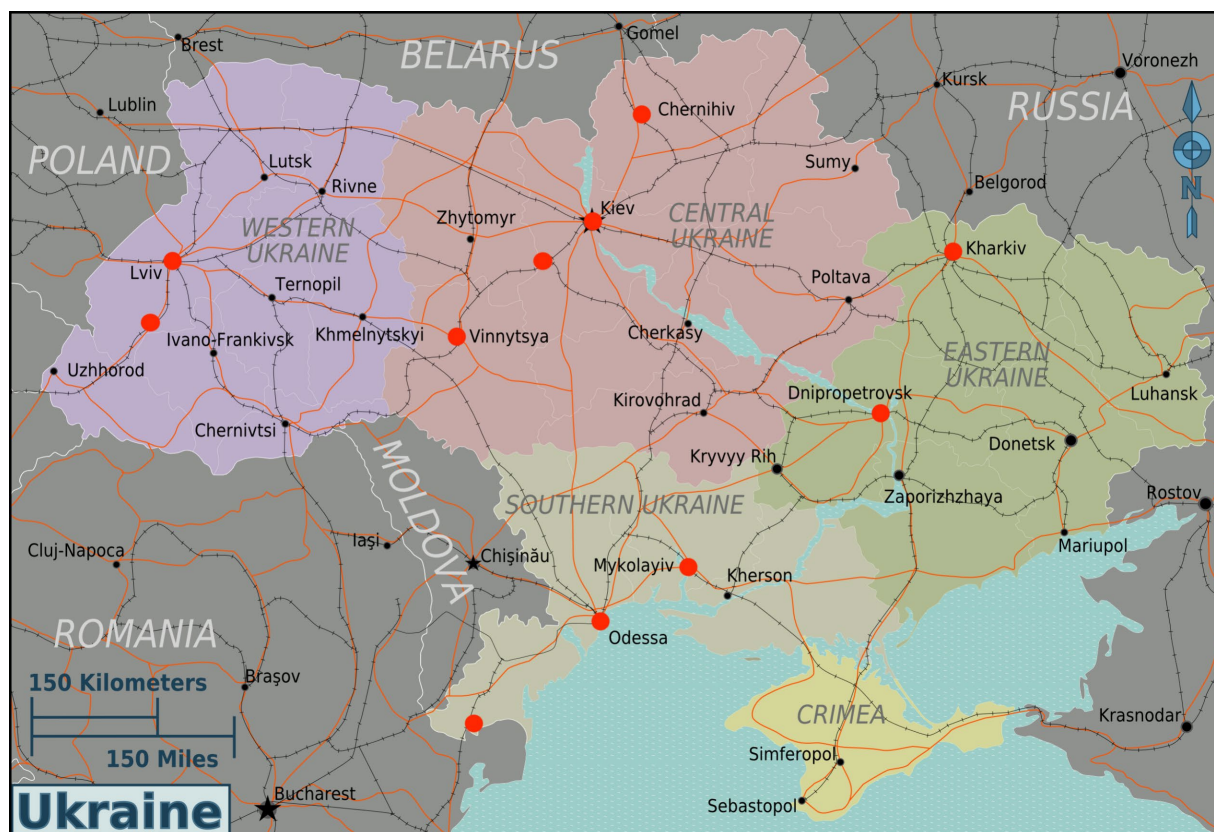
FIGURE 1
Location of PTF course delivery in 11 cities across Ukraine.

matched pre-and post-tests demonstrated a significant improvement in knowledge (Table 3). Participant matched 21-question self-confidence and self-efficacy pre-and post-surveys were completed by PTF participants. Variance in total number of participants and number of participants with matched test results were due to multiple reasons including course incompletion by participants and data entry errors resulting in the inability to match participants. Results demonstrated a significant increase in all self-confidence and self-efficacy questions for participants trained by international and Ukrainian instructors. Table 4 demonstrates the aggregate results of all PTF participants. Supplementary Table S1 provides disaggregated tables for each PTF time phase.

A six to eight-week follow up evaluation was sent to course participants via preferred messaging platforms to understand post-course skills utilization and stewardship. Evaluations were sent to all course participants. 91/446 (20.4%) of PTF participants responded. Results of the responses can be found in Supplementary Table S2. Over 73% of PTF participants reported teaching information learned in the course to others including trauma management knowledge and/ or procedural skills. When asked if any additional training topics should be taught in the future, over 75% of respondents requested further educational opportunities in pediatric non-trauma emergency care.

Participants filled out immediate post-course evaluations for international instructor-led PTF courses ($n = 376$, 99.5% response rate; Table 5) and the Ukrainian instructor-led PTF courses ($n = 122$, 93.1% response rate; Table 6). While both cohorts received overwhelmingly positive feedback, Ukrainian instructors received higher raw scores across all evaluation points as compared to the international instructors.

Discussion

During war and conflict, a significant shift in medical care is required to prioritize trauma and acute care injuries (16). This transition involves upskilling or task-shifting healthcare providers to handle the surge of traumatic injuries caused by unique wartime mechanisms of injury and for special populations, including pediatrics (17, 18). Ukraine's network of pediatric hospitals and academic institutional partners across the country provided a basic infrastructure and setting to undertake a large-scale, country-wide pediatric trauma educational initiative tailored to this population (19). Given the special focus of pediatrics, our unique pediatric trauma fundamentals course provided pediatric-focused education for providers tasked with caring for children during an active war setting in Ukraine. This educational course filled a gap in pediatric trauma education, as other established courses may only briefly address pediatric trauma education in overarching curricula focused on adult emergency and trauma care or focus on providing pediatric trauma education outside of the acute care setting. Furthermore, this course sought to provide a knowledge foundation both for providers with pediatric expertise but no trauma experience, and providers with significant trauma experience but minimal pediatric exposure. During the PTF conceptualization and development, it was clear that the course should be both applicable and

tailored to medical providers with specific training and expertise in pediatrics, emergency practitioners, general practitioners and surgeons who may encounter pediatric trauma patients. To accommodate a spectrum of potential learners, the course considered pediatric differences in anatomy, physiology, pathophysiology and common presentations across the pediatrics spectrum of injury.

Over the course of the educational intervention, 509 medical providers were trained in PTF across 11 cities in Ukraine. In addition, this included a cohort of 63 participants in the PTF ToT courses. These participants immediately started to implement independent PTF courses across several regions in Ukraine. The pre−/post-knowledge assessments and self-efficacy surveys demonstrated competency and confidence in participants' knowledge and their willingness to utilize the skills and knowledge gained during the course. The consistent pre−/post-test knowledge improvement and overwhelmingly positive course feedback for both international and Ukrainian instructors demonstrated a degree of uniformity in the course instructor training

and knowledge delivery to participants after transition to fully Ukrainian led instruction. Importantly, evaluation data demonstrated higher raw evaluation scores by Ukrainian instructors as compared to international instructors. This finding suggests the success and importance of the transition to locally taught courses. These findings also suggest other factors, including course delivery in maiden language without interpretation, educational delivery style, and other cultural considerations that may provide more effective course delivery. These findings should be referenced when considering future iterations of PTF across other contexts. Additionally, it is important to note that education is not valuable unless it reaches patient care. Learners reported having already taught information or skills to other medical providers and used those skills in the six to eight-week follow up surveys, indicating that this program is reaching the target population.

There were several limitations to this study. six to eight-week feedback response rate was approximately 20%, likely biased to highly engaged instructors. This provides a limited understanding of how course participants continue to utilize the knowledge gained from PTF. Given the breadth and length of the intervention, 17 international instructors were required to undertake this intervention. This included instructors with backgrounds in pediatric emergency medicine, pediatric and general surgery, and adult emergency medicine. To mitigate variations in teaching content and quality of teaching, a detailed, point-by-point international instructor manual was provided to all instructors and discussed in depth during the pre-departure orientation. For those instructors with significant trauma experience but limited pediatric experience, a pediatric-specific pre-departure orientation was provided in addition to the required pre-departure orientation. Additional challenges to the standardization of classes included the risk of active conflict affecting course delivery. This reality included interruptions of classes due to air raid sirens, requiring courses to be held in bomb shelters, basements, or parking garages due to periods of high threat, and unmeasured psycho-social stressors that are ever present in a war-time society. Risks to personnel were mitigated through safety and security protocols and risk assessments by our partner organization, International Medical Corps. Despite these disruptive forces, monitoring and evaluation of the courses consistently demonstrated improvement in knowledge and skills and uniformity of classes over the course of the longitudinal intervention.

Conclusion

The PTF educational initiative demonstrates a successful three-phase model for implementing an educational initiative for providers caring for children in active conflict zones. Despite the safety and security challenges, this model also demonstrates the value of an academic/non-governmental organization partnership to help mitigate risks through safety and security preparation,

TABLE 2 Demographics of Ukrainian participants in PTF courses.

Demographics	
Total number of participants	509
Sex	
Female	379 (74.5%)
Male	130 (25.5%)
Age [median (IQR)]	36 (28,48)
Healthcare workers	
Yes	509 (100.0%)
No	0 (0.0%)
Experience	
Years of experience in trauma care (median(IQR))	2 (0,12)
Years of experience in profession (median(IQR))	1 (0,8)
Training/expertise	
Doctor	377 (74.1%)
Nurse	118 (23.2%)
Medical assistant	14 (2.8%)
Specialty	
Pediatrics	125 (24.6%)
Emergency medicine	128 (25.1%)
Family/internal medicine	46 (9.0%)
Anesthesiology	56 (11.0%)
Surgery	86 (16.9%)
Other	35 (6.9%)
Not specified	33 (6.5%)

TABLE 3 Participant pre-and post-course knowledge assessment, aggregated and stratified by PTF instructor.

PTF Instructor	Participants (n=)	Pre-test mean (SD)	Post-test mean (SD)	p-value*
International Instructor led courses	310	71.3% (11.5)	86.9% (9.0)	$p < 0.05$
Ukrainian Instructor-led courses	118	73.1% (12.0)	88.4% (9.0)	$p < 0.05$
Total	428	71.8% (11.7)	87.3% (9.0)	$p < 0.05$

*Paired t-test.

TABLE 4 Participant pre-and post-course self-confidence and self-efficacy results ($n = 351$), aggregate of all PTF courses.

Self-confidence and self-efficacy questions	Pre-course	Post-course	p-value
I feel comfortable caring for pediatric patients with traumatic injuries	177 (50.4)	307 (87.5)	$p < 0.001$
I feel that I have the skills to provide care for pediatric patients with traumatic injuries	108 (30.8)	313 (89.2)	$p < 0.001$
I feel that I have the knowledge to provide care for pediatric patients with traumatic injuries	125 (35.6)	320 (91.2)	$p < 0.001$
I feel that I understand the ABCDEs of trauma care	204 (58.1)	345 (98.3)	$p < 0.001$
I feel I have an organized approach that allows me to be prepared to care for pediatric trauma patients	199 (56.7)	329 (93.7)	$p < 0.001$
I feel like I have the ability to recognize a critically injured child	246 (70.1)	334 (95.2)	$p < 0.001$
Emergency management of the injured child	97 (27.9)	297 (84.6)	$p < 0.001$
Emergency management of blast injuries in children	53 (15.1)	248 (70.7)	$p < 0.001$
Emergency management of penetrating injuries in children	76 (21.7)	265 (75.5)	$p < 0.001$
Emergency management of blunt trauma in children	109 (31.1)	287 (81.8)	$p < 0.001$
Emergency management of the pediatric patient with shock	106 (30.2)	268 (76.4)	$p < 0.001$
Emergency management of spinal trauma	108 (30.8)	293 (83.5)	$p < 0.001$
Emergency management of the patient with altered mental status	100 (28.5)	269 (76.6)	$p < 0.001$
Emergency management of the patient with difficult breathing	144 (41.0)	296 (84.3)	$p < 0.001$
Emergency management of the pediatric burns	124 (35.3)	302 (89.0)	$p < 0.001$
Emergency management of chemical injuries	61 (17.4)	255 (72.6)	$p < 0.001$
Understanding of Emergency drugs	134 (38.2)	289 (82.3)	$p < 0.001$
Have skills to manage an obstructed blocked airway	104 (29.6)	278 (79.2)	$p < 0.001$
Have skills to manage a patient with difficulty in breathing	129 (36.8)	294 (83.8)	$p < 0.001$
Have skills to manage a patient with bleeding problems	167 (47.6)	318 (90.6)	$p < 0.001$
Have the skills to immobilize injured patients	133 (37.9)	310 (88.3)	$p < 0.001$

TABLE 5 International instructor PTF post-course evaluation forms ($n = 376$).

Question	Yes	Somewhat	No	Missing
The lecture content was customized to the setting that I work or live in	322 (85.6)	50 (13.3)	4 (1.1)	0(0.0)
The skills stations were customized to the setting that I work or live in	303 (80.6)	66 (17.6)	7 (1.9)	0(0.0)
The teaching offered was relevant to me	337 (89.6)	36 (9.6)	3 (0.8)	0(0.0)
The course expanded my clinical knowledge on conditions my patients or community members may have	336 (89.4)	34 (9.0)	6 (1.6)	0(0.0)
The course expanded my clinical practice and assessment skills	333 (88.6)	38 (10.1)	5 (1.3)	0(0.0)
The course was a good balance between instruction and skill practice	335 (89.1)	35 (9.3)	6 (1.6)	0(0.0)
The course was at an appropriate difficulty level for me	321 (85.4)	49 (13.0)	6 (1.6)	0(0.0)
I feel more confident in using specific skills taught during the course as a result of the teaching	335 (89.1)	38 (10.1)	2 (0.5)	1(0.3)

TABLE 6 Ukrainian instructor PTF post-course evaluation forms ($n = 122$).

Question	Yes	Somewhat	No	Missing
The lecture content was customized to the setting that I work or live in	110 (90.2)	12 (9.8)	0 (0.0)	0 (0.0)
The skills stations were customized to the setting that I work or live in	114 (93.4)	8 (6.6)	0 (0.0)	0 (0.0)
The teaching offered was relevant to me	122 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)
The course expanded my clinical knowledge on conditions my patients or community members may have	115 (95.0)	6 (5.0)	0 (0.0)	1 (0.8)
The course expanded my clinical practice and assessment skills	118 (96.7)	4 (3.3)	0 (0.0)	0 (0.0)
The course was a good balance between instruction and skill practice	116 (95.1)	6 (4.9)	0 (0.0)	0 (0.0)
The course was at an appropriate difficulty level for me	112 (91.8)	10 (8.2)	0 (0.0)	0 (0.0)
I feel more confident in using specific skills taught during the course as a result of the teaching	119 (97.5)	3 (2.5)	0 (0.0)	0 (0.0)

planning, and real time risk mitigation in an active conflict zone such as Ukraine. Ukrainian instructors provide course experiences similar or superior to international instructors, likely due to multiple factors related to language, culture and context. Finally, building partnerships between academic institutions is a proven and promising model for sustainability and localization of long-term training programs.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Mass General Brigham (MGB) Institutional Review Board (IRB) reviewed the protocol which met criteria for Non-Human Subjects Research and a reliance on the MGB IRB was approved by Boston Children's Hospital. Ternopil National Medical University and the Dnipro State Medical University provided written ethical approval for data collection in Ukraine.

Author contributions

DM: Conceptualization, Data curation, Formal analysis, Writing – original draft, Writing – review & editing. AS: Data curation, Formal analysis, Methodology, Writing – review & editing. DL: Data curation, Formal analysis, Methodology, Software, Writing – review & editing. MG: Data curation, Formal analysis, Investigation, Writing – review & editing. OL: Data curation, Project administration, Supervision, Writing – review & editing. OD: Data curation, Investigation, Project administration, Supervision, Writing – review & editing. OS: Data curation, Project administration, Supervision, Writing – review & editing. AB: Data curation, Project administration, Supervision, Writing – review & editing. RS: Data curation, Project administration, Supervision, Writing – review & editing. SK: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing – review & editing. KM: Data curation, Formal analysis, Methodology, Project administration, Supervision, Writing – review & editing. MN: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing – review & editing.

Conflict of interest

MG, OL, and OD were employed by International Medical Corps.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2024.1448075/full#supplementary-material

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Learning interventions in the WHO Eastern Mediterranean region: supporting Member States to get prepared for better response to health emergencies in the region

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Background: The Eastern Mediterranean Region (EMR) faces numerous public health risks caused by biological, chemical, man-made, and natural hazards. This manuscript aimed to assess the multifaceted interventions and strategies used to strengthen the EMR's preparedness capacities to respond properly to current and upcoming health emergencies.

Objective: To address these challenges, it is crucial to implement comprehensive and robust strategic risk assessments and health emergency preparedness frameworks. The World Health Organization (WHO) takes a risk-based approach, emphasizing the significance of all-hazards emergency management and the creation of national health risk profiles using the Strategic Toolkit for Assessing Risk (STAR). Furthermore, the International Health Regulations (IHR) Monitoring and Evaluation Framework (MEF) ensures continuous learning and capacity building among Member States, enhancing their ability to manage health emergencies effectively. Key components include State Party Annual Reporting (SPAR), Joint External Evaluation (JEE), After Action Review (AAR), Intra Action Review (IAR), and Simulation Exercises (SimEx). Moreover, initiatives like One Health, Emergency Care Systems, Safe Hospitals, and Public Health Emergency Operations Centers (PHEOCs) reinforce preparedness and response capacities. Risk communication and community engagement (RCCE) strategies play a pivotal role in disseminating timely information and fostering community resilience. Furthermore, the management of Chemical, Biological, and Radiological (CBRN) incidents remains a priority, necessitating collaboration between the public health and security sectors. This comprehensive approach aims to strengthen health systems, reduce risks, and improve emergency response capabilities throughout the EMR, thereby promoting global health security and resilience.

Conclusion: The EMR is addressing public health challenges through frameworks like IHR-MEF, and RCCE. It is strengthening emergency care systems, ensuring safe hospitals, and establishing PHEOCs. Proactive measures to address CBRN events and collaboration are enhancing resilience. The inclusion of the One Health approach underscores the EMR's holistic strategy to address the health threats at the human-animal-environment interface. This demonstrates the EMR's commitment to global health security.

KEYWORDS

Eastern Mediterranean region, strategic risk assessment, health emergency preparedness, international health regulations, risk communication and community engagement, chemical biological and radio nuclear events

Introduction

Overview of the EMR and its public health threats

The Eastern Mediterranean Region (EMR) encompasses over 500 million people across 22 diverse countries: Afghanistan, Bahrain, Djibouti, Egypt, Iraq, Iran (Islamic Republic of), Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Pakistan, Palestine, Qatar, Saudi Arabia, Somalia, Sudan, Syrian Arab Republic, Tunisia, United Arab Emirates, and Yemen. These nations vary in their gross domestic products, socio-demographic profiles, health indicators, and health system capacities and coverage (1). Today, the world confronts significant health challenges affecting people, animals, and the environment. Previously, experts addressed these issues separately, but now it is recognized that these health aspects are interconnected and require a collective approach.

In the context of global health emergencies, the WHO-EMR is at a critical juncture. The enormous challenges of public health threats posed by biological, chemical, man-made, and environmental hazards necessitate powerful and proactive response systems based on adequate preparedness and health security in the region. Zoonotic diseases account for 75% of new and emerging infectious diseases in humans, posing major public health threats as seen with COVID-19, Ebola, and MERS-CoV. The Eastern Mediterranean Region faces risks from these and other emerging zoonoses, such as the recent monkeypox outbreak. Dengue fever, Crimean-Congo hemorrhagic fever (CCHF), and avian influenza continue to pose severe health risks with high mortality rates and economic impacts. Human brucellosis is also endemic in many regional countries (2).

The area is also plagued by conflict and civil unrest in Iraq, Syria, Libya, and Yemen. On 15 April 2023, violent clashes erupted in Sudan, resulting in the displacement of over 8.6 million people, including internally displaced persons (IDPs), asylum seekers, and refugees. This conflict has exacerbated many of Sudan's existing challenges, such as ongoing conflicts, disease outbreaks, economic and political instability, and climate emergencies. Since 7 October 2023, the ongoing crisis between Israeli armed forces and Hamas in the occupied Palestinian territories has led to numerous civilian deaths and injuries. In Gaza, airstrikes and severe shortages of medical supplies have critically strained the health system. The WHO is providing life-saving supplies to address these urgent health needs. With the WHO's endorsement of a risk-based approach to health emergency management, the EMR is taking various measures to address all these challenges.

Objectives of the manuscript

This paper looks at the many initiatives and tactics utilized to strengthen the EMR's preparedness to respond appropriately to existing and upcoming health emergencies. It emphasizes the critical function of strategic risk assessment and the creation of health risk profiles as the first steps toward building a resilient health system. By combining the various strands of emergency care systems, the International Health Regulations, 2005 (IHR) Monitoring and Evaluation Framework (MEF), and the One Health approach, this narrative provides a comprehensive overview of the efforts made to protect public health and ensure a timely, coordinated response to emergencies in the region.

The main objective of this manuscript is to elucidate the comprehensive strategies and learning interventions implemented in the EMR of the WHO to improve preparedness for health emergencies, with a focus on the integration of the IHR 2005 into the regional health security architecture, highlighting its role in building capacity, identifying gaps and facilitating continuous improvement in emergency response.

TABLE 1 Summary of Regional Emergency Preparedness Strategies and interventions in the EMR.

Strategy/intervention	Purpose	Initiatives
Strategic Risk Assessment and Health Risk Profiles	Identify and prioritize health risks to enhance preparedness	WHO Strategic Tool for Assessing Risks (STAR) - WHO
International Health Regulations (2005) Monitoring and Evaluation Framework (IHR-MEF)	Strengthen health security through core capacity building	State Party Annual Reporting (SPAR) - WHO Joint External Evaluation (JEE) - WHO After Action and Intra Action Reviews (AAR/IAR) - WHO Simulation Exercises (SimEx) - WHO
Points of Entry and Border Health trainings	Enhance capacities at points of entry for rapid response	Member States, IHR (2005) core capacity building training at PoEs - WHO Ship Sanitation inspections and certification training - WHO
One Health Approach	Address zoonotic diseases through multisectoral collaboration	Joint Risk Assessment Operational Tool (JRA OT) - WHO, WOAH, FAO, UNEP
Emergency Care Systems	Improve timely response to acute illnesses and injuries	Emergency Care Framework - WHO Integrated Inter-Agency Triage tool (IITT) - WHO Basic Emergency Care Course (BEC) - WHO, ICRC
Hospital Safety and Hospital Resilience	Ensure hospitals continue functioning during emergencies	Hospital Safety Index Tool - WHO
Public Health Emergency Operations Centers (PHEOC)	Coordinate public health emergency responses	PHEOC Guidance - WHO
Risk Communication and Community Engagement (RCCE)	Strengthen community preparedness and response	Social listening taxonomies - WHO RCCE trainings - WHO
Risk Management of Chemical, Biological, and Radiological (CBRN) Events	Manage risks from CBRN events	Regional Strategic Plan with clear strategic objectives: Advocate for the Health Security Interface (HSI) function, including CBRN - WHO, UNODA, BWC, ISU, UNICRI, OPCW, INTERPOL

WHO, World Health Organization, EMR, Eastern Mediterranean Region, IHR, International Health Regulations, RCCE, Risk Communication and Community Engagement, PHEOC, Public Health Emergency Operations Center, CBRN, Chemical, Biological, Radiological, Nuclear, HSI, Hospital Safety Index, BEC, Basic Emergency Care, UHC, Universal Health Coverage.

Regional capacity strengthening

Strategic risk assessment and developing and updating health risk profiles in the eastern Mediterranean region (EMR) (Table 1)

The connection between public health risks and emergencies is recognized as arising from the interaction of biological, technological, social, and natural hazards within communities, depending on factors such as likelihood, severity, vulnerabilities, and existing coping capacities. Identifying and assessing hazards and associated risks are critical components of effective emergency management. The World Health Organization (WHO) adopts a risk-based approach to managing health emergencies and mitigating risks, by using an all-hazards approach to emergency management in which health risk management functions are consistent across various types of hazards (3).

To reduce the risks associated with emergencies, WHO-EMRO works closely with countries to develop and regularly update their national health risk profiles, strengthening preparedness and response capacities for identified current and anticipated hazards. WHO EMRO helps countries use the WHO Strategic Toolkit for Risk Assessment (STAR), which allows countries and regions to conduct a strategic, rapid and evidence-based assessment of public health risks to plan and prioritize risk management activities. The assessment results in a country's risk profile, defining priority hazards and risk calendars where possible (predicting the timings/seasonality of hazards) (4) (Table 2).

The hazards prioritization enables rational and effective planning, as well as the most efficient use of limited resources, to improve health emergencies and disaster risk management capacity in the face of multiple and competing priorities. WHO-EMRO efforts are focused on improving health planners' strategic risk assessment skills and implementing a risk-based approach to emergency planning. This allows countries to develop risk mitigation plans, establish and maintain early warning systems, and initiate and promote multisectoral coordination preparedness and response mechanisms prior to emergencies (5).

International health regulations (2005) monitoring and evaluation framework

The IHR-MEF, 2005 is critical to improving health security in the EMR by ensuring a well-coordinated and responsive approach to public health emergencies. One of the key components of the IHRMEF is its emphasis on learning interventions and training, which are critical for developing and maintaining the capacity of regional Member States to manage health emergencies and crises. The

TABLE 2 Processes for Defining Global Public Health Emergency Preparedness Strategies and assessing their impact.

Process for defining need (Strategies and interventions)	Process for assessing impact	Examples
Risk Assessment and Profiling: identifying hazards, assessing risks, and prioritizing actions based on likelihood, severity, and vulnerabilities.	Monitoring and Evaluation: Using tools like SPAR, JEE, AAR/IAR, and SimEx to assess preparedness, identify gaps, and improve response capabilities.	- Development of national health risk profiles using WHO's Strategic Toolkit for Risk Assessment (STAR).
Implementation of IHR Monitoring and Evaluation Framework (MEF): ensuring core capacities are met through continuous learning and improvement.	Feedback Mechanisms: Annual reporting, joint evaluations, after-action reviews to identify strengths and weaknesses.	- Use of SPAR for annual evaluations and JEE for comprehensive evaluations in EMR countries.
Capacity Building: enhancing skills and knowledge through training and exercises.	Performance Metrics: Tracking progress in emergency response readiness and effectiveness.	- Basic Emergency Care Course (BEC) to train healthcare providers in acute care management.
Integration of One Health Approach: addressing zoonotic diseases through multisectoral collaboration.	Cross-Sectoral Coordination: Ensuring alignment and cooperation across health, agriculture, and environmental sectors.	- Joint Risk Assessment Operational Tool (JRA OT) for assessing risks at the human-animal-environment interface.
Hospital Resilience and Safety: strengthening health facility preparedness and response capabilities.	Hospital Safety Index (HSI): Assessing hospital readiness to withstand emergencies.	- Use of HSI tool to evaluate hospital safety and resilience in disaster-prone areas.

SPAR, State Party Annual Report; JEE, Joint External Evaluation; AAR/IAR, After-Action Review / Integrated Action Report; SimEx, Simulation Exercise; IHR, International Health Regulations; EMR, Eastern Mediterranean Region; WHO, World Health Organization.

IHR-MEF encourages continuous development of skills and knowledge among healthcare workers and emergency responders, ensuring they are well-prepared to deal with a wide range of health threats (6).

Through systematic assessment and feedback mechanisms, the framework supports the identification of gaps in core capacities, knowledge, and skills, through different tools including the State Party Annual Reporting (SPAR), the Joint External Evaluation (JEE), the After Action and Intra Action Review (AAR/IAR), and the Simulation Exercises (SimEx), enabling targeted interventions that enhance the IHR core capacities and the regional workforce's ability to respond to emergencies efficiently and effectively (7–10).

The assessment tools and exercises used enable Member States to identify specific gaps in the health system and develop a National Action Plan for Health Security (NAPHS), by providing the necessary recommendations and standards for preparedness and response, as well as ensuring that countries have access to the best practices and most recent knowledge in the field of public health emergency preparedness. This includes areas such as risk assessment and profiling, health emergency preparedness, One Health, risk communication and community engagement (RCCE), and the implementation of health measures that respect people's dignity, human rights, and equity. As a result, Member States are better equipped to prevent, detect, assess, notify, and respond to health emergencies quickly, reducing the possible impact on public health and international trade and travel (11). During the final round of SPAR 2023, all Member States (22 countries) completed their annual evaluation; up until January 2024, 20 EMR Member States had completed the first round of JEE, with two countries completing the second round in 2023. AAR has been conducted in six countries in the region in response to various events such as infectious disease outbreaks, natural disasters, and chemical events, whereas IAR was used by 12 countries to review the response to the coronavirus 2019 (COVID-19) pandemic and implement the necessary correction plans. Furthermore, 19 countries used various types of SimEx to review, evaluate and test the procedures, operational plans, guidelines, and standard

operating procedures developed to be better prepared to respond to future health threats.

The Universal Health and Preparedness Review (UHPR), which was piloted in Iraq as the second global pilot country, is a significant initiative aimed at improving global health security by encouraging transparency, accountability, and collective action among member states to prepare for and respond to health emergencies. The UHPR is a voluntary peer-review mechanism that encourages the exchange of best practices, challenges, and lessons learned in health emergency preparedness and response. Its significance stems from the promotion of a global culture of health security that transcends borders, emphasizing the interconnectedness of public health and the need for international solidarity. It is critical for identifying gaps, mobilizing resources, and driving improvements in national and international health systems. This proactive approach not only improves the ability to manage and mitigate the impact of health emergencies but also contributes to the achievement of Universal Health Coverage (UHC), ensuring that all people, everywhere, have access to quality health services without financial hardship (12).

Moreover, the IHR-MEF facilitates international cooperation and assistance, leveraging the collective expertise and resources of the global community to support countries in need.

Points of entry and border health in the EMR

WHO EMRO has been supporting Member States in building the International Health Regulations (2005) core capacity requirements in order to respond to Public Health Emergencies of International Concerns at the designated Point of Entry (PoEs), in different countries, including the airports, ports and ground crossings. This support included regional, sub-regional, and national training programs focused on assessing these capacities at PoEs level. Since the IHR (2005) mandates that Member States should designate PoEs that shall develop the IHR capacities provided according to Annex 1 of IHR (2005), the provided trainings have been centered on conducting

risk assessments at PoEs level, designating the PoEs, and engaging the PoEs in simulation exercises to evaluate the trained capacities.

Additionally, specialized training has been provided on ship sanitation inspections and certification, along with vector surveillance and control, food safety, inspection, and environmental health considerations at PoEs. Training sessions specific to event management on aircraft and ships have been rolled out, alongside the development of public health emergency contingency plans and Standard Operating Procedures (SoPs) for use during emergencies (13).

In response to COVID-19, Ebola, and other PHEIC, risk assessment training was conducted to develop travel risk mitigation measures in the context of international travel including guidelines on screening, quarantine, vaccination, and other travel-related measures, in line with WHO recommendations. At the regional level, an important development has been the creation of tailored training packages by WHO-EMR-Office. These packages come in introductory, intermediate, and advanced levels and aim to build the capacities of various stakeholders operating at PoEs (both health and non-health) and guide the development of a national training curriculum. The materials are piloted in several countries and country case studies are documented to reinforce the practical understanding and implementation of the presented technical concepts (13).

One health

Emerging and reemerging infectious diseases, especially those originating from animals (zoonotic diseases), are a persistent global health threat. Addressing these challenges requires a comprehensive, multisectoral approach, exemplified by One Health (14). WHO-EMR Office in close collaboration with regional and subregional offices of the Food and Agriculture Organization of the United Nations (FAO), the World Organization for Animal Health (WOAH), and the United Nations Environment Program (UNEP) has been collaborating to advance the implementation of On Health and support member states to undertake multiple initiatives, and activities that enhance countries preparedness and efficiently respond for health threats at the human-animal-environment interface (15, 16).

One of the initiatives is to enable professional staff from human, animal, and environmental health authorities to jointly assess the risk of those threats, estimate its likelihood and consequences ahead of time based on existing epidemiological data and expert opinion, and end up with key science-based recommendations and communication messages using Joint Risk Assessment Operational Tool (JRAOT) (17). Several countries have been capacitated to perform this assessment, including Pakistan, Afghanistan, Egypt, Sudan, Qatar, Tunisia, Libya, Iraq, and the UAE. Following the building of capacity at the national level, the national staff in the EMR countries have appreciated the importance of this exercise and the usefulness of the JRAOT in their work, so they have taken this forward through different means, such as organizing a cascade training for professional staff at the province level as in Egypt while other countries have used this exercise to assess the risk of zoonotic diseases spread and its related consequences before celebrating large events and mass gatherings in the country as assessing middle east respiratory syndrome coronavirus (MERS-COV), Brucellosis and HPAI in Qatar before the FIFA World Cup.

Emergency care system: emergency care toolkit, basic emergency care course

Well-developed emergency care systems provide timely recognition of urgent conditions, resuscitation and referral for severely ill patients, and the delivery of definitive care for a range of acute illnesses and injuries in both children and adults. Emergency care is an essential part of UHC. Moreover, emergency care systems are indispensable to achieving Sustainable Development Goal (SDG) targets in maternal and child health, non-communicable and infectious diseases, disasters, injuries, and violence. The challenges of the COVID-19 pandemic, climate change, urbanization, and recognition of the need to improve the quality and efficiency of health services have led Ministries of Health to focus on developing effective emergency care systems over the last decade. Recognizing that the effectiveness of many proven health interventions is reduced when care is delayed, the Member States of the World Health Assembly passed a resolution in 2023 on Integrated emergency, critical, and operative care for UHC and protection from health emergencies, recognizing that emergency, critical, and operative care services are necessary to execute the core capacities under the IHR (2005) and to promote the enjoyment of human rights.

The WHO Emergency Care Framework, developed by WHO, describes the essential functions and components of an effective emergency care system – from where the emergency occurs, through prehospital care and transport, to the emergency unit, and on to definitive care (18). Additionally, an Emergency Care Toolkit was developed which is a range of clinical process guidance tools that can be implemented in facilities to ensure that life-threatening conditions are not missed and that timely life-saving interventions are performed. This includes; the integrated inter-agency triage tool (IITT) to categorize and prioritize patients arriving at the emergency room, the Emergency Care Checklists for trauma and medical emergency cases management, Standardized Clinical Forms for trauma and medical emergency cases to ensure proper patient registry and data collection, the Resuscitation Area Designation (Checklist) to ensure optimal availability of staff, space, and stuff to treat critically ill and injured patients in emergency units and finally the Basic Emergency Care Course (BEC) (19).

Developed by WHO and ICRC, in collaboration with the International Federation for Emergency Medicine, Basic Emergency Care (BEC): Approach to the acutely ill and injured is a training course for front-line healthcare providers who manage acute illness and injury with limited resources. BEC teaches a systematic approach to the initial assessment and management of time-sensitive conditions where early intervention saves lives. The course trains participants to be prepared to deal with a variety of critical illnesses, with a focus on trauma, breathing, shock, and altered mental status. The BEC course is intended for individuals who might be able or expected to provide emergent patient care, including students, trainees, nurses, physicians, and even prehospital or inpatient care providers, among others. This course is not only intended for emergency medicine physicians, but for all types of locally appropriate providers. The Methodology of training is comprised of didactic lectures, Interactive workbook questions, Case scenarios and hands-on skills sessions (19).

The WHO-EMR Office recognizes the regional need to support the clinical processes in the emergency units and improve the clinical capacity of front-line healthcare providers to deal with the complex

emergencies happening in the EMR that comprise a wide range of events from natural disasters to conflicts, climate change induced emergencies, and other manmade disasters. The support provided to countries includes training the concerned nationals on the different components of the emergency care toolkit with a focus on the basic emergency care course. The goal is to scale up emergency care capacities in countries with the main goal of improving emergency conditions outcomes and decreasing mortality and morbidity by providing participants with the knowledge and skills to practice a systematic approach to the initial assessment and management of time-sensitive conditions where early intervention saves lives (20).

Safe, emergency and disaster resilient hospitals: hospital safety index tool

Developing safe and disaster-resilient health facilities and hospitals has been a major focus of support provided by the WHO-EMR Office with various training and technical assistance extended to the member states in the region. This initiative aims to develop the capacity of hospitals to manage emergencies and disasters and to continue providing health services to the affected population even after the impact of a danger. To strengthen hospital resilience in countries, WHO-EMR Office supports member states in developing their capacity to identify and better understand the vulnerabilities of hospitals that can potentially hinder their operations during emergencies and to strengthen capacities across the different levels of the disaster management cycle while pooling in all existing resources and tools for operationalization. By doing so, hospitals will be able to integrate improvement actions into their development plans to reduce disaster risks and be better prepared to respond to emergencies and develop disaster resilience.

The Hospital Safety Index tool, developed by WHO, provides a snapshot of the probability that a hospital or health facility will continue to function in emergencies, based on structural, non-structural, and functional factors, including the environment and the health services network to which it belongs. By determining a hospital's safety index or score, countries and decision-makers will have a general idea of their ability to respond to major emergencies and disasters and will be able to improve capacities when needed (21). In this connection, the CPI unit in the WHO-EMR Office trains national teams of evaluators in countries on the hospital resilience concept and its operational resources, with a focus on the Hospital Safety Index tool along with hands-on training on its application using information from existing hospitals. This step is important to provide an opportunity for the teams to build on this initiative and apply the Health Security Interface (HIS) Tool by learning how to conduct the assessment in their respective countries.

Public health emergency operations center

EMR Office has been working to strengthen the emergency preparedness and readiness capacities of the country to support a well-planned and coordinated emergency response. The WHO as a leading public health agency globally adopts the PHEOC concept and develops PHEOC guidance for public health, building on other sectors' successes and lessons learned. A functional emergency

management system through a well-established PHEOC is crucial for coordinating the prevention, preparedness for, and response to public health emergencies. It is a platform that facilitates the participation of various stakeholders and ensures better management of information and resources before and during response operations. The functionality of PHEOCs in countries is vital to their response capacity. Many countries have established PHEOCs, and some were successful in utilizing them in their COVID-19 response alongside other emergencies (22, 23).

Human resources are one of the most precious and scarce resources in the region in terms of number and mix of skills. Strengthening national capacities on the role and functionality of the PHEOC for emergency management is one of the modalities. Staff working in PHEOC need well-defined Terms of Reference (ToRs) clear works SOPs and a regular training program that equips them with the right competencies to perform their duties (24). Staff should not be assigned to roles and responsibilities unknown to them: The PHEOC roles must be aligned as closely as possible with their established skill sets. Staff should receive thorough orientation in a PHEOC setting and training specific to the functions, roles, and procedures they will undertake therein. A training needs assessment – either at the organizational/institutional level or for individuals—proceeds from an assessment of the knowledge, skills, and abilities (competencies) people require to be able to work effectively in a PHEOC, as well as of their training needs and the existing opportunities for collaboration with partners and other sectors. These needs are then compared with known or identified shortfalls to formulate training objectives. The training program is then designed, developed, delivered, evaluated, and projected forward to the next level of training requirements as successive groups of trainees progress from basic awareness to working-level knowledge, and then to advanced competence. Participants in a training program will undertake pre-and-post-training evaluations to confirm that their training objectives have been addressed.

Personnel assigned to work in a PHEOC have three types of training requirements: Training in the incident management system used at the PHEOC, training in the specific function the person is expected to perform within the PHEOC, and emergency management training is part of the subject matter expertise the trainee brings to the operation. There are many recognized training processes to establish knowledge and skills to plan, train, exercise, evaluate, and monitor emergency management. Preparedness phases abilities required to function effectively in a PHEOC staff include the following: Training options include classroom-based courses, e-learning, PHEOC planning and procedure development, site and field assignments for hands-on experience, and team-building exercises. The maintenance program for a PHEOC requires ongoing support from government and private donors in many areas including conducting training and exercises.

Risk communication and community engagement

RCCE strategies have been instrumental in bolstering support during various health emergencies, as demonstrated by the robust response to crises such as the Syria-Türkiye earthquake, the monkeypox (Mpox) outbreak, and the Sudan conflict. Targeted

training packages on crucial health concerns including water, sanitation, and hygiene (WASH), vaccine-preventable diseases, mental health support, and more were deployed across impacted countries. These interventions, created in partnership with entities such as the International Federation of Red Cross and Red Crescent Societies (IFRC) and the Syrian Arab Red Crescent (SARC), aimed to strengthen community preparedness and streamline access to critical health services. Complementing these efforts, the RCCE employed social listening taxonomies and biweekly reporting systems to capture community insights, thus informing customized RCCE and public health interventions (25).

Subsequent RCCE training in the EMR adopted a comprehensive approach to empower communities. Training for the Mpox response highlighted the necessity to raise awareness and allow community participation in prevention efforts, focusing on stigma reduction and community resilience through tailored messaging. Collaborative efforts with academic institutions expanded the efficacy of health interventions through KAP studies to assess community knowledge, attitudes, and practices (26). Moreover, RCCE leveraged social listening for the strategic development of communication materials targeted at cholera and vector-borne disease risks in the aftermath of the Libya floods, showcasing adaptability amidst diverse health emergencies. Building on the foundation of immediate crisis response, RCCE invested in capacity building for health personnel, particularly evidenced by the tailored three-day training that responded to the surge in meningitis in northwest Syria. The training integrated behavioral insights, risk communication, and community feedback mechanisms, highlighting the necessity of community engagement at all levels of the health response continuum.

On a broader scale, the reinvigoration of the Eastern Mediterranean Region Interagency Working Group (IAWG), initiated initially for COVID-19, attested to RCCE's far-reaching commitment to capacity building across multiple health emergencies, ensuring consistent messaging and cooperative response to the Mpox and cholera outbreaks, Morocco earthquake, Libya floods, and escalating hostilities in Gaza. This collaborative framework enabled stakeholders to harmoniously share expertise and resources, enhancing emergency response quality and unity (27).

Furthermore, infodemic management training in countries like the Islamic Republic of Iran and Jordan is indicative of a comprehensive educational philosophy aimed at equipping health systems and communities to withstand future crises. The regional social listening system, which uses AI-driven tools and diverse online platforms, was vital for timely and effective risk communication and health messaging across a spectrum of pressing health crises. In parallel, hands-on exercises, such as SocialNet simulation and deployment training, facilitated a rich interregional exchange of knowledge and practices, which are invaluable for the Region's strengthened response structures. These learning experiences inform crucial insights into RCCE, adaptable to various settings, thus strengthening preparedness and response capacities for health emergencies. The scope of RCCE educational initiatives has played a significant role in the resolution of health crises, underscoring a commitment to capacity building and ongoing community involvement throughout the EMR. These strategic educational efforts have

contributed to the strengthening of health systems and supported the well-being of communities in Egypt, Jordan, Lebanon, Libya, Morocco, Pakistan, Sudan, Syria, and Tunisia, improving the regional emergency response framework as it adapts to emerging public health challenges (28).

Risk management of chemical, biological, and radio nuclear events

Countries in the EMR are frequently affected by various public health emergencies, including disease outbreaks, natural disasters, conflicts, and civil wars. Vulnerability to these risks, *inter alia*, is increased by factors such as low immunization rates in some conflict-affected countries, and high numbers of internally displaced people. Furthermore, full achievement of the public health capacities required under the IHR (2005) to effectively prevent, detect, and rapidly respond to any public health threat remains a work in progress. Although the primary responsibility for the management of the risk of Chemical, Biological, and Radiological (CBRN) events lies with the national governments, WHO is well placed to coordinate specific global public health preparedness and operational readiness, including early warning, threat detection and prioritization, risk management, and global surveillance. In addition, WHO can support Member States in epidemiological investigations and health consequence management of CBRN, in collaboration with key partners in international law enforcement and security domains. A regional risk assessment was conducted in the EMR using the WHO strategic tool for assessing risks (STAR) to identify potential natural and human-induced hazards in the Region. Twenty-three risks were identified as potential hazards that currently or may potentially require regional intervention, of which CBRN events were identified as one of the three highest risks, alongside armed conflict and forced population displacement.

The EMR Office developed a health and security function and initiated a draft Regional Strategic Plan with clear strategic objectives: Advocate for the HSI function, including CBRN, improve EMR capacities for country preparedness for CBRN events, and promote partnerships to support public health and security in the EMR. The implementation of public health work, in coordination with the security sector, increased the effectiveness of preparedness and response to global health security risks. New challenges to public health are being faced worldwide in the form of increasingly and easily accessible dual-use technologies, and growing disease burdens from emerging and reemerging pathogens due to the effects of climate change, in combination with increased mobility. These are compounded by population growth due to displacement, and an increasing frequency of terrorist incidents and perceived terrorist threats in the EMR and neighboring regions, among other challenges. Most of the HSI activities have been implemented in partnership with key partners (such as UNODA/ BWC/ ISU, UNICRI, OPCW, INTERPOL and WHO sister units from different specialties) with objectives to enhance EMR member states capacities for country preparedness for CBRN events and promote partnerships to support public health and security sectors (29).

Lesson learned from the implementation of the emergency preparedness strategies and interventions in the EMR

Several critical lessons have been learned from the adoption of emergency preparedness methods and interventions in the emergency management system. Comprehensive evaluations, particularly the JEE, have been crucial in showing strengths and flagging critical gaps in preparedness among EMR countries. These assessments highlight the importance of identifying baseline preparation levels and prioritizing improvements. Capacity-building initiatives, such as the BEC, have proven critical in providing healthcare workers with the skills required to efficiently handle acute care during crises.

Multisectoral collaboration, as illustrated by the One Health Approach, has proven important in combating zoonotic diseases and health concerns at the human-animal-environment interface. This strategy emphasizes the necessity of coordinating efforts in the health, agriculture, and environmental sectors. Feedback methods, such as SPAR and AARs, have supplied useful information about emergency response systems' strengths and deficiencies. The continuous review and modification of tactics is crucial for improving reaction capabilities over time.

Adaptation to local contexts has been critical, with distinct cultural, socioeconomic, and geographical factors determining response efficacy in various EMR regions. Assessing hospital resilience using instruments like the HSI has highlighted the significance of ensuring that healthcare facilities can resist and respond to emergencies successfully. Integrating technical breakthroughs and innovations, such as digital health and telemedicine, has improved the efficiency and effectiveness of emergency response activities.

The lessons learned from implementing emergency preparation in the EMR will shape future initiatives, stressing comprehensive capacities assessments like JEE, focused capacity building like BEC training, and multisectoral collaboration via the One Health Approach. Feedback mechanisms and local flexibility will improve reaction frameworks, whereas incorporating digital health will improve communication and healthcare delivery during crises. Lessons in hospital resilience from technologies like HSI will strengthen healthcare facilities and ensure effective crisis management. These findings aim to increase readiness, collaboration, and adaptable tactics for future emergencies in the region.

The implications of lessons learned for further emergency preparedness research in the EMR underscore the need for targeted research in the EMR to improve emergency preparedness. This includes continuous refining of different assessment tools like the SAPR, JEE, and AAR, assessing the efficacy of capacity-building efforts like BEC training, investigating the integration of digital health technology, and researching hospital resilience using tools like the HSI. These research activities are critical for developing future disaster preparation plans and interventions in the region, ensuring that they are evidence-based and responsive to changing health concerns and dangers.

Global capacity strengthening

The International Health Regulations and One Health approach play a pivotal role in integrating national and global preparedness measures, ensuring a cohesive and comprehensive strategy for managing health emergencies. The IHR, adopted by WHO State Parties, is designed to prevent, protect against, control, and provide a public health response to the international spread of disease. It mandates countries to develop core capacities to detect, assess, report, and respond to public health threats, thereby strengthening internal preparedness. In addition, the IHR fosters international collaboration and transparency through IHR MEF including, SPAR, JEE, and AAR (7–10). These tools help countries identify gaps in their health systems and implement targeted interventions, which are crucial for aligning national preparedness efforts with global health security objectives. By participating in these evaluations and reporting systems, countries enhance their ability to manage health threats internally while contributing to a coordinated international response.

The One Health approach, which recognizes the interconnectedness of human, animal, and environmental health, further integrates internal and external preparedness measures. This approach promotes multisectoral collaboration among various stakeholders, including health, agriculture, and environmental sectors, to address zoonotic diseases and other health threats that arise at the human-animal-environment interface. By implementing Joint Risk Assessment Operational Tools (JRA OT) and other collaborative frameworks, countries can assess and manage risks more effectively, enhancing their national capacity to respond to health emergencies. Simultaneously, the One Health approach facilitates global cooperation and knowledge sharing, enabling countries to benefit from global expertise and resources. This dual focus on internal capacity building and international collaboration ensures a holistic and robust preparedness strategy, capable of addressing complex and evolving health challenges.

Conclusion

The EMR confronts a wide range of evolving public health challenges, necessitating comprehensive preparedness and response strategies. Countries in the EMR are improving their ability to manage health emergencies through tools and frameworks such as STAR and the IHR-MEF, as well as initiatives such as RCCE. Additionally, efforts to strengthen emergency care systems, ensure safe hospitals, and establish PHEOCs demonstrate a commitment to increasing the resilience of the health system. Furthermore, proactive measures to address CBRN events demonstrate the region's commitment to mitigate emerging threats. By encouraging collaboration, capacity building, and knowledge sharing, the EMR is well-positioned to navigate future health crises with agility and resilience. This collaborative effort highlights the importance of global health security and the EMR's commitment to protecting public health and well-being in the face of adversity.

Author contributions

ME: Conceptualization, Data curation, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. SDH: Writing – original draft. SG: Writing – original draft. JA: Writing – original draft. HM: Writing – original draft. FA: Writing – original draft. NA: Writing – original draft. SM: Writing – original draft. HA: Writing – original draft. AS: Writing – original draft. RG: Conceptualization, Formal analysis, Resources, Supervision,

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Evaluation of a massive open online course for just-in-time training of healthcare workers

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Introduction: COVID-19 created a global need for healthcare worker (HCW) training. Initially, mass trainings focused on public health workers and physicians working in intensive care units. However, in resource-constrained settings, nurses and general practitioners provide most patient care, typically lacking the training and equipment to manage critically ill patients. We developed a massive open online course (MOOC) for HCWs in resource-constrained settings aimed at training bedside providers caring for COVID-19 patients. We describe the development, implementation and analysis of this MOOC.

Methods: From May through June 2020, the course was developed by a multi-disciplinary team and launched on two online platforms in July. The 4-hour course comprises 6 video-based modules. Student knowledge was assessed using pre- and post-module quizzes and final exam, while demographics and user experience were evaluated by pre- and post-course surveys and learning platform data.

Results: From July 17th to September 24th, 30,859 students enrolled, 18,818 started, and 7,101 completed the course. Most participants worked in healthcare (78%) and resided in lower middle- (38%) or upper middle- (20%) income countries. Learners from upper middle-income and lower middle-income countries had higher completion rates. Knowledge gains were observed from pre-module to post-module quizzes and a final exam. Afterward, participants reported increased self-efficacy regarding course objectives, a 0.63 mean increase on a 4-point scale (95% CI [0.60,0.66]). Most participants (93%) would recommend the course to others.

Conclusion: This article demonstrates the potential of MOOCs to rapidly provide access to emerging medical knowledge during a public health crisis, particularly for HCWs in high- and middle-income countries.

Introduction

Since the first patients with COVID-19 were reported in Wuhan, China, at the end of 2019, cases have been documented on every continent in the world with current estimates in excess of 766 million cases worldwide (1). While countries spanning the entire income spectrum have been impacted, low- and middle-income countries (LMICs) as well as remote and rural healthcare systems in high-income countries (HICs) have been particularly vulnerable — they are at increased risk of being completely overwhelmed, potentially leading to enormous, yet preventable, loss of life (2). Though many health system elements are required to respond to this health crisis, equipping the world's 60 million healthcare workers with the appropriate knowledge and skills to care for patients with COVID-19 infections is one critical component. Evidence suggests that the early case fatality rate for infected patients quickly dropped 20%, in part, through increased provider experience and the resulting improvements in their routine care (3). This pandemic has highlighted the need for timely, widespread, and effective healthcare worker training focused on the bedside care of patients during global health crises, both now and into the future.

In early 2020, during the initial stages of the pandemic, a number of educational initiatives were launched at global, national, and local levels. The first open-access COVID-19 educational programs focused on caring for critically ill patients requiring invasive mechanical ventilation or public health interventions (4, 5). These programs mirrored synchronous efforts to strengthen infrastructure, such as increased intensive care unit bed capacity and ventilator availability. While the vast majority of patients suffering from COVID-19 did not require invasive mechanical ventilation, the mortality of those who did require intubation remained stubbornly high (6, 7).

In most settings worldwide, and particularly in resource-limited settings, patient care is primarily provided by nurses and other non-physician providers in conjunction with generalist physicians. These providers typically have minimal training in performing advanced airway interventions or managing complex, critically ill patients (8–10). Consequently, the opportunity for improving patient outcomes in most regions of the world was in strengthening the skills necessary for the identification, evaluation and treatment of COVID-19 patients with mild to moderate illness — where appropriate early intervention could obviate the need for invasive mechanical ventilation (11–13). To date, however, there is a paucity of evidence that exigent inservice training targeting providers in LMICs and rural and remote areas (i.e., resource-limited), particularly in the midst of a global health crisis, can be effective for knowledge uptake or influencing clinical practice (14, 15).

Massive open online courses (MOOCs) may be a valuable method of disseminating optimal patient care recommendations to bedside healthcare workers during healthcare crises. Thus far, the vast majority of MOOCs have been designed for, and utilized by, students in North America and Europe (16, 17). Very little published literature has reported on MOOCs designed for inservice training of healthcare workers in LMICs, despite their significant potential impact in this space (18–21).

Abbreviations: HCW, healthcare worker; HICs, high-income countries; ICUs, intensive care units; LMICs, low- and middle-income-countries; MOOC, massive open online course; PPE, personal protective equipment; SD, standard deviation.

In addition to identifying effective methodologies for reaching and training healthcare workers in lower resource settings, presenting credible and evidence-based training materials is also critical. An infodemic — where vast amounts of information and misinformation on a topic are readily available leading to confusion and fallacy — has been a consistent challenge during the COVID-19 pandemic, documented across over 30 countries (22, 23). To combat this, a WHO technical consultation on the COVID-19 infodemic has called for strategic partnerships across all sectors, including social media/technology, academia, and civil society, to serve as trusted information sources (24).

Using a self-directed learning theory, we developed and deployed a free-of-charge MOOC entitled "COVID-19: Training for Healthcare Workers" (16). Self-directed learning theory allows individuals to guide their learning, establish their learning objectives, and manage their time based on their needs while still benefiting from access to carefully curated content (25). Our aim was to evaluate the viability of MOOCs to provide rapid access to emerging medical knowledge in the early stages of the COVID-19 pandemic. We hypothesized that participants would show improvement in knowledge gain and self-efficacy toward relevant course topics centered around diagnostic assessment and treatment of COVID-19.

Materials and methods

Educational design and delivery

In May through July of 2020, we developed a massive open online course using an international team of 22 emergency medicine physician educators, 3 medical illustrators, 3 video editors, 2 education technology staff, and 1 project manager. The majority of the development team had prior experience designing and building online educational programs. The framework used to construct the learning objectives was the backward design process: (1) Identify desired results; (2) Determine acceptable evidence; and, (3) Plan learning experiences and instruction (26). Learning objectives were defined by a core physician leadership team. The academic faculty that developed the COVID-19 course learning objectives were all medical school faculty from U.S. academic institutions—many with extensive experience designing medical school courses and developing online curricula for medical education. These objectives focused on the essential knowledge and skills deemed necessary for bedside healthcare workers to recognize and care for suspected and confirmed COVID-19 patients in the early and middle stages of their disease course. The course was broken down into 6 modules comprising 15 topic-focused lecture videos (Box 1).

We anticipated that the majority of our target learners — self-directed, currently practicing healthcare workers in LMICs and remote and rural settings — would engage in course content via mobile devices. To optimize uptake by these learners, we aimed to produce brief (≤10 min) videos with minimal amounts of simplified text and universal imagery. We followed design principles developed through prior work aimed at using visual styles that resonate across diverse global audiences. The 15 video-based lectures totaled approximately 3-h in length and were accompanied by lecture handouts for review and reference. The course was subsequently launched on two online platforms, Coursera and EdX, on July 17th, 2020. It was also offered as a course on the free mobile application, Digital Medic.

BOX 1 COVID-19 course modules.

Key features and PPE

- Recognizing key features
- PPE and scene safety

Clinical assessment

- Approach to the sick patient
- Shock evaluation at the bedside
- Assessing the dyspneic patient - clinical

Diagnostic assessment

- Assessing the dyspneic patient - diagnostic
- Ultrasound in COVID-19

Early treatment

- Treating the mildly dyspneic patient
- Treating the moderately dyspneic patient - part 1
- Treating the moderately dyspneic patient - part 2

Advanced treatment

- Treating the severely dyspneic patient - part 1
- Treating the severely dyspneic patient - part 2
- Treating the severely dyspneic patient - part 3

Invasive mechanical ventilation

- Ventilator management - part 1
- Ventilator management - part 2

Course analysis

From July 17th to September 24th, 2020, we recruited all learners who enrolled in the course on Coursera and EdX to participate in our course evaluation. Written informed consent was obtained digitally through a request on the course platforms. Learners who chose not to participate in the evaluation could still access the same course materials. Consenting participants completed questionnaires before and after the course and their course quiz and exam scores were de-identified and included in the analysis. Ethical approval was obtained by the Institutional Review Board at Stanford University (Protocol 57831).

In the baseline survey, participants reported their age, gender, profession, context of employment, education level, and ethnicity/race. Participants' country of occupancy was obtained from Coursera and EdX directly. Participant knowledge was assessed using pre- and post-module quizzes and a final exam. Knowledge questions were drafted by the faculty content experts who designed the module materials and reviewed by at least two additional faculty and education and instructional design team members. The percentage of correct answers during a participant's first attempt was used to determine their score. Students were asked to rate their confidence before and after the course in various domains using a 4-point Likert scale. A 4-point scale was chosen in order to force a specific opinion and eliminate a "neutral" option. Each item was rated as follows: 1 = Strongly disagree, 2 = Somewhat disagree, 3 = Somewhat agree, 4 = Strongly agree.

Data from the pre-course demographic survey were summarized using descriptive statistics. To evaluate predictors of course completion, univariate and multivariable logistic regression was used. Paired t-tests were used to detect differences in participant knowledge and self-efficacy scores before and after the course. To assess changes

in knowledge, we compared pre-module versus post-module scores, as well as pre-module versus final exam scores. To examine whether there were differences between learners from different backgrounds, knowledge and self-efficacy scores were stratified by occupation and country income level for additional analysis. Data from the participants' course satisfaction ratings were summarized using descriptive statistics. All statistical analyses were performed using STATA SE version 16.

Results

Course engagement

Between July 17th and September 24th, 2020, 30,859 learners enrolled in the course with 18,818 starting the course. Of those who started the course, 10,714 participated in the pre-course survey, 7,101 completed the course, and 5,184 completed the post-course survey (Figure 1). Female participants accounted for 55% of enrollees that started the course (Table 1). The majority of participants (69%) were less than 40 years of age. The median time to course completion was 4.2 days (IQR 1.0–11.9 days).

Participants by provider type

MOOC participants were predominantly healthcare workers and held higher education degrees. Healthcare workers that were neither physicians nor nurses accounted for the highest percentage of course participants who started the course (33%) while physicians accounted for one-fifth of all learners (Table 1). Students made up one quarter of participants. This included both those who identified as working at a clinical site and those that reported not practicing clinically. Non-healthcare workers accounted for 9%.

Geographic distribution of participants

A plurality of participants (40%) came from high-income countries (HICs) followed closely by lower-middle (38%) and upper-middle-income (20%) countries (Table 1). Participation by geographic region was highest in North America (25%) but closely followed by South Asia (24%) and Latin America and the Caribbean (17%). The smallest percentage of participants came from Sub-Saharan Africa (6%).

Knowledge gain

Overall course participants demonstrated significant improvement in knowledge upon course completion. While the mean score of pre-module quizzes was 52%, participants averaged 74% on post-module quizzes and 78% on the final exam (mean difference pre vs. post 23% [$p < 0.001$] and pre vs. final 26% [$p < 0.001$]). Non-physician healthcare workers and students demonstrated knowledge gain on par with physician participants (Figure 2). Similar improvements in knowledge were obtained by participants from HICs compared to LMICs, with participants in LMICs demonstrating slightly greater
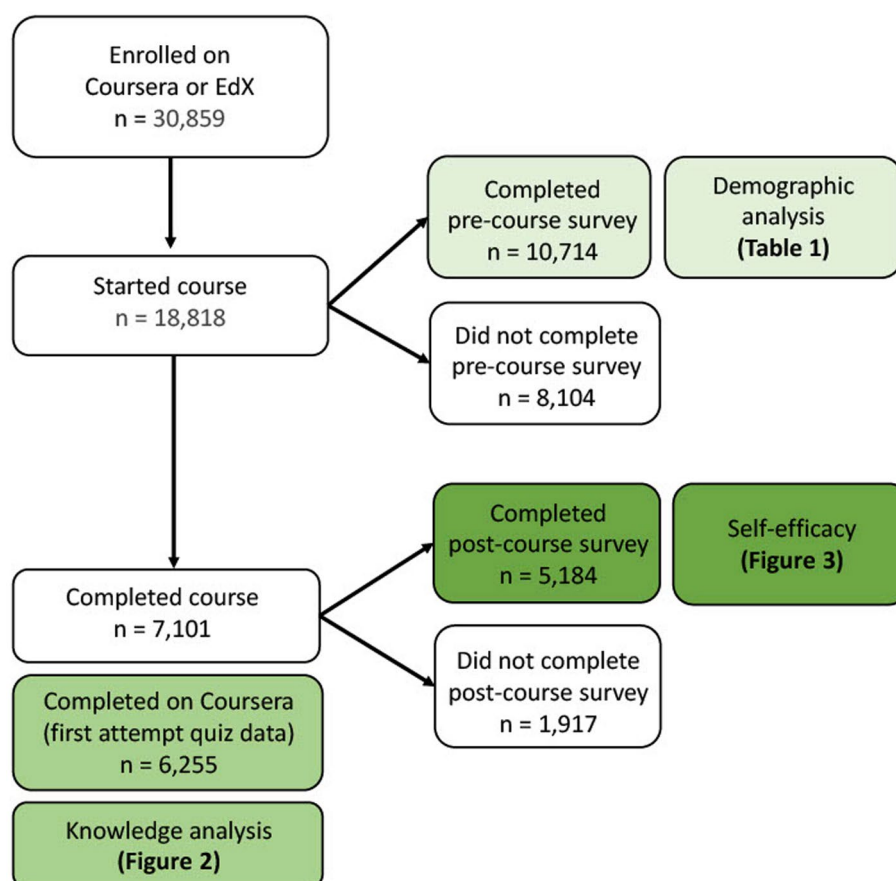
FIGURE 1
Participant enrollment and completion.

improvements in knowledge (mean difference, pre vs. post: 23% LMICs vs. 22% HICs ($p < 0.001$) and pre vs. final: 27% LMICs vs. 25% HICs [$p < 0.001$]) (Figure 2).

Predictors of course completion

On multivariable analysis, participants from low-middle and high-middle-income countries were more likely to complete the course compared to learners from HICs (Table 2). Physicians, nurses and students had similar course completion rates with lower completion rates noted in other healthcare workers and non-healthcare workers. Additionally, participants reporting female gender and from 40 to 59 years old, compared with those <39 years of age, were less likely to complete the course.

Survey results

Following course completion, there were substantial improvements in learner confidence in caring for COVID-19 patients and in their self-assessment of both the adequacy of their training and access to information regarding COVID-19 (Figure 3). Further, healthcare workers who completed the course strongly agreed that the course was relevant and provided them with new knowledge about

COVID-19. Most learners (92.5%) stated they were likely to recommend this course to their colleagues.

Discussion

Principle findings

This article demonstrates that MOOCs can effectively reach practicing healthcare workers in both high-income and middle-income countries and provide timely clinical training during a healthcare crisis. Providers from a multitude of backgrounds sought out self-directed clinical training on the recognition and care of COVID-19 patients, with a high percentage of learners completing the course. Survey findings revealed that knowledge scores improved regardless of provider background and geography. Supplementing these gains, providers reported increased confidence in their clinical skills to care for COVID-19 patients as well as the availability of both relevant and accurate information regarding the pandemic.

Findings in context

Just-in-time learning during a pandemic or other health crisis is imperative to improving patient outcomes and protecting the

TABLE 1 Characteristics of participants who started the course.

	N (%)
Age (N=10,323)	
18–39 years	7,353 (71%)
40–59 years	2,445 (24%)
60 years or older	525 (5%)
Gender (N=10,587)	
Male	4,325 (41%)
Female	6,161 (58%)
Other	101 (1%)
Profession (N=10,264)	
Healthcare (non-physician/nurse)	3,346 (33%)
Physician	2,204 (21%)
Nurse	1,286 (13%)
Student (clinical)*	1,185 (12%)
Student (non-clinical)*	1,368 (13%)
Non-healthcare	875 (9%)
Context of employment (N=10,185)	
Hospital/Inpatient	3,891 (38%)
Non-hospital/Outpatient	3,428 (34%)
Non-healthcare	2,866 (28%)
Highest level of education (N=9,768)	
High school degree or less	1,982 (20%)
College degree	3,060 (31%)
Master's degree	1,419 (15%)
Doctorate, professional, or medical degree	3,307 (34%)
Race (N=9,838)	
Arab	600 (6%)
Black, African, or African American	1,041 (11%)
East Asian	557 (6%)
Hispanic	1,848 (19%)
South or Southeast Asian	3,148 (32%)
White or Caucasian	1,855 (19%)
Other	789 (8%)
World Bank Income Group (N=10,662)	
High income	4,299 (40%)
Upper middle income	2,183 (20%)
Lower middle income	4,041 (38%)
Low income	139 (1%)
Geographic Region (N=10,662)	
East Asia & Pacific	1,130 (11%)
Europe & Central Asia	957 (9%)
Latin America & Caribbean	1,920 (18%)
Middle East & North Africa	855 (8%)
North America	2,638 (25%)

(Continued)

TABLE 1 (Continued)

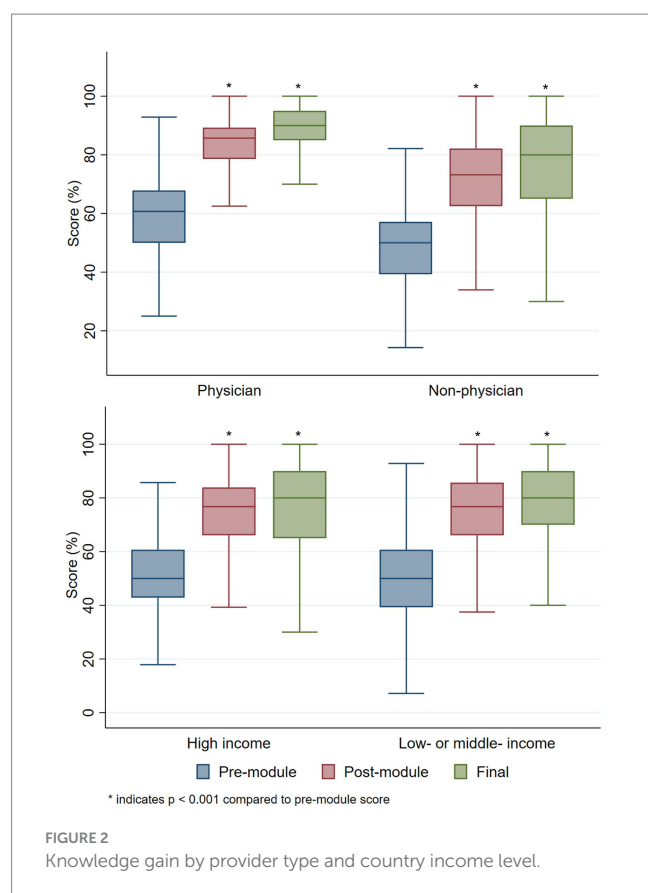|	
South Asia	2,489 (23%)
Sub-Saharan Africa	673 (6%)

*Students were categorized as clinical if they reported working in an inpatient or outpatient clinical context. Due to rounding, percentages may not sum to 100.

healthcare workforce. While healthcare resources have been strained in many environments during the pandemic, those in LMICs and rural and remote areas are scarce at baseline, making their response to the pandemic even more challenging (27–32). Furthermore, HCWs in LMICs may experience lower access to pandemic-related training, potentially impacting preparedness and quality of care (33). The immediate necessity of HCW training during the pandemic adds substantially to the ongoing burden of delivering quality care to patients. However, with the rapid rise in access to smartphones over the past decade, mobile online training has become feasible and accepted in many settings (34). This approach allows for the development of rapidly scalable training programs with the potential for broad distribution, without taxing the already-limited local resources.

Evans and colleagues reported on a MOOC deployed during the Ebola outbreak in 2014–2015 aimed at educating the general population on the virus. One-third of their learners came from developing economies, however, only a small fraction of their learners came from nations with active Ebola outbreaks and they did not report specifically on HCW participation or knowledge gain (35). Sneddon et al. (20) conducted a MOOC aimed at improving HCW antimicrobial stewardship. While 70% of their learners were HCWs, the course was administered as live participation over 6 weeks and assessment of knowledge gain and course efficacy by participant clinical job, demographic factors, or country income level were not evaluated.

During the COVID-19 pandemic in addition to our course, other international health organizations, universities, and nations have launched online training programs that have enrolled large numbers of users (5, 36, 37). Utenen et al. launched a course on the OpenWHO platform that covered multiple topics related to COVID-19, from emerging respiratory viruses to community engagement (5). This MOOC experienced tremendous enrollment in both the Spanish and English versions of the course. Interestingly, the Spanish version of the course had a dramatically higher completion rate (36%) than the English version (3%). Sixty percent of users were listed as "Other" or "Student" and they did not specifically report the percent of HCWs practicing clinically nor include knowledge assessments. The distribution of users accessing the OpenWHO COVID-19 course, our offering, and other similar MOOCs has repeatedly skewed toward middle- and high-income-countries. While governments in low-income countries (LICs) have implemented pandemic-related information dissemination and contact tracing through mobile applications, pandemic-related online education for HCW in LICs remains relatively underexplored (38). While MOOC's can clearly reach healthcare workers in these nations, it remains unknown whether open-access online training solutions are equally viable options in low-income countries (LICs), given limited data due to low enrollment of providers from LICs.

Encouragingly, course completion rates, knowledge scores, and survey responses all suggested — despite the course materials being

FIGURE 2
Knowledge gain by provider type and country income level.

TABLE 2 Course completion rates by characteristic[a].

Characteristic	Adjusted odds ratio	Std. Err.	p-value	[95% Conf. interval]
Age				
18–39 years	Ref			
40–59 years	0.894	0.049	0.042	0.802–0.996
60 years or older	1.009	0.105	0.929	0.824–1.237
Gender				
Male	Ref			
Female	0.869	0.039	0.002	0.795–0.95
Other	0.764	0.179	0.251	0.482–1.21
Profession				
Physician	Ref			
Nurse	1.158	0.100	0.090	0.977–1.371
Other healthcare (non-physician/nurse)	0.835	0.057	0.008	0.731–0.954
Student (clinical)	1.159	0.101	0.090	0.977–1.374
Student (non-clinical)	0.877	0.101	0.254	0.700–1.099
Non-healthcare	0.602	0.067	<0.001	0.484–0.748
Context of employment				
Hospital/inpatient	Ref			
Non-hospital/outpatient	0.924	0.048	0.125	0.835–1.022
Non-healthcare	0.904	0.073	0.214	0.771–1.060
Highest education level				
Doctorate, professional, or medical degree	Ref			
Master's degree	0.830	0.061	0.011	0.719–0.959
College degree	0.946	0.057	0.357	0.840–1.065
High school degree or less	1.063	0.075	0.385	0.926–1.221
World Bank Income Group				
High income	Ref			
Upper middle income	1.087	0.066	0.171	0.965–1.226
Lower middle income	1.177	0.062	0.002	1.062–1.304
Low income	0.739	0.144	0.120	0.505–1.082
N	8,945			
Likelihood ratio chi-squared (G^2)	159.32			
Pseudo R^2	0.013			

[a]Multivariate logistic regression, univariate regression model provided in Supplementary Appendices.

developed in English and mostly by providers based in the United States — that the course was effective across diverse geographic locals. In contrast to the typical <10% completion rates among MOOCs, our course had a completion rate of 38% (39). Additionally, knowledge scores improved significantly regardless of provider geography. The improvement in knowledge was also reflected in learner sentiment, with over 90% of learners reporting the receipt of adequate training and improved confidence in their ability to care for patients with COVID-19. These positive findings were consistent for non-physician healthcare workers too, as this cohort reported strong improvements in knowledge and self-efficacy.

Non-physician providers make up the majority of all healthcare workers, and account for even higher percentages of the workforce in LMICs (40). A plurality (31%) of learners in our program were healthcare workers representing neither physicians (21%) nor nurses (12%), such as pharmacists (3%) and emergency medical technicians (2%). The diverse training backgrounds of our enrolled providers, including non-physician healthcare workers, attests to their substantial interest in clinical training during a global health crisis; and, a free-of-charge MOOC effectively contributed to meeting this widespread demand.

Several factors may have contributed to the course's relatively high completion rate, knowledge gain, and feedback scores documented in this report. First, our education and design teams have extensive experience in delivering both in-person and online content to healthcare providers from across the globe. This experience enabled course creators to adopt a versatile style that incorporated limited text, simple language, references to trusted materials, and highly focused

content with direct relevance to clinical practice. Second, unlike traditional MOOCs, which often take months to complete, our MOOC was developed with an eye toward practicing healthcare workers whose time for continuing education was extremely limited and who required information on COVID-19 immediately. In line with self-directed learning theory, the entire course was designed to be completed within 5 hours, and its duration was segmented into brief modules requiring <15 min of continuous engagement. This
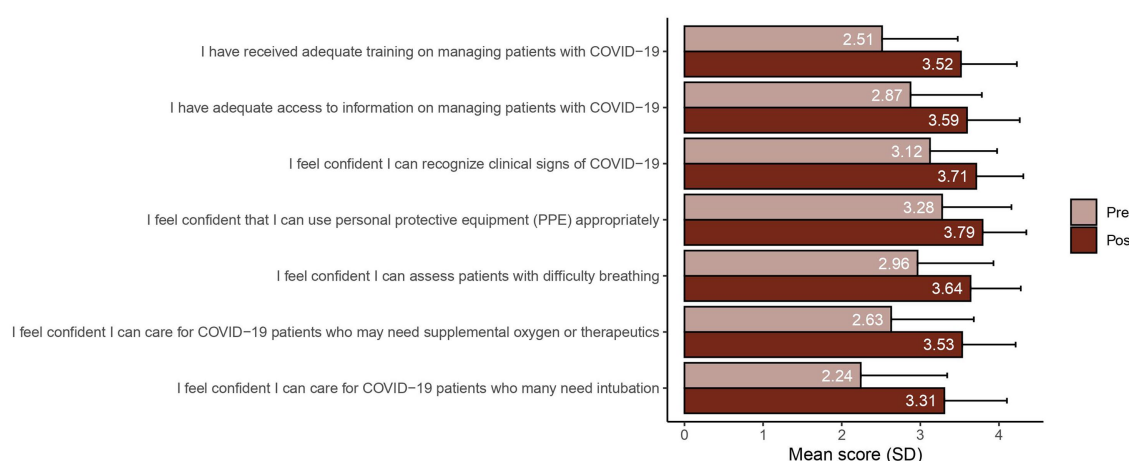
FIGURE 3
Learner self-assessment of training and access to information.

time-sensitive format was intended to boost engagement from providers in LMICs, who might have restricted availability (due to job or home commitments) or unreliable internet access. Third, we were able to offer the course and certification free of charge (Coursera) or at an extremely reduced cost (EdX). Many non-physician healthcare workers in LMICs are often living near the poverty line themselves and cost may heavily influence their ability to access training programs.

Challenges and next steps

Our evaluation found the course was successful on many fronts, however, a number of limitations exist. First, the COVID-19 pandemic has brought with it innumerable challenges, one of which is the deluge of information, and misinformation, available to individuals and communities (22–24). The rapidly evolving evidence used to guide best clinical practices along with the disparate recommendations from local, national, and international health organizations, particularly early on during the pandemic, made it challenging to produce educational materials that could gain broad acceptance yet contain clinically actionable information. Furthermore, as information evolves, keeping materials and guidelines up to date poses a significant challenge, particularly at an international level (41). Even when course materials are kept current, providers that have completed the course may not continue to engage with new or revised materials, leading to knowledge decay (42).

Second, while our findings of short-term knowledge gain and improvements in participant self-assessment are encouraging, they may not be clinically meaningful. Future research is required to evaluate if inservice training for healthcare workers via a MOOC during a healthcare crisis improves long term knowledge, clinical decision making and patient-oriented outcomes.

Third, while thousands of healthcare workers were trained, millions more healthcare workers are practicing on the frontlines and require clinically relevant information during the pandemic. From our results, it is unclear if MOOCs can effectively reach providers in low-income countries and in rural and remote environments, where access to the internet may be tenuous or nonexistent. Alternative course delivery options and additional languages are being launched

as prior evidence demonstrates that offering MOOCs in multiple languages can dramatically increase enrollment (5).

Conclusion

Future pandemics and outbreaks will require a rapid, consolidated global response to minimize patient morbidity and mortality. Several strategies have been identified to prevent further escalation to the level of a global health crisis, notably HCW education on infection prevention and control strategies (43). Given the country-to-country variability regarding infection prevention guidelines, MOOCS can address the need for rapid, standardized access to emerging medical knowledge during public health crises (41).

This study demonstrates that MOOCs can effectively reach practicing HCWs in low-income countries and provide inservice training during a global health crisis. Physician and non-physician providers from a multitude of geographies and backgrounds sought out self-directed clinical training on recognizing and caring for COVID-19 patients with a high percentage of learners completing the course. Knowledge improved across all participant groups regardless of demographic and other characteristics. Future research is required to understand the impact on patient-oriented outcomes and how to better reach HCWs in low-income countries.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Institutional Review Board at Stanford University (Protocol 57831). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

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Conflict of interest

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2024.1395931/full#supplementary-material

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Determinants for the humanitarian workforce in migrant health at the US-Mexico border: optimizing learning from health professionals in Matamoros and Reynosa, Mexico

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Introduction: Shortages of health professionals is a common problem in humanitarian settings, including among migrants and refugees at the US-Mexico border. We aimed to investigate determinants and recruitment recommendations for working with migrants to better understand how to improve health professional participation in humanitarian efforts.

Methods: Semi-structured interviews were conducted with health professionals working with migrants at the US-Mexico border in Matamoros and Reynosa, Mexico. The study aimed to identify motivations, facilitators, barriers, and sacrifices to humanitarian work, and recommendations for effective learning approaches to increase participation. Participants included health professionals working within humanitarian organizations to deliver healthcare to migrants living in non-permanent encampments. Interviews lasted approximately 45 min and were analyzed in NVivo14 using a validated codebook and team-based methodology.

Results: Among 27 participants, most were female (70%) with median age 32. Health professionals included nurses (41%), physicians (30%), logisticians (11%), social workers (7%), an EMT (4%), and a pharmacist (4%) from the US (59%), Mexico (22%), Cuba (11%), Peru (4%), and Nicaragua (4%) working for four organizations. Participants expressed internal motivations for working with migrants, including a desire to help vulnerable populations (78%), past experiences in humanitarianism (59%), and the need to address human suffering (56%). External facilitators included geographic proximity (33%), employer flexibility (30%), and logistical support (26%). Benefits included improved clinical

skills (63%), sociocultural learning (63%), and impact for others (58%). Negative determinants included sacrifices such as career obligations (44%), family commitments (41%), and safety risks (41%), and barriers of limited education (44%) and volunteer opportunities (37%). Participants criticized aspects of humanitarian assistance for lower quality care, feeling useless, and minimizing local capacity. Recommendations to increase the health workforce caring for migrants included integration of humanitarian training for health students (67%), collaborations between health institutions and humanitarian organizations (52%), and improved logistical and mental health support (41%).

Conclusion: Health professionals from diverse roles and countries identified common determinants to humanitarian work with migrants. Recommendations for recruitment reflected feasible and collaborative approaches for professionals, organizations, and trainees to pursue humanitarian health. These findings can be helpful in designing interventions to address workforce shortages in humanitarian migrant contexts.

1 Introduction

Health worker shortages are one of the most pressing problems affecting humanitarian and global health settings (1). This burden is exacerbated in low-middle income countries (LMICs), as 83 of 186 countries did not meet minimum health professional thresholds as outlined by the World Health Organization (2). While multiple components are needed for quality care delivery including adequate resources, access pathways, and political willingness, availability and capacity of health workers remains one of the hardest to solve in resource-constrained environments (3). With more than 100 million forcibly displaced persons worldwide depending on humanitarian health systems for necessary care (4), determining how to better motivate, recruit, and empower health professionals to work in such systems is imperative to optimizing migrant care (3). At the US-Mexico border, over 2.4 million migrants annually are seeking safe passage into the United States, with drastic increases in recent years (5). There, asylum seekers and refugees are living in non-permanent encampments lacking basic public health measures, face increased risks for disease and violence, and depend on humanitarian organizations for basic medical care (6). Despite increased health needs and potential acuity of vulnerable migrants at the US-Mexico border, there is a dearth of health professionals working with this population (6).

It is unclear why health worker shortages remain such a persistent problem in humanitarian and other low-resource health contexts (7, 8). Some factors are well-known, including a lack of compensation, fear of burnout or emotional exhaustion, and concerns for safety (8–11). In 2023, 2,562 incidents of violence against health professionals working in conflict settings were reported across 30 countries, a 25% increase from the previous year (12). Additional hypotheses include a lack of humanitarian career development pathways and limited opportunities for education among health professional students (13). Studies aimed at investigating motivations for humanitarian health work have demonstrated that religious and moral motivations,

self-perceived usefulness, increased compensation, training opportunities, and leadership development can all incentivize health workers to work in these contexts (8, 14, 15). Some efforts have explored the impact of medical education initiatives to address health worker shortages in underserved areas, including exposing medical students to global health, service-learning opportunities, and increasing admissions of students from these areas (16, 17). However, many of these efforts focus specifically on rural or global health and fail to account for the specific characteristics of humanitarian contexts including safety risks, acute mobilization, and shorter-term commitments (17). Even less is understood about health worker motivations to care specifically for migrants in humanitarian settings, including refugees and asylum seekers at the US-Mexico border (18).

In this study, we aimed to investigate the determinants which motivate health professionals to work with migrant populations at the US-Mexico border, as well as recommendations for motivating others to address health workforce shortages among refugee populations. Specifically, we sought to understand the internal motivations and sacrifices, external facilitators and barriers, and challenges of humanitarian aid experienced by health professionals caring for migrants at the US-Mexico border. These findings could prove valuable in understanding best practices to promote facilitators, mitigate barriers, and enhance recruitment of qualified health professionals to improve health worker availability for vulnerable migrant populations.

2 Methods

2.1 Study design

To determine the motivations, facilitators, sacrifices, barriers, and recruitment strategies for humanitarian health professionals, a qualitative study with a phenomenological approach was undertaken. This methodology was considered most appropriate given the complex

internal and external, individual-centered factors involved in the study question and the opportunity to elicit detailed explanations provided by qualitative methods (19). First, a semi-structured interview script was created following a literature search of qualitative studies examining the experiences of health professionals working in migrant and other humanitarian contexts (20). Preliminary questions were content validated by administering the interview and receiving feedback from health professionals working at the US-Mexico border ($n = 4$). Following clarification of questions and purging repetitive items, the final interview script was designed to last 45 min and contained 25 items covering participant characteristics, incentives and disincentives, and tangible solutions to address health workforce shortages (Supplementary material 1).

2.2 Study setting and participants

This study took place at the US-Mexico border in Matamoros and Reynosa, Mexico. These study sites were selected as they are two of the major points of entry for those seeking asylum in the United States, and where migrant encampments have been established following changes to US immigration policy beginning in 2019. In these locations, migrants including asylum seekers and refugees live in non-permanent encampments with limited access to public health measures and face increased exposure to disease and violence (6). Humanitarian non-governmental organizations provide most health and other social services to migrants in these locations, while asylum seekers await processing into the US for indeterminate amounts of time (21). Global Response Medicine (GRM) and Médicos Sin Fronteras (MSF) are two of the major organizations providing physical and mental health services, respectively, to these populations in Matamoros and Reynosa (22). Eligible participants for this study included health professionals, defined as those delivering clinical care or health services to migrants residing within these camps. Such professionals included physicians, nurses, emergency medical technicians, logisticians, social workers, physical therapists, and clinical psychologists. Participants spoke English, Spanish, or both and were required to have worked with migrants for at least 1 week. Lawyers, paralegals, legal advocates for asylum seekers, and others without formal health professional training or limited clinical experience with migrants were excluded from this study.

2.3 Data collection

The first round of interviews was conducted in Matamoros, Mexico in the main migrant encampment in July 2020. The second round was conducted in February 2023, in Reynosa, Mexico in four camps located throughout the city. At both locations, a snowball sampling method was utilized to recruit participants with diverse ages, roles, and humanitarian experiences. First, investigators approached health professionals from GRM and MSF within the migrant camps and at established clinical sites. These participants were asked to recommend additional eligible persons from other humanitarian organizations who may be interested in participating. All interviews were administered by a bilingual, qualitative researcher who was not affiliated with a local humanitarian organization, and in a private location in English or Spanish according to patient preference.

Interviews were audio recorded with the EasyVoiceRecorder app on iPhone and uploaded to a secure DropBox (Dropbox, Inc.; San Francisco United States) only available to study researchers. Interviews were continued until data saturation was reached, defined as the cessation of new themes according to preliminary analysis of the study team.

2.4 Data analysis

Participants were assigned a numeric code to further guarantee anonymity and interviews were transcribed verbatim in Microsoft Word. Analysis was conducted using a team-based content analysis approach with a validated codebook (23). Specifically, two researchers underwent inductive immersion into the transcripts to develop a codebook with major themes, which then underwent an interactive process of independent coding, calculating interrater agreement, and refinement to clarify themes (Supplementary material 2). Following three rounds of iteration, a Cohen's Kappa of 0.79 ($\kappa = 0.79$) was achieved and considered adequate (24). The final codebook contained 61 subthemes categorized into seven major themes: motivations, facilitators, benefits, sacrifices, barriers, challenges, and solutions (Figure 1). Transcripts were coded in NVivo14 (QSR International, Burlington, MA, United States) and theme frequencies were calculated. Quotes were selected to represent a diverse range of participants and translated into English. Measures were taken to ensure trustworthiness of data including (i) using a team-based and validated coding method, (ii) independent and cooperative data analytic techniques by multiple study members, (iii) member checking with health professionals on the research team, and (iv) consensus on final results by research members.

2.5 Ethical compliance

This study adheres to SRQR guidelines for qualitative research (25).

3 Results

3.1 Participant characteristics

Twenty-seven interviews were conducted among humanitarian health workers in Reynosa ($n = 17$) and Matamoros, Mexico ($n = 10$; Table 1). Participants were mostly female (70%), with ages ranging from 22 to 67 years old (median = 32, IQR = 29–54). Participants hailed from the United States (59%), Mexico (22%), Cuba (11%), Peru (4%), and Nicaragua (4%), with varying levels of education and professional roles. Two-thirds performed patient consultations: "*I am a general physician. So what I normally do is consult any patient that arrives: chronic patients, children, well-child visits, prenatal care, or whatever arrives, I administer treatments or any other procedure you would do in a consult*" -Physician. Other roles included doing triage and patient intake (11%), providing psychosocial services (15%), logistics management (19%), interpreter services (4%), and pharmacy management (4%). There was a mix of short-term volunteers (41%

Determinants for Humanitarian Work Among Health Workers

Motivations & Facilitators	Sacrifices & Barriers	Benefits	Challenges	Solutions
Internal drivers and external factors which positively influenced involvement in humanitarian work	Personal sacrifices and external barriers which prevented humanitarian involvement	Personal or professional outcomes from humanitarian work which positively impacted health professionals	Difficulties experienced by participants when engaging in humanitarian work, including criticisms of humanitarian aid	Recommendations to address service challenges and motivate more health professionals to engage in humanitarian efforts

FIGURE 1
Major themes describing determinants to work with migrants in humanitarian contexts among health professionals in Matamoros and Reynosa, Mexico.

<1 month) and long-term humanitarian workers (26% >1 year), with many having experience in other humanitarian settings (74%) and specifically with asylum seeker populations (41%). Participants from Matamoros had a higher likelihood of working in the camp for a longer period of time (>6 months) than those from Reynosa ($p = 0.049$; Figure 2).

3.2 Motivations

Participants identified internal motivations to pursue humanitarian health work with migrants. Most commonly, participants expressed a personal desire to help vulnerable populations (78%; Table 2). There were multiple components of personal identity which motivated participation, including a belief in universal justice (41%), using one's skills and privilege as a health professional for good (33%), a religious calling (11%), and family upbringing which encouraged service work (19%). Others expressed having a high level of personal resilience (7%), which they believed obligated them to humanitarian work given their unique persistence. Empathy was commonly mentioned, as participants witnessed the intense suffering of refugees (56%) or had undergone their own hardships (15%). Two providers from Matamoros who were asylum seekers themselves felt an especially deep form of solidarity and call to serve this population (7%). Some had positive experiences in the past with humanitarian or disaster relief work which inspired them to seek further opportunities (59%), while others were motivated by recommendations from colleagues and mentors (33%). Participants reported being frustrated with their home health systems (19%), which prioritized efficiency, revenue generation, and protocolization above care for those needing it most. These professionals hoped that doing humanitarian work could provide an antidote to burnout and recenter their original motivations for pursuing a health career: to care for others. Some motivations were unique to work at the US-Mexico border. US participants expressed a moral obligation to

care for migrants at their Border, as they attributed the vulnerable health status and residence in camps of migrant patients to restrictive US immigration policy, which they felt responsible to reconcile (11%).

3.3 Facilitators

Participants expressed external facilitators which allowed them to do humanitarian work. The greatest facilitator was employer related. Among full-time humanitarian workers, they appreciated having employment which allowed them to use their skills while addressing a social problem. For short-term volunteers traveling from the US, employer support was a key facilitator (30%). In some cases, clinicians received salary or logistical support for their humanitarian work (19%), facilitated by employer-sponsored disaster, humanitarian, or global health institutes with the funding and flexibility to allocate this time. Participants in Reynosa were more likely to mention employer support, as many worked for institutions with established partnership to GRM's Reynosa project. More commonly, participants sacrificed personal vacation time, were between jobs, or intentionally structured their careers with the freedom to volunteer, such as the case among travel nurses or career humanitarians (22%). A key facilitator even for seasoned humanitarians was logistical support from the organization, as GRM provided free housing and travel (26%). For those sacrificing vacation or salary, this support proved financially and emotionally beneficial. Finally, the US-Mexico border context yielded additional facilitators leading to commitment to do this work. Participants expressed that most organizations require commitments of months to years to do humanitarian work, place workers in distant and unfamiliar contexts, and may require willingness to work in conflict and other unsafe areas. While participants recognized safety concerns at the US-Mexico border, particularly with the presence of cartels, they felt that the opportunity to volunteer for shorter amounts of time (19%), proximity to home for US clinicians (33%), and relative safety (22%) increased their ability to dedicate time to this work.

TABLE 1 Participant characteristics among humanitarian health workers in Reynosa and Matamoros, Mexico.

	Total $n = 27$ (%)	Reynosa $n = 17$ (%)	Matamoros $n = 10$ (%)
Gender			
Male	8 (30%)	3 (18%)	5 (50%)
Female	19 (70%)	14 (82%)	5 (50%)
Age			
18–25	4 (15%)	4 (24%)	0 (0%)
26–40	12 (44%)	7 (41%)	5 (50%)
41–65	8 (30%)	5 (29%)	3 (30%)
> 65	3 (11%)	1 (6%)	2 (20%)
Country of origin			
USA	16 (59%)	11 (65%)	5 (50%)
Mexico	6 (22%)	6 (35%)	0 (0%)
Cuba	3 (11%)	0 (0%)	3 (30%)
Peru	1 (4%)	0 (0%)	1 (10%)
Nicaragua	1 (4%)	0 (0%)	1 (10%)
Highest education			
Terminal degree (PhD, MD, DNP)	8 (30%)	5 (29%)	3 (30%)
Master's (NP, MS, MPH)	11 (41%)	7 (41%)	4 (40%)
Bachelor's	7 (26%)	4 (24%)	3 (30%)
Associates	1 (4%)	1 (6%)	0 (0%)
Occupation			
Nurse	11 (41%)	8 (47%)	3 (30%)
Physician	8 (30%)	5 (29%)	3 (30%)
Logistician	3 (11%)	1 (6%)	2 (20%)
Social Worker	2 (7%)	2 (12%)	0 (0%)
Interpreter	1 (4%)	0 (0%)	1 (10%)
Pharmacist	1 (4%)	0 (0%)	1 (10%)
Emergency Medical Technician	1 (4%)	1 (6%)	0 (0%)
Work with humanitarian organization			
Patient consultations	18 (67%)	12 (71%)	6 (60%)
Triage and patient intake	3 (11%)	2 (12%)	1 (10%)
Psychosocial services	4 (15%)	2 (12%)	2 (20%)
Logistics management	5 (19%)	3 (18%)	2 (20%)
Interpreter services	1 (4%)	0 (0%)	1 (10%)
Pharmacy management	1 (4%)	0 (0%)	1 (10%)
Time working with current humanitarian organization			
< 1 month	11 (41%)	7 (41%)	4 (40%)
1–6 months	5 (19%)	5 (29%)	0 (0%)
7–12 months	4 (15%)	0 (0%)	4 (40%)
> 1 year	7 (26%)	5 (29%)	2 (20%)
Worked in asylum health in the past	11 (41%)	7 (41%)	4 (40%)

(Continued)

TABLE 1 (Continued)

	Total $n = 27$ (%)	Reynosa $n = 17$ (%)	Matamoros $n = 10$ (%)
Worked in humanitarian health in the past	20 (74%)	12 (71%)	8 (80%)
Time working in humanitarian medicine over lifetime			
< 1 month	9 (33%)	7 (41%)	2 (2%)
1–6 months	3 (11%)	3 (18%)	0 (0%)
7–12 months	1 (4%)	0 (0%)	1 (10%)
> 1 year	14 (52%)	7 (41%)	7 (70%)

3.4 Benefits

Health professionals identified multiple benefits to working with migrants. First, most expressed feeling a personal joy, fulfillment and increased sense of purpose from helping others and making a positive difference (58%): "*It feels good to know you have helped someone, knowing you were a face that made them seen and valued despite what the rest of the world is telling. I enjoy being able to affirm people's value in that way.*" -Nurse. Others felt accomplished recruiting and empowering others to care for vulnerable migrants (22%): "*The most satisfying piece is enabling people to do this work for the first time and in a professional, respectful, appropriate way. My hope is they go off and find a piece of this world which inspires them to keep doing this work.*" -Nurse. Many appreciated the adventure of travel (22%) and increasing their network of colleagues with similar values and career interests (44%). Most benefited from learning about new cultures, as asylum seekers with diverse beliefs arrived from all over the world, particularly Latin America and the Caribbean (63%): "*The biggest benefit is meeting people from all over the world. Listening to their stories and having friendships from other countries including with volunteers. It is beautiful to experience new places through the stories of others*" -Logistician. Four clinicians even improved their Spanish language skills through patient consultations and collaboration with Mexican physicians (15%).

US workers gained a heightened awareness of social issues, particularly the politico-legal dimensions of immigration and asylum. 37% felt that their work with asylum seekers changed their perception on the best way to deliver care to vulnerable groups, including the importance of psychosocial issues, preventive care, and empowering migrant populations by involving them in health service co-design. Participants reported new clinical skills from the difficulty of this work, including caring for patients requiring extensive social services, treating diseases which were uncommon at home, and using creativity to provide quality care in a resource-constrained environment (63%). They reported improved care delivery methods and ways of relating to patients, particularly when language and resource barriers impaired care. Clinicians believed working with migrants made them better health professionals for their improved clinical skills, medical knowledge, and rapport-building: "*I've gained so much knowledge, especially working in this context. When I started, I had a 'school ideology' based in North American textbooks but have learned how to integrate needed skills and learning. I'm always seeing the sickest patients, so that pushes me to do all I can for them. It has helped me grow into a better clinician*" -Physician.

FIGURE 2
Subthemes of internal motivations, external facilitators, and benefits to working with migrants in humanitarian contexts among health professionals in Matamoros and Reynosa, Mexico.
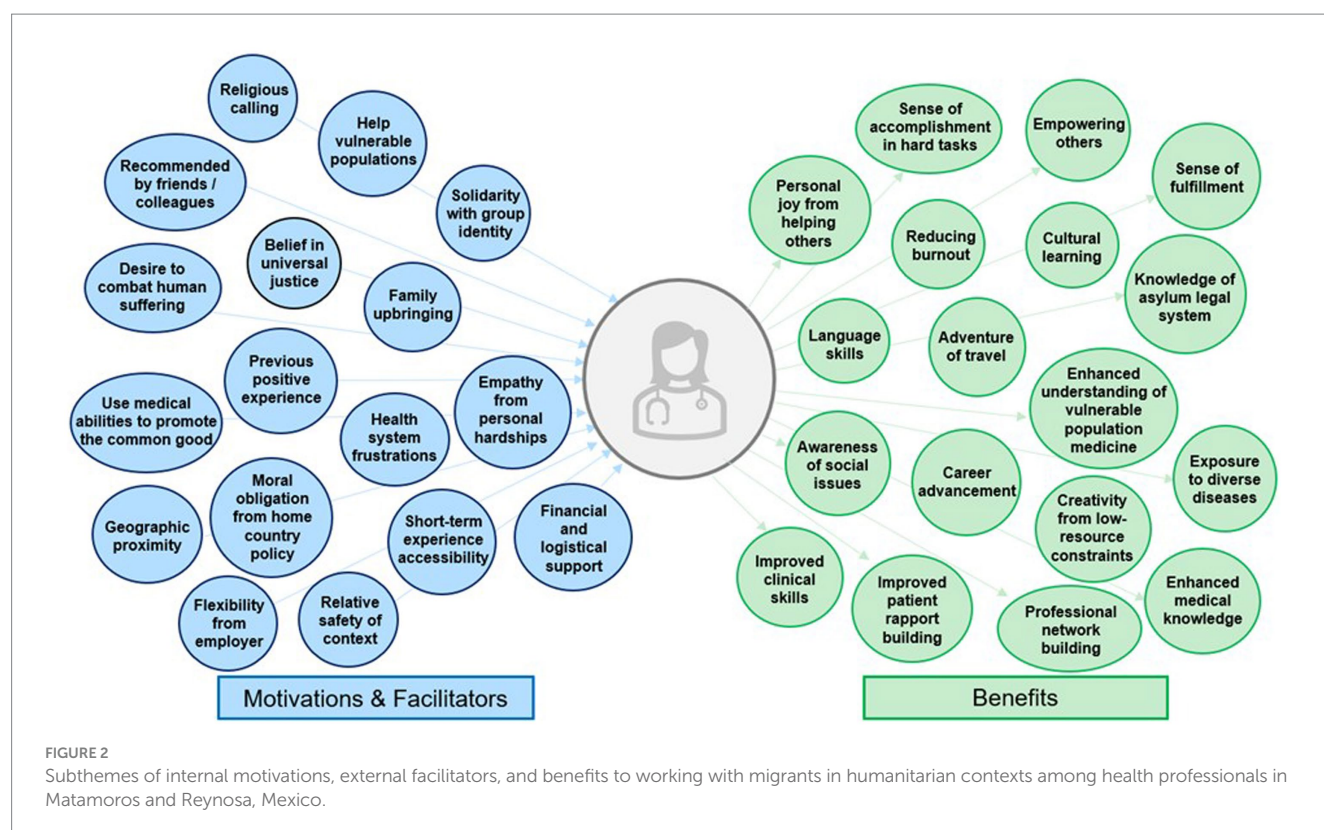
3.5 Sacrifices

Participants also counted personal sacrifices which disincentivized them from humanitarian work. Most frequently mentioned were career obligations, as many found it difficult to sacrifice time from work or devote vacation to humanitarian work (44%). While many reported improved patient skills, most employers did not value humanitarian work in a way that facilitated career rewards. Physicians more frequently mentioned this struggle when compared with other health professionals, as time away had to be compensated by practice partners. Participants reported financial sacrifices, including forgoing salary and self-funding travel and lodging to do this work (26%). Family commitments were second most common (41%). First-time volunteers expressed wanting to work with migrants earlier but not wanting to leave children or partners to do so. Long-term humanitarian professionals found it harder to establish long-term connections to a home base area and described the challenge of living a nomadic lifestyle (11%). Almost half of participants sacrificed safety and comfort for humanitarian work, causing nervousness when becoming involved (41%). Finally, one-third listed emotional difficulties, including witnessing intense human suffering and stark health inequities, leading to an emotional burden and occasional burnout (33%). One-third of participants explicitly stated they encountered no or negligible sacrifices to their humanitarian work (33%). Those living close to the border including Mexican physicians, asylum seeker health workers, and US clinicians residing in border states were more likely to report having no sacrifices to humanitarian work.

3.6 Barriers and challenges of humanitarian aid

Alongside personal sacrifices, participants cited external barriers to humanitarian health work, including overall criticisms of the field. Barriers included limited knowledge, education, and career development in humanitarian activities (44%). From the time of being students to fully certified clinicians, participants struggled to learn about, apply, and be accepted to volunteer with assistance groups (37%). Most actively sought out extracurricular or service-oriented volunteering but discovered limited long-term career development opportunities, as few planned academic or clinical careers around humanitarian work. Certain aspects of clinical work challenged participants' effectiveness, including language barriers with primarily Spanish and Haitian Creole speaking patients (11%), limited autonomy depending on local delivery structures (7%), and unfamiliar protocols with different standards of care from typical practice (19%). Health professionals criticized aspects of humanitarian aid generally, including that organizations did not track reliable patient care metrics (7%), had limited resources and funding (19%), and created tensions between migrant community expectations with feasible resource provision (7%). Some professionals believed that quality standards were being lowered due to a lack of resources and objective accountability (22%). Five worried that the presence of humanitarian organizations could unintentionally minimize the capacity of local communities and governments to help themselves, particularly when done without equitable partnership (19%). Many worried that the rapid turnover and varied clinical specialties of volunteers limited consistency and standardization. Finally, participants expressed frustration with bureaucracy of humanitarianism (15%), the prioritization of

TABLE 2 Internal motivations and external facilitators to work with migrants in humanitarian contexts among health professionals in Reynosa and Matamoros, Mexico.

Theme	Count (%)	Representative quote
Internal motivations		
Desire to help vulnerable populations	21 (78%)	"I like the idea of helping people that have nothing. I feel comfortable and enjoy it. It does not feel like work, but something natural." -Logistician
Past positive experience in humanitarian work	16 (59%)	"I think my previous experience definitely makes me more likely work with asylum seekers. I felt a huge push from past experiences for the passion to be in places like this and do this work." -Nurse
Witnessing human distress and suffering	15 (56%)	"There are people who do not deserve the treatment they receive. I've seen cases of rape, abuse, and mistreatment that breaks your heart listening to these stories." -Physician
Belief in justice and fairness	11 (41%)	"I think that everyone with privilege should realize the needs of others and work with vulnerable persons. Once you meet these inspiring people, you realize this is where I should be working." -Social worker
Obligation to use professional skills for common good	9 (33%)	"It's a justice issue. If you have the ability as someone in healthcare to alleviate another's suffering, then you have an obligation to do so." -Nurse
Recommendations from friends or colleagues	9 (33%)	"One night my attending [physician] happened to be the director of GRM, and she mentioned something about humanitarian work so I inquired and learned about it from there." -Nurse
Family upbringing	5 (19%)	"I grew up with parents talking about how lucky we are. There are people who aren't as fortunate and I want you to see and interact with them. If you are that lucky, you should help them." -EMT
Religious calling	3 (11%)	"I've lived here my whole life and this is where God has me now. My skills and talents are being used where God thinks is best." -Logistician
Frustration with home health system	5 (19%)	"The health system in the US is so focused on making money. I just want to help people and all this humanitarian work, especially with migrants, reminds you to help those without consistent care." -Nurse
Empathy from personal hardship	4 (15%)	"It is easy to feel connected because I hear their traumas and feel so bad because I was feeling bad for my problems, but they do not compare." -Interpreter
Moral obligation related to home country's restrictive policies	3 (11%)	"I've been upset and sad about the behavior of our country towards our neighbors. And so as a physician, one of the ways I try to make restitution for our sins is to help out medically." -Physician
High level of resilience	2 (7%)	"Living through my own challenges, I know what my capacities are. I can tolerate beyond what the average person can. So if I can do that and have the clinical skills, I should help." -Nurse
Solidarity with group identity	2 (7%)	"I am one of them. I am a doctor, but also am a migrant asylum seeker. I'll never lose that part of myself, and feel a great solidarity to relate myself more to these patients." -Physician
External facilitators		
Geographic proximity to volunteer site	9 (33%)	"I started working because it was accessible. I was already staying in the area, and the project manager knew of my skills and asked if I wanted to help." -Interpreter
Permission from employer	8 (30%)	"The fact that my hospital offers support to be here is pretty outstanding. They have a flexible enough schedule that I can work a little extra then take time off as a block and have coverage for those two weeks." -Physician
Logistical support	7 (26%)	"It normal takes a lot of money to travel. But GRM now has Airlink to cover travel expenses and a guest house, which is unheard of for work like this, but makes it much more financially accessible." -Nurse
Flexibility in work life, career change, or unemployment	6 (22%)	"Originally I was travel nursing and finished an assignment in April. I decided it was a good time to come because I had some savings and no work commitments." -Nurse
Relative safety of context	6 (22%)	"There's all these issues around the world of much bigger scale: Syria, Yemen, Sudan, and they are inaccessible for our hospital from a safety and security perspective. The border has safety challenges but is a more chronic problem with known concerns." -Nurse
Financial support	5 (19%)	"I do not have a barrier because my hospital is taking care of everything financially. Even my airfare was covered, either by the organization or my employer." -Nurse
Short-term experience	5 (19%)	"I had always been interested in this work, but many of the well-known groups like Doctors without Borders and UNICEF require extreme commitments like a minimum six months commitment. This commitment is much easier, because I can live in the states and volunteer for one week or two." -Nurse
Working within comfort of personal capacity	3 (11%)	"One of my personal concerns is personal safety. I'm not going to go to a war zone unless I'm trained to do that, so I was glad to find something where I could contribute without putting myself in harm's way." -Physician

appearances over quality work (15%), and conflicts between overlapping organizations (7%). Overall, first-time volunteers were just as likely to criticize humanitarian aid as experienced participants, as there was no association between the number of previous humanitarian experiences and likelihood of a participant to share critiques (Table 3).

3.7 Recommended solutions

Participants recommended solutions to better motivate, support, and recruit health professionals to humanitarian health delivery for migrants. Solutions generally mirrored the sacrifices, barriers, and challenges identified by participants (Table 4; Supplementary material 3). First, participants highlighted the need for active recruitment and collaboration of health professionals and students (67%). Some believed that humanitarian electives should be a requirement to obtain a professional health degree. Many believed that pathways for career humanitarians should be better defined and that humanitarian clinical or research opportunities should be made accessible for health professionals working at private and academic medical centers (22%). Second, participants recommended fostering partnerships between aid organizations, US medical institutions, professional societies, and health education schools (52%). Such connections could provide mutual benefit by facilitating volunteering, demonstrating to younger trainees examples of long-term careers in humanitarianism, fostering research and fundraising collaborations, mitigating employer-related barriers for practicing clinicians, and providing mentors to trainees and young health professionals interested in this work. Participants emphasized the importance of actively encouraging colleagues to become involved, as this was an influential factor for many of them (59%). They recommended doing so with an interdisciplinary approach, where social workers, public health professionals, advocates, interpreters, and others outside of clinical care could contribute valuable skills to migrant care. Third, participants emphasized the importance of demonstrating the health needs of their migrant patients (67%). They believed that exposing this reality to their colleagues and trainees would motivate those who were previously unaware to become involved. Fourth, participants encouraged aid organizations to take steps to mitigate the uncertainties and nervousness of first-time volunteers by providing comprehensive information including travel logistics, role descriptions, and safety protocols prior to applying for a volunteer role (26%). Fifth, health professionals recommended improving knowledge and accessibility of humanitarian work by highlighting opportunities beyond premier, well-known organizations such as the United Nations and Médecins Sans Frontières (Doctors Without Borders), which can be restrictively competitive due to popularity (30%). Specifically, they suggested that smaller organizations engage in writing and publishing activities or provide examples of creative approaches from volunteers who successfully navigated commitments of work or home to participate (22%). Finally, they encouraged organizations to support humanitarian workers through mental health support services, logistical support including for housing and travel, and institutionalized mechanisms to identify and mitigate burnout (41%).

4 Discussion

In this qualitative study of health professionals at the US-Mexico border, our sample identified common positive and negative

determinants for working with migrant populations, as well as recommendations to address health worker shortages in migrant humanitarian contexts. Positive factors included internal motivations, external facilitators, and personal and professional benefits including a desire to help vulnerable populations, career flexibility, improved clinical skills, and a sense of joy and fulfillment from their work. Negative measures reflected internal sacrifices and external barriers such as career and family commitments, safety risks, limited education and volunteer opportunities, and criticisms of humanitarianism in general. Considering these determinants, participants suggested several strategies to increase recruitment of health professionals caring for migrants in humanitarian settings. These recommendations, which aimed to enhance benefits and mitigate challenges, could provide feasible and attainable solutions for organizations, individuals, and health employers to address health workforce shortages in humanitarian settings.

Positive determinants reflected concepts of altruism including a desire to help and vocation for justice, positive past experiences of previous volunteering or colleagues' recommendations, and personal identity through group affiliation, family values, or moral responsibility based on citizenship. External facilitators enabled the feasibility of humanitarian work including employer or social flexibility, geographic proximity and shorter commitments, mitigating safety risks, and financial support. Multiple benefits realized from this work impacted participants personally and professionally through improved clinical skills and knowledge, sociocultural and language learning, and network building, among others. These positive incentives have been shown to be common among health volunteers, including improved physical and emotional wellbeing and that there may be a reciprocally beneficial relationship between these factors (26). Negative determinants shared similar themes, including internal sacrifices of family, career, personal stability and safety, and external barriers which limited effective clinical work including language differences and limited education, career development, and volunteer opportunities. Though not explicitly referenced by our sample, many of these negative determinants can have negative long-term consequences including burnout, career stagnation, and a psychological toll from working in high-stress environments. Both positive and negative determinants to migrant work have been well documented in other humanitarian contexts. A systematic review among health professionals working with migrants in Europe demonstrated the importance of sociocultural competence, adequate training and funding, and collaboration among interdisciplinary actors, but that health workers frequently reported exhaustion and reliance on coping mechanisms for emotionally stressful work (20). For those working in refugee settings similar to our sample, key challenges included linguistic and cultural barriers, lack of training, and feelings of helplessness among providers (27).

These findings contribute to understanding how to better address health worker shortages in migrant and humanitarian contexts. Our sample recommended dozens of tangible and feasible interventions to better recruit, support, and retain qualified health professionals caring for migrants. Such recommendations included early educational interventions for health professional students including integration of humanitarian curricula, formalizing partnerships between established academic institutions and humanitarian organizations, and better defining and rewarding career pathways through mentor, research, and clinical rotation opportunities. While the number of

TABLE 3 Perspectives on internal sacrifices, external barriers, and common challenges to humanitarian assistance from health professionals in Reynosa and Matamoros, Mexico.

Theme	Count (%)	Representative quote
Internal sacrifices		
Career obligations	12 (44%)	"The problem is you need to be available to deploy on short notice, and most employers aren't down for that. You cannot tell your boss you are taking two weeks off tomorrow." -Nurse
Family commitments	11 (41%)	"With responsibilities from a full-time job, family, pet, or parenting, it is hard to break away from all that to do something." -Nurse
Risks to safety and comfort	11 (41%)	"All the horrible things, even being in Reynosa, you have to have a heightened safety awareness because of cartels and the real danger they pose. It can expose you to horrible things in the world." -Nurse
Emotional difficulties including witnessing suffering	9 (33%)	"The greatest challenge is it hurts my heart. It's hard to see people, especially children, in these conditions without food or security. They have suffered so much, and I try to love them as much as I can." -Nurse
No perceived sacrifices	9 (33%)	"This has not been a sacrifice. I live in Reynosa, so I've enjoyed giving back to the community." -Physician
Financial cost and lower salary	7 (26%)	"I think humanitarian work tends to be mobile and does not pay well. Those are some barriers, lifestyle of limited money and being away from home." -EMT
Limited stability in personal life	3 (11%)	"I'm kind of living a nomadic life, with storage in one place, apartment in another, and car somewhere else. I miss being able to be in one area and have a home, but it comes with the territory of this much travel." -Physician
External barriers		
Limited education and training	12 (44%)	"Most people just do not know. In school, I had a professor that spent two weeks each year medical volunteering, but that was the only thing I ever heard." -Nurse
Limited volunteer opportunities	10 (37%)	"The organizational piece to get here was so hard. It took me 3 years of planning just to volunteer for a week. If I have a skill set, why is it so hard to find opportunities? You cannot figure out the right people to talk to or groups to work with" -Nurse
Language barriers	3 (11%)	"The language barrier was a big challenge. Interacting with English-speaking volunteers and with a completely different culture, being at the Border for the first time can be strange." -Logistician
Already overburdened clinicians	2 (7%)	"Helping is very limited due to time. Most Mexican doctors have three different jobs, so they become robots in the hospital who are there 24/7. It does not give much time for altruistic work." -Physician
Limited autonomy	2 (7%)	"Having to choose how to utilize my time. If I'm here, I'm not there, which limits me to focus on priorities." -Logistician
Challenges of humanitarian aid		
Provider feelings of uselessness	6 (22%)	"The emotional burden comes from seeing so much and feeling hopeless, when there's so many things you want to do but cannot. Seeing some sick kid without shoes when it's 40 degrees out and we cannot even find him socks. You feel helpless when you cannot provide the care they need." -Nurse
Lower quality care	5 (19%)	"You cannot really offer consistent care without resources to be effective in these situations. The resources are so limited we are treating symptoms when they really need something like respiratory treatment or an entire workup with labs. At the end of the day, we just do not have the access needed for them." -Nurse
Funding limitations	5 (19%)	"Most of us are volunteers. I've made it clear my contribution is voluntary, but most people cannot do this work without economic remuneration." -Logistician
Minimization of local capacity	5 (19%)	"You look at places which suffer the worst disasters like Haiti which has tons of disaster dollars poured in. And they are still doing terribly, because we go in and strip the capacity of local people to respond to their own emergencies." -Nurse
Protocol differences	5 (19%)	"Learning what the typical treatment plan algorithm where you are working is difficult. There's things the local staff does which are different than at home." -Nurse
Prioritization of appearances	4 (15%)	"The hospitals like to have a disaster group because it looks good for them, but I do not know that they want a lot of people doing it because it probably does not make money. So that's a tension." -Physician
Bureaucracy	4 (15%)	"I wanted to work with migrant populations, though the bureaucracy of it all is complicated. I've learned that with bureaucracy, you cannot do much. So I sought out an organization which limited that so I could do something." -Social worker
Burnout	3 (11%)	"When people are finally in positions of power, I feel they get burned out. So new volunteers come in bright eyed and bushy tailed but are trying to work under people who have been there so long they are jaded or have low expectations of what they can actually provide." -Nurse
Secondary trauma	3 (11%)	"There is secondary trauma that happens with doing this work that can lead you to be harmed, either emotionally, psychologically, or physically. You put yourself in a dangerous way, it can lead to depression or moral injury." -Physician

(Continued)

TABLE 3 (Continued)

Theme	Count (%)	Representative quote
Poor data collection metrics	2 (7%)	"There's a huge lack of quantifiable data on patients. No one has been doing research, which means they will not get the funding they deserve. They need to quantify the health issues related to limited clean water, or engage with patients to figure out the health barriers." -Nurse
Balancing community expectations with feasibility	2 (7%)	"They wanted certain foods like chicken, but there's no refrigeration. And we do not want people getting sick from rotten food. It's a constant balance of how to allocate resources." -Logistician
Interorganizational conflict	2 (7%)	"We developed a great plan, except it wasn't accepted. It was just bypassed because honestly I think the Mexican officials from Instituto Nacional de Migracion felt like we were overstepping our boundaries." -Logistician

humanitarian-specific training opportunities has been increasing, there remains global inequality in access to these programs due to financial and geographical constraints (28). Furthermore, such concepts are rarely integrated into health professional education in a way that is mandatory or accessible to interested students (29). These approaches may be effective, as early exposure to medical care among vulnerable populations, service-learning, and partnerships between institutions and volunteer organizations have all been shown to increase health worker interest and participation in medical work among vulnerable populations (30, 31). Examples of such programs could include sponsored clinical rotations in humanitarian settings, mentored research projects with contextual experience through data collection, and courses on adaptation to medical practice in humanitarian care delivery, some of which have already been successfully implemented at health education training programs in the US, Democratic Republic of the Congo, Thailand, Canada, Australia, and New Zealand (32). Other strategies from our sample focused on raising awareness to recruit current health workers including advertising through professional societies, running medical outreach trips to raise awareness for migrant health disparities, information dissemination through publication and presentation to colleagues, and for organizations to expand research efforts and volunteer pools to include interdisciplinary fields. Potentially most impactful, our sample recommended formalizing collaborations between health employers and humanitarian organizations to mitigate one of the greatest barriers of career obligations and create bidirectional benefit for each institution. While such approaches have been proposed for humanitarianism, few have been actualized in practice (33). Finally, material and emotional support could increase participation including assisting with travel and other financial logistics, defining roles to mitigate uncertainty, and attentiveness to the mental health needs of health professionals (20).

There were several novel aspects to this study. First, we interviewed health professionals at the US-Mexico border, which despite the large increases in migrant populations and health needs, remains an understudied area compared with other refugee contexts. Since most humanitarian contexts overlap with under-resourced or LMIC health systems, our findings could have greater impact for resource mobilization from the US given proximity to deployable resources and US-based charities. Compared with the experiences of health professionals in other humanitarian settings, our sample revealed many unique determinants that were specific to working at the US-Mexico border. These included a moral obligation from US citizens to counteract restrictive immigration policies implemented by their own country, geographic proximity, and accessibility of short-term commitments. These differences suggest the importance of

context-specific determinant assessments in recruiting and retaining humanitarian health professionals. Second, we intentionally recruited participants across two ports of entry at the US-Mexico border and selected for a diverse sample of providers across multiple organizations, health professional roles, humanitarian experiences including long and short-term commitments, and varied countries of origin and primary language. This diversity revealed differences across participant groups, including that Matamoros workers were longer-term, Reynosa participants more often benefited from employer-humanitarian organization partnership, physicians more often emphasized employer flexibility as a key facilitator, and those living close to the border were less likely to report sacrifices. There were unique challenges between short and long-term workers, such as career or family obligations and instability in social lives, respectively. Interestingly, criticisms of humanitarian aid and most benefits and motivators did not differ between participants of varied experience level, age, or health professional role, as might be expected. Despite the variation in our sample, common responses from participants demonstrated the universality of many determinants to humanitarian work and that recommended solutions could hold promise for other humanitarian contexts. Third, three of the health professionals in our study were part of the asylum seeker population they served. When such efforts have been made in other settings, unintentional negative consequences may arise, such as the case with refugee health workers in Uganda who faced increased discrimination, costly credentialing processes, and unclear clinical scope (34). These barriers were not identified by our sample, suggesting the influence of contextual factors, such as the heterogeneous nature of the migrant population themselves, as well as GRM's hiring and credentialing process as an effective approach to equitable inclusion of asylum seeker health professionals. Finally, our sample enumerated 12 criticisms of humanitarian aid which limit organizations from optimizing care delivery. While challenges with humanitarian assistance have been hypothesized previously, limited in-depth evidence has evaluated the nuance behind and consequences of these critiques for health professionals working in the field (35, 36). Our qualitative evidence provides multifaceted and diverse accounts of how these challenges can have direct impacts on health professionals and the populations they serve.

Other findings from our study were notable. First, it was surprising that participants listed limited volunteer opportunities as a major barrier to humanitarian work. In light of evidence showing quantifiable health worker shortages in such contexts, there is a notable discrepancy in willingness to volunteer and opportunities to do so. Exploring the etiology for this discrepancy and piloting quality improvement efforts aimed at increasing the capacity of humanitarian organizations to accept

TABLE 4 Recommended solutions to handle challenges of humanitarian assistance among migrants in Reynosa and Matamoros, Mexico.

Sacrifices, barriers, or challenges	Potential solutions	Representative quote
Burnout and secondary trauma	Provide mental health or spiritual support services such as chaplains Allow decompression opportunities following traumatic experiences Foster strong communities where secondary trauma can be processed	"There definitely needs to be a piece of this work where you are in a community where people acknowledge the secondary trauma that can happen. I actually trained to be a chaplain for the disaster team. And one of the experiences we had on assignment was so awful, I felt that support was needed and appreciated." -Physician
Career obligations	Institutionalize humanitarian work opportunities through employers Promote leadership which will dedicate time to humanitarian work Select a job in humanitarianism Select a practice with multiple and flexible partners who can cover Negotiate time for humanitarian work into one's contract	"I do not create the motivation, rather facilitate it from a professional perspective. If I can wedge out a bit of our employees' time and professional responsibilities and keep them getting paid, I can create a safety net to bring in all kinds of people who normally would not work in these settings." -Nurse
Family and social obligations	Pursue humanitarian work when commitments are minimal Select opportunities which mitigate tension between family and work Involve families in work, where appropriate	"I've always wanted to explore a humanitarian project, but timing wise, I could not do this until my kids were out of the house. And then this opportunity appeared, where there was a need in my own backyard, so I jumped at it." -Physician
Financial burden	Provide salary coverage Offer logistical support in covering travel or lodging expenses Formalize volunteer time commitments for logistical support	"The big barrier for me was financial assistance to come here. So that's a huge incentive if things like airfare or housing can be provided. It could be done in conjunction with some sort of commitment, like if we pay for X amount of your trip, then you'll give us three week of volunteer time per year." -Nurse
Ignorance to humanitarian needs	Write or publish stories, blogs, or research about humanitarian need Demonstrate need to friends and colleagues with stories and photos Offer short-term medical outreach campaigns	"I think it would be great to do medical campaigns, show people what is really happening here. Because most doctors do not actually know what is occurring. They just say 'oh, they are migrants, but they already have help,' when really that's not true." -Physician
Limited knowledge, education, and career development pathways	Collaboration between health schools and humanitarian organizations for clinical rotation or research opportunities Hiring health education faulty with humanitarian expertise Integrate humanitarianism into medical education Design curricula and service-learning opportunities for health students	"It needs to be readily available in education. Having a professor that has done humanitarian work, who students can speak to and hear from someone whose actually done it and has knowledge on the subject. And then if students want to, opportunities could be created. If an organization partnered with a school, they could schedule a clinical rotation to give that student a very real, hands-on experience to get their feet wet. If there was more of an emphasis on it in schooling, it would not be such an unknown path forward or difficult thing to do." -EMT
Limited opportunities	Actively recruit colleagues with well-suited skills Promote volunteering with smaller organizations Recruit through national societies Present humanitarian experiences to social networks Create organizational partnerships	"One way is to increase recruitment. Something like providing lectures, or contacting organizations like the American college or any national society and letting people know these opportunities are available. Because I know many health professionals who want to do this work but they do not know about how to go about it or the right organizations to contact. Even newspapers, or paying to get a marketer. And for us, doing all we can to get the word out to others we work with. -Nurse
Provider feelings of uselessness	Take time to develop clinical, humanitarian, and language skills before volunteering Align volunteer skills with community needs Provide resources for adequate care delivery	"When I started my new job, I felt that I finally developed a baseline skill set in clinical care. But that's one thing, and the entire other skill set in the humanitarian sphere is a whole other. I started to volunteer with our disaster response team." -Nurse
Risks to safety and comfort	Transparency on role and day-to-day activities Well-designed safety protocols Working in less risky environments	"One improvement would be more transparency, what a typical day looks like with responsibilities. I think the unknown scares people away. If you say I'm going out of the country for a humanitarian medical trip, people think it's crazy. They think its so unsafe. If we can make the work more transparent, it would definitely get more interest." -Nurse

Barriers in Table 4 were intentionally selected to reflect personal barriers for health professionals and those relating to the most commonly mentioned recruitment strategies. A full list of sacrifices, barriers, and challenges with corresponding solutions and representative quotes is available in Supplementary material 3.

health workers or improve recruitment materials could be valuable. Second, participants infrequently mentioned fear of indiscriminate violence or political pressure, which are common among humanitarian workers in other settings (27). This difference could be attributed to the relative stability of the US-Mexico border compared with other refugee contexts and freedom of movement and expression for US or Mexican nationals. Our sample did not mention rigidity of the health system as a barrier, despite this being a frequent challenge for health providers in other refugee settings (27). Given that GRM and MSF worked in small, mobile health teams, these operations may have increased flexibility for staff. Opposingly, a lack of rigidity may contribute to unstandardized protocols, treatment guidelines, or resource availability. Humanitarian organizations could benefit from determining the appropriate amount of operational structure to facilitate quality care for patients, while granting sufficient autonomy to health workers. Finally, our participants mentioned operational challenges including bureaucratic inefficiencies and a lack of standardized protocols. A persistent challenge for many health systems, such issues could be addressed through systematic approaches to organization, care delivery, and outcomes reporting through frameworks such as implementation science (37). More specifically, implementing evidence-based approaches could mitigate these challenges, including standardized clinical practice guidelines derived from organizational resources and forming humanitarian clusters based on the World Health Organization model through which organizations can collaborate (38).

4.1 Limitations

This study had several limitations. First, the qualitative nature of our methods limits generalizability to health workers outside of the US-Mexico border or even other ports of entry. Therefore, the challenges and determinants identified here may not fully represent those faced by health workers in all other global humanitarian settings. For example, the accessibility of volunteering, shorter-term commitments, and employer support as facilitators are likely unique to our sample and may not be available to those working in conflict zones or long-term development projects. We postulate that our findings may closely reflect those of other health workers working in border migrant settings but situated within more well-resourced environments. An additional limitation to generalizability was our smaller sample size with participants representing a limited number of humanitarian organizations. However, the in-depth explanations, varied roles, and extensive past humanitarian experiences from our sample suggest these results may be applicable in other settings, particularly when discussing determinants of border and migration humanitarianism. Second, our sample worked at the US-Mexico border for a limited amount of time among a select number of humanitarian organizations, which did not include all groups providing aid in Reynosa or Matamoros. This limitation could influence participant perspectives on operational challenges and intraorganizational dynamics. Our data collection periods were separated by approximately two and a half years, which could lead to different perspectives particularly in the US-Mexico border setting, where immigration policies are rapidly changing in nature and could have implications for migrant health. However, it was determined during analysis that major themes were shared between each location and that many of the providers who were interviewed in Reynosa had also worked in Matamoros over the preceding 3 years. Finally, our results

only included health professionals. Though we included a diverse group of physicians, nurses, and logisticians among others, incorporating the perspectives of humanitarian organization administrators, government officials, or migrant patients themselves could produce more robust data.

5 Conclusion

Health professionals working with asylum seekers and refugees at the US-Mexico border were able to identify common positive and negative determinants to delivering health services to migrants in humanitarian settings, as well as recommendations to address health worker shortages. Determinants included incentivizing motivations, facilitators, and benefits, alongside disincentivizing sacrifices, barriers, and challenges. Recommendations reflected feasible and early intervention strategies for recruiting health professionals including integration of clinical and research opportunities into health professional education, collaboration between health institutions and humanitarian organizations to reduce employment-related barriers, and increasing transparency and professional support services to clarify the process for working with humanitarian organizations.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the University of Michigan Institutional Review Board (HUM00186322). The studies were conducted in accordance with the local legislation and institutional requirements. The ethics committee/institutional review board waived the requirement of written informed consent for participation from the participants or the participants' legal guardians/ next of kin because oral informed consent was obtained in accordance with recommendations of the IRB to further guarantee anonymity of participants.

Author contributions

CR: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing. SR: Formal analysis, Investigation, Methodology, Validation, Writing – review & editing. EA: Formal analysis, Investigation, Methodology, Validation, Writing – review & editing. IB: Formal analysis, Investigation, Visualization, Writing – review & editing. SB: Investigation, Methodology, Project administration, Resources, Supervision, Writing – review & editing. BT: Project administration, Resources, Supervision, Writing – review & editing. JB-A: Resources, Writing – review & editing. JI: Data curation, Project administration, Resources, Supervision, Writing – review & editing. PV: Data curation, Project administration, Resources, Writing – review & editing. LO: Data

curation, Project administration, Writing – review & editing. SD: Investigation, Methodology, Resources, Supervision, Writing – review & editing. AM: Investigation, Supervision, Validation, Writing – review & editing. FS: Conceptualization, Investigation, Project administration, Resources, Supervision, Validation, Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2024.1447054/full#supplementary-material

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Healthcare capacity strengthening in conflict settings through virtual emergency medical training and outreach: Ukraine and Sudan case studies

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The use of digital learning in healthcare is expanding in a range of contexts including for settings of armed conflict. Humanitarian emergencies and war often lead to a surge of traumatic injuries, emotional distress, and disruption to health systems risking neglect and exacerbations of chronic illness, and acute infectious disease outbreaks, often requiring an international response. On the ground humanitarian response is often essential though logistical and security challenges can delay these responses, and the reliance on an international workforce unfamiliar with local cultures can create challenges in response efforts. In crises where local healthcare workers have limited training, or experience in emergency care, digital health care education can augment in-person response and training efforts. In recent years digital emergency care education programs have been deployed to both Ukraine and Sudan. A review of each of these programs demonstrates successes in and potential utility of remote healthcare capacity strengthening through digital education in settings of war. These programs provide important lessons in strengths of and challenges in developing and delivering just in time learning programs to settings of active armed conflict suggesting similar potential utility in a variety of humanitarian emergency contexts.

KEYWORDS

health emergencies, digital learning, war, humanitarian response, capacity strengthening, conflict

1 Introduction

In May 2023, the 76th World Health Assembly (WHA) adopted Resolution 76.2; "Integrated Emergency, Critical, and Operative Care for Universal Health Coverage and Protection from Health Emergencies." This resolution calls on WHO member states to bolster their capabilities in these areas noting that "emergency, critical and operative care embedded within the broader health system is vital to maintaining the continuity of essential health

services in fragile and conflict-affected settings" (1). To meet the resolution's aims, it is crucial to develop innovative strategies that complement traditional humanitarian responses and enhance health system strengthening. We highlight two emergency response projects that used virtual emergency care training as a timely adjunct to on-ground efforts, improving emergency care in conflict settings. These programs are characterized by rapid deployment, cost-efficiency, reduced security risks, and the utilization of a global pool of content experts including diaspora of the affected countries.

Humanitarian emergencies often lead to a surge of traumatic injuries (2), emotional distress (3), disruption to health systems risking neglect and exacerbations of chronic illness (4), and acute infectious disease outbreaks (5), requiring an international response. These emergencies are complex, involving multiple sectors and international responders, and necessitate a multifaceted approach.

The role of international humanitarian response is essential to save lives and reduce suffering during complex emergencies. Humanitarian response organizations provide critical services and materials including vital, lifesaving resources and personnel. However, logistical and security challenges can delay these responses, and the reliance on an international workforce unfamiliar with local cultures can create challenges in response efforts. Despite their irreplaceable and essential nature, these missions are expensive and financially limited. With these challenges in mind, there is a significant opportunity to augment on-ground efforts with digital and remote capacity strengthening, which can mobilize certain global human resources more swiftly and effectively than traditional methods.

In most humanitarian emergencies, local healthcare workers (HCWs) are indispensable, providing continuous care throughout all phases of a crisis (6). Often, these workers must deliver emergency medical and psychological trauma care without prior training. While natural disasters such as earthquakes and floods cause immediate mortality and morbidity, highlighting the need for rapid emergency medical response, protracted crises, especially when complicated by disruptions to the healthcare system, can lead to prolonged trauma and medical needs. Despite the presence of international agencies, local HCWs are critical in delivering consistent care and often require sustained training, consultation, and support in emergency medical and psychological interventions. Furthermore, as emergency care requires a multidisciplinary response of health professionals, HCWs from a range of backgrounds and specialties may benefit from emergency care training. In such circumstances, providing just-in-time emergency care training for local HCWs is a priority.

2 Ukraine armed conflict trauma training (ACCT)

In June 2022, shortly after the onset of the ongoing Ukraine-Russia conflict, the Swiss Foundation for Innovation (SFI) in collaboration with the Ukraine Ministry of Health (MOH) identified a pressing need for trauma care training for healthcare workers (HCWs) in Ukraine, particularly those in prehospital roles. The SFI team initiated a partnership with Project ECHO at the University of New Mexico, and together they rapidly developed an emergency trauma care distance learning course concept. This was followed by a series of rapid information-gathering meetings with leaders from various sectors including humanitarian, disaster medicine, and global

health. Notable participants included the World Health Organization (WHO), the American College of Emergency Physicians, the Harvard Humanitarian Initiative, and the Uniformed Services University Center for Deployment Psychology. From these meetings and a review of existing trauma care education curricula, the Project ECHO-SFI teams crafted a course curriculum based on the WHO-International Committee of the Red Cross (ICRC) Basic Emergency Care (BEC) trauma module; additionally, this program integrated a 10-min segment into each learning session focused on trauma mental health. This comprehensive program, named the Ukraine Armed Conflict Trauma Training (ACTT), was launched within just 15 days from the initial planning session.

2.1 Ukraine ACTT course overview

The Ukraine ACTT course comprised 16 one-hour training sessions conducted over 8 weeks, starting in June 2022 and ending in August 2022. Each session began with a 20–30 min didactic presentation based on the ICRC/WHO BEC Trauma module curriculum. Instructors were asked to follow the BEC Trauma module content and sequence though were also welcomed to share their own experience and elaborate on topics based on their area of expertise. This was followed by a discussion between the program moderators and the didactic presenter informed by questions from the participants submitted through the webinar Q&A feature. Each session concluded with a 10-min trauma mental health training segment delivered by specialists from the Uniformed Services University's Center for Deployment Psychology. The course utilized the Zoom webinar platform, as opposed to the Zoom meeting format, to address potential security concerns that could arise from participant visibility in a meeting format. The webinar allowed for visual instruction and interaction between presenters and moderators while limiting participant communication to a text-based question and answer format. Simultaneous Ukrainian-English interpretation was provided, enhancing accessibility. A core team of four SFI personnel collaborated closely with the Ukraine MOH to recruit participants, monitor the course's impact, and gather feedback. The design of this just-in-time virtual learning program was informed by the 20 years of experience of the UNM Project ECHO team in designing and delivering remote continuing professional development programs, including many learning programs related to the global COVID-19 pandemic response (7–11).

2.2 Ukraine ACTT instructor recruitment

A significant advantage of the remote training program was the immediate availability and accessibility of a global pool of WHO/ICRC BEC certified instructors ready to assist. Recruitment efforts were initially directed through email invitations to this roster and other specialists from the networks of planning team members, prioritizing Ukrainian-speaking experts. Subsequently, the recruitment widened to include trauma and emergency care specialists across various disciplines, aiming to engage skilled medical educators. This strategy successfully assembled a diverse faculty of instructors from Ukraine, Tanzania, India, and the United States, each bringing valuable perspectives to the educational sessions.

2.3 Ukraine ACTT trauma mental health component

The concept of including a trauma mental health component in the training program was a strategic decision made during the program planning phase. Despite the short timeline available, a team from the Center for Deployment Psychology (CDP) at the Uniformed Services University in the United States committed to providing a longitudinal, 16-part trauma mental health program with the time allotted of 10 min per session and one session with the full 1-h program dedicated to mental health trauma education. This team provided didactic education and shared resources for HCWs working in settings of armed conflict to address mental health trauma principles for patients as well as the mental health and well-being of the HCWs. Given the challenge of limited didactic time, the team took a microlearning approach to the curriculum (12) and developed small units of training focused on acquisition of knowledge and skills. Topics were designed to be utilized by prehospital HCWs without prior in-depth mental health training. The goal was to provide information and resources sufficient for immediate implementation by HCWs in the field. Quick response (QR) codes were embedded with links to web-based resources that could be used in the field. Whenever possible, the CDP team intentionally linked mental health content with the focus of the trauma topic subject for the overall session. For example, mental health aspects of amputation were provided following the extremity BEC didactic and assessment of Traumatic Brain Injury (TBI) using the Military Acute Concussion Examination followed the blast didactic (Table 1).

2.4 Ukraine ACCT observations

The Ukraine ACTT program was pioneering as it represents one of the first rapidly developed and deployed remote trauma care training programs for HCWs in an active conflict setting. The program was delivered in 16 sessions offered twice weekly between June 9th and August 2nd 2023. This just-in-time capacity building program engaged 238 unique participants with a total of 758 attendances suggesting that there were repeated attendances among individual attendees. Among the unique participants ($N = 238$), 42% were nurses, nurse practitioners and physician assistants; 32.15% were first responders; 13.09% were medical doctors; and 3.83% were mental health providers (see Table 2 for details).

Anonymous feedback was collected from the attendees after each of the learning sessions. With respect to knowledge acquisition, participants self-rated their knowledge acquisition on aggregate as significant: 5.24% of attendees who responded to the post-session surveys ($N = 708$) rated their knowledge as Extremely Knowledgeable before and this increased to 11.3% after; 24.93% of attendees rated their knowledge as Very Knowledgeable before and this increased to 52.60% after (see Table 3 for additional information). Attendees who completed the post-session surveys ($N = 708$) rated the relevance of the ACTT training program as overall highly relevant to their practice; data aggregated across all 16 learning sessions rated them as: Extremely Relevant (27.7%); Very Relevant (50.52%); Moderately Relevant (14.98%); Slightly Relevant (6.45%); and Not at All Relevant (0.35%) (Table 4).

The virtual format's rapid development and deployment represented a significant benefit, contrasting with the lengthy timelines typically associated with coordinating in-person training

TABLE 1 ACTT course curriculum with attendance.

Ukraine ACTT course syllabus with attendance				
Session	Trauma topic (BEC)	Mental health topic	Session date	Attendees
1	Primary survey ABCDE	Psych first aid (Part 1)	6/9/22	113
2	Trauma secondary/Sample Hx	Psych first aid (Part 2)	6/14/22	51
3	Breathing and airway management	Psych first aid (Part 3)	6/16/22	63
4	Head and neck	Psych first aid (Part 4)	6/21/22	61
5	Chest	Provider resilience (Part 1)	6/23/22	54
6	Abdominal	Provider resilience (Part 2)	6/28/22	55
7	Spinal cord, internal and pelvic	iCOVER	6/30/22	56
8	Extremity	Amputation	7/5/22	46
9	Crush	Sleep (CBTi – Combat Sleep)	7/7/22	50
10	Blast	TBI (MACE2)	7/12/22	53
11	Burn	Stress first aid (Part 1)	7/14/22	46
12	Triage	Stress first aid (Part 2)	7/19/22	37
13	Pediatric trauma	Age related reactions to trauma	7/21/22	38
14	Trauma in pregnancy	Combat injured families	7/26/22	11
15	CBRNE	Mortuary affairs	7/28/22	12
16	Clinical mental health	PTSD, ASD, MDD, AUD, suicide	8/2/22	12

Represents the course syllabus and title of each session emergency care and mental health content along with participant attendance per session.

TABLE 2 Ukraine ACTT representation of professions among attendees.

Attendee profession	Percentage of attendees present
Nurse/nurse practitioner/physician assistant	42.53%
First responder (such as EMT, paramedic)	32.15%
Medical doctor	13.09%
Mental health provider (such as counselor, psychologist, social worker)	5.83%
Testing or laboratory personnel	2.42%
Community health worker	1.56%
Teacher/educator	1.28%
Public health official	0.43%
Other	0.28%
Other medical provider (such as pharmacist, dentist, veterinarian)	0.28%
Administrator	0.14%

Describes the professions represented among attendees for all sessions of the Ukraine ACTT program ($N = 758$).

TABLE 3 Ukraine ACTT rating of subject knowledge before and after the program by attendees.

Knowledge before Session	Percentage	Knowledge after session	Percentage
Extremely knowledgeable	5.41%	Extremely knowledgeable	11.30%
Very knowledgeable	24.93%	Very knowledgeable	52.60%
Moderately knowledgeable	52.14%	Moderately knowledgeable	31.90%
Slightly knowledgeable	16.52%	Slightly knowledgeable	4.30%
Not at all knowledgeable	1%	Not at all knowledgeable	0%

Summarizes post-session responses of attendees regarding level of knowledge of program content before and after sessions.
This table represents aggregated data ($N = 708$) from all 16 sessions.

TABLE 4 Ukraine ACTT attendee rating of relevance to practice.

How relevant is the session to your current work?	Percentage
Extremely relevant	27.70%
Very relevant	50.52%
Moderately relevant	14.98%
Slightly relevant	6.45%
Not at all relevant	0.35%

Reflects participant responses when asked how relevant the session was to their current work ($N = 708$).

initiatives. The streamlined logistical process, including assessments of wireless connectivity and participant recruitment, was efficiently managed by a small team on the ground in Ukraine which also reduced personnel exposed to security risks. The choice of webinar format over a more interactive video conference platform was assumed to be warranted to mitigate security risks, though it may have limited participant interaction. Convenience and safety of participants in the program was an additional strength. Participants were able to join from a location of their choice and learning sessions were able to be viewed both live and on an asynchronous basis as all the learning sessions were recorded and made available on a private YouTube channel (https://www.youtube.com/playlist?list=PLM3v2ae2FB_xGA9dOP9LQ9vIsQ0e_xCQv) which was shared with participants. The involvement of the Ukraine MOH was found to significantly boost attendance and engagement, suggesting substantial added value of ministry involvement. Finally, the program's ability to recruit a diverse pool of global instructors ensured that training was not constrained by local availability of expertise, maximizing the number of instructors available on short timeline, and enriching the content of the educational sessions.

Based on the implementation experience, the planning team also identified many opportunities for improvement and several steps to avoid for future programs. For example, there was an observed positive association between MOH involvement and session attendance. The first session which included an introduction by a representative from the MOH had 113 attendees. Later sessions, when MOH representatives were not available to participate, had lower attendance. Ideally the MOH would have been able to participate in all 16 of the learning sessions. Related to this is the challenge of recruiting HCW participants in a setting of war, especially with the constrained communications channels common in early phases of an active conflict. More information about best practices for recruiting participants is needed. Another opportunity for improvement was the observed very limited engagement and

interaction from the audience during each session. This was felt to be related to the use of the webinar format on the Zoom platform in contrast with the meeting format which allows participants to share their name, video and audio and use their microphone. The invisible and anonymous nature of the participant experience may have limited a sense of community among the HCWs and thus restricted a willingness to communicate in each session. Was engagement by participants reduced due to the use of the webinar format versus the video conference meeting format or for other reasons? Was there a reduction in the number of live participants because of other pressing needs for the attention of HCWs during the early days of the conflict or because they were able to watch the recordings asynchronously at their convenience? Further exploration of these questions and of the true security risks associated with using a videoconference meeting format in which all participants could be seen weighed with benefits of improving engagement is needed.

3 The Sudan emergency ECHO

With the onset of hostilities in Sudan in April 2023, there was a recognized need for rapid emergency medicine and trauma care education among healthcare workers (HCWs). Unlike the ACTT program in Ukraine, which was initiated without a pre-existing remote digital education community of practice, Sudan already had a robust remote healthcare education and primary care support program. This HCW learning network, which also included medical and nursing students, was developed during the COVID-19 pandemic in partnership with Project ECHO at The University of New Mexico (UNNM) and had been operational across multiple states in Sudan since 2020. The program, housed within the Sustainable Development Response Organization (SUDRO)—a non-profit focused on achieving sustainable communities through partnership, knowledge exchange, and capacity building—has engaged in a broad array of community-based health strengthening activities.

As of April 2023, the Community Medical Response Team (CMRT) group, integral to this program, included of over 5,000 HCWs linked through the Telegram messenger app. This platform was chosen for its ability to engage a large number of participants with simple smartphones, requiring very low bandwidth. It also facilitates a blend of SMS and document sharing, along with the capability to launch webinars directly within the app. This setup sparked a demand for emergency care education, particularly among primary care providers and physicians-in-training.

SUDRO led a collaborative effort with Project ECHO and the WHO Eastern Mediterranean Regional Office (EMRO) to deliver trauma care and public health emergency response training to the Telegram CMRT group members. This program drew on experiences from the Ukraine ACTT initiative, intending to use the BEC trauma materials as the foundational structure for the course. However, the Sudan Emergency ECHO program also diverged in several ways from its Ukrainian counterpart. Capitalizing on the existing CMRT network, the program was able to, very rapidly, launch within 5 days. The curriculum initially focused on BEC content but was quickly adapted based on continuous assessment of field reports from HCWs, reflecting emerging priority needs. This adaptability was further enhanced by frequent reliance on Sudanese trauma care experts as instructors, who provided contextually relevant and culturally

nuanced content directly in Arabic, eliminating the need for interpretation.

3.1 Sudan emergency ECHO observations

Between April 29th and October 25th, 2023, the Sudan Emergency ECHO, in collaboration with the WHO EMRO Case Management team, delivered 43 training sessions. These sessions included a total of 2,697 attendances with an average of 65.8 participants per session. One of the most significant strengths of the Sudan Emergency ECHO program was its delivery to a pre-established network of over 5,000 healthcare workers linked through Telegram. The advertisement of the first trauma training session in late April 2023 saw the group's membership more than double within a week and reach over 14,000 members in the following weeks. This expansion significantly increased the number of HCWs invited to participate in programs and is believed to have positively influenced attendance of live sessions and viewing recorded materials asynchronously. Direct access to such a large group of HCWs proved highly efficient for disseminating learning session resources like PowerPoint presentations, articles, WHO guidance documents, and links to recordings. It also opened the possibility of not only rapidly and widely disseminating information, but also gathering critical information from a large group of participants related to local healthcare capacity and infectious disease surveillance to inform response efforts. Future programs should consider increasing bidirectional information sharing between program hosts and participants to further support response efforts. This direct engagement model also addressed challenges noted in the Ukraine ACTT program related to limited participant engagement and unclear outreach strategies, which had been compounded by the lack of direct guidance and involvement from the Ukraine MOH.

The use of Telegram, a low bandwidth digital communication platform, was a critical strength, allowing the program to continue without interruptions despite frequent information technology infrastructure disruptions in Sudan. The program's model of ongoing, responsive assessment enabled swift adaptation to the changing needs of the learning community, such as shifting focus temporarily from trauma management to maternity care during a rise in home births or to cholera management following outbreaks related to water supply infrastructure disruption.

The involvement of Sudanese experts as lecturers, both locally and from the global Sudanese diaspora, enriched the program by providing direct instruction that was both clinically and culturally informed. These experts brought firsthand experience and understanding of the local context, enhancing the relevance and impact of the training provided. While partnering with local experts presented challenges related to communication infrastructure and security, these were not insurmountable and highlighted the need for a careful approach to ensure safe and reliable involvement in future programs.

Recognizing the urgent need for just-in-time emergency care expertise, a novel crowd-sourced virtual consult service was established via a Telegram messenger group specifically for healthcare workers to pose real-time clinical questions to a pool of regional trauma and emergency care experts. These experts were quickly identified and vetted by a WHO trauma and emergency medicine specialist and made accessible to healthcare workers in Sudan. However, the use of this virtual consultation group by members of the

Community Medical Response Team (CMRT) was modest and much less than expected. The reasons for this limited engagement are not entirely clear, but may be due to the service being an additional component of a larger program, which possibly stretched the program team too thin to effectively foster an active dialog among HCWs. Considering this, future programs might benefit from having a dedicated leadership and coordination team specifically dedicated to managing virtual clinical consultations. Despite the underutilization of this service, we believe it represents a valuable opportunity and warrants further development and improvement in future implementations.

The Sudan Emergency ECHO program offers valuable lessons on the benefits of leveraging existing HCW learning networks and technology to deliver timely and culturally relevant emergency care education in crisis settings. It also underscores the importance of deploying emergency programs on existing virtual networks, maintaining flexibility to adapt program content, and incorporating content experts who are also familiar with the cultural and clinical context such as local experts or diaspora, when addressing the specific needs of HCWs in conflict zones. An additional benefit of delivering a emergency training on a standing digital learning network is that the resources and network of instructors can be documented and stored by program coordinators to be reactive if needed. This retention of resources and contacts provides a level of sustainability which was is not present in a program that has limited or no ongoing digital learning activities in the affected country.

In 33 of the 43 sessions a two item poll was presented to attendees through the Telegram app during the program. For question one, "How confident are you in applying information from this session?," among respondents across all sessions (N = 1,104) 86.32% of respondents described feeling "extremely" or "moderately" confident about applying information from the session with 6.34% reporting feeling "slightly" confident and 7.34% responded feeling "not confident." From responses to poll item number 2 (N = 986) "Tell us what you think about the session" 58.6% of respondents reported learning something new that they have either applied or are eager to apply in their work. Table 5 describes a summary of responses to the polls. During analysis of individual session data, the authors found 6 duplicated entries as well as a blank entry for 2 question responses. The responses for these questions from the corresponding individual session were removed from the data set prior to final analysis.

Due to the rapid pace of program development and the planning team's focus on curriculum, a formal evaluation tool wasn't available in the initial program sessions. Starting on July 27th, 2023,

demographic data were gathered from attendees in addition to poll responses. Moving forward, it's imperative to plan and implement data collection methods for evaluating programs prior to the launch of similar digital learning initiatives.

4 Discussion

The Ukraine ACTT program and the Sudan Emergency ECHO program present similarities and differences in their approaches to deploying remote emergency care training programs. Four critical elements were common to both initiatives: 1. A shortage of functional healthcare facilities capable of treating patients, 2. An increase in emergency cases, including trauma, 3. A knowledge gap in trauma care and public health emergency response among local healthcare workers (HCWs), and 4. A reliable telecommunications infrastructure for reaching and communicating with HCWs. The absence of any of these elements would compromise the program's benefits and the rationale for pursuing similar initiatives. For instance, following the outbreak of hostilities in Gaza, the collapse of the healthcare system resulted in a lack of essential resources like food, water, and electricity. In such extreme conditions, prioritizing remote health systems strengthening activities becomes less critical compared to meeting basic needs (13). However, if the needs of HCWs align with the critical elements mentioned above during a conflict, a remote virtual education program can be strategically deployed as part of a broader effort to rapidly enhance healthcare emergency response capabilities in active conflict zones.

Each of the programs was rapidly developed in response to urgent and ongoing crises. The coordinating teams were primarily focused on providing essential educational resources to healthcare workers in active conflict zones. Consequently, attention was largely directed toward preparing the programs for effective delivery rather than prioritizing comprehensive data collection efforts. However, in each program, attempts were made to gather data on participant experiences. The Ukraine ACTT program benefitted from participant evaluations conducted after every session, whereas the Sudan Emergency ECHO program had more limited evaluations, with expanded data collection beginning several months after the program's launch. In the future, digital learning initiatives tailored for acute humanitarian emergencies, such as conflict zones, should incorporate data collection tools from the outset and comprehensive evaluation at the completion of the training to more thoroughly

TABLE 5 Responses among Sudan emergency ECHO participants rating how confident they are in applying information from this session (*N* = 1,104) and to describe their thoughts of the session (*N* = 986).

How confident do you feel about applying information from this session?		Tell us what you think about the session?	
Extremely confident	59.96%	I learned something new that I have applied in my field of work	30.07%
Moderately confident	26.36%	I learned something new that I am eager to apply in my field of work	27.53%
Slightly confident	6.34%	I was reminded by things that I already knew that are related to my field of work	11.09%
Not confident yet	7.34%	Unfortunately, I have not learned anything new	2.29%
		Unfortunately, I did not attend this session	28.01%

evaluate the efficacy and impact of such programs. Importantly, prioritizing security considerations for participants should be considered and reevaluated when conceiving and delivering such programs.

The lessons learned from both the Ukraine ACTT and Sudan Emergency ECHO programs can serve as a foundation for designing future initiatives. Feedback from participants and coordinators, though limited, indicates that these programs were valued, suggesting a net positive impact and potential for replication and improvement under similar circumstances.

The aim of this paper is to disseminate two case examples of ways to use technology to rapidly deploy training and education for healthcare workers in conflict areas and in complex emergencies. In crises where local healthcare workers have limited training or experience in emergency care, digital health care education can be rapidly delivered independent of, or to augment in-person response and training efforts with minimal risk to additional healthcare resources. While recognizing that the quality of in person training may not be matched with remote training, these case examples provide important examples of the strengths and challenges associated with the development and delivery just-in-time learning programs in active armed conflict settings and suggest similar potential utility in a variety of humanitarian emergency contexts.

5 Conclusion

The 76th World Health Assembly calls for a range of actions by member states to improve emergency care including the promotion of "inclusive and accessible approaches to safeguard effective emergency, critical and operative care in disasters, fragile settings and conflict-affected areas" (1). Effective response to humanitarian crises requires robust on-the-ground action and precise assessments to prioritize responses. Given that local HCWs often perform critical clinical work during such emergencies and may lack prior training in emergency medical care, learning and capacity strengthening are essential to ensure a strong and effective response. While in-person training offers numerous benefits and remains indispensable for certain aspects of emergency care, remote training can significantly enhance and expedite capacity building through education, training, and ongoing bidirectional information sharing.

The Ukraine ACTT and Sudan Emergency ECHO have demonstrated success in rapidly deploying remote just-in-time capacity strengthening strategies and highlighted areas for improvement. Future efforts should focus on improved monitoring and evaluation strategies to better assess the strengths and weaknesses of these approaches. A thorough evaluation of program effectiveness is crucial. By embracing and enhancing remote learning and capacity strengthening, along with traditional response models, the international health community, leveraging the expertise of in-country and global diaspora professionals and additional global experts as appropriate, can make significant strides toward achieving more coherent, inclusive, and accessible approaches to ensure effective emergency, critical, and operative care in disasters, fragile settings, and conflict-affected areas. These initiatives can help minimize loss of life and reduce suffering and answer the call of the 76th World Health Assembly.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

SD'A: Writing – review & editing, Writing – original draft, Project administration, Conceptualization. NF: Writing – review & editing, Writing – original draft, Project administration. MD: Writing – review & editing, Writing – original draft, Project administration. WB: Writing – review & editing, Writing – original draft. AI: Writing – review & editing. BS: Writing – review & editing, Writing – original draft, Project administration, Conceptualization.

Conflict of interest

Two authors have roles in SUDRO, the organization that coordinated and lead the Sudan emergency ECHO; Dr. Fadul as President and Dr. D'Andrea as Director of Training and Capacity Building.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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A health security-based framework for prioritizing regions for digital learning in complex health emergencies

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Digital health and learning have expanded significantly in recent decades though their use in settings of acute health emergencies has only recently begun. Growing experience among organizations working in the digital health and learning space suggest that virtual communities of practice in these areas may have value in response to health emergencies. Evaluation of recent virtual programs applied in acute health emergencies suggest that a pre-established digital learning network can serve as a valuable resource when an acute health emergency strikes. This paper introduces the concept, and explores the potential value of developing a prioritization framework, informed by health security assessments, to identify countries most vulnerable to future health crises. By using an anticipatory approach and framework to identify high risk regions, digital learning programs can be developed proactively, building networks that can be activated during emergencies. Creating and prioritizing virtual learning networks in regions at high risk of health emergencies can improve response capacities. Developing a framework to identify countries and regions of greatest risk can help policy makers, educators, and donors, focus limited resources on high need areas.

KEYWORDS

digital learning, health emergencies, health security, health security index, regional prioritization, humanitarian response

Introduction

Digital health has rapidly expanded in the 21st century, with telemedicine, remote clinical encounters, and digital education experiencing significant growth, especially during the COVID-19 pandemic. Public health emergencies encompass a range of population level health events such as epidemics or pandemics, natural disasters, and wide-ranging health effects of war and conflict on public health. Digital learning in humanitarian or public health emergencies is a more recent application of this educational approach. In the past several years organizations such as Project ECHO at the University of New Mexico, a WHO Collaborating Centre for Digital Learning in Health Emergencies, and Health Tech Without Borders (HTWB) which has provided both education and tele-health services in crisis settings, have supported countries facing epidemic and pandemic response (1) as well as humanitarian emergencies including armed conflicts (2, 3) and natural disasters (4).

As adaptation of digital learning in the response to health emergencies grows, a vulnerability assessment-based approach to prioritize countries and regions most likely to benefit from such resources may help optimize the benefit of these programs. By using pre-existing, or *de novo*, assessments of the health security status of countries, states, and

regions, those at high risk of future health emergencies, and with critical preparedness gaps, can be identified. This approach can help policymakers, donors, and digital learning program leaders allocate limited resources and attention more effectively when developing digital learning infrastructure and programs to ensure the ability to respond rapidly to health emergencies.

Recent lessons learned: digital learning in Ukraine and Sudan

While digital learning for health has been an educational practice for decades, it has recently been leveraged to enhance emergency medical care capacity in active conflict settings. In June 2022, Project ECHO, in collaboration with the Swiss Foundation for Innovation and the Ministry of Health of Ukraine, rapidly developed and deployed an eight-week real-time, interactive, virtual trauma care training program based on the World Health Organization/International Committee of the Red Cross (WHO/ICRC) Basic Emergency Care (BEC) Trauma Module to teach trauma care to non-emergency trained healthcare workers (5)(HCWs). Similarly, following the outbreak of hostilities in Sudan in April 2023, a virtual learning program was developed within one week to provide emergency care training to a wide range of healthcare professionals affected by the conflict (3).

These programs offer important lessons for using limited digital learning resources for acute health emergencies in high-risk settings. For instance, the Sudan program contrasted with the Ukraine training as it was deployed on a pre-existing virtual network of healthcare providers organized through an established digital learning program. This Community Medical Response Team (CMRT) program, organized by the Sustainable Development Response Organization (SUDRO), had been established to help respond to the COVID-19 pandemic and was a successful virtual community of practice for several years, offering primary care training and education to medical students and HCWs in Sudan. With the outbreak of war in April 2023, a real-time, interactive digital emergency care training program was rapidly coordinated, providing emergency medical and trauma training to Sudanese healthcare workers within the CMRT network. The time from conception to activation of this program was less than one week. Prior to launch of the emergency care training program the CMRT network included approximately 5,000 Sudanese HCWs. When the training was announced this network expanded to over 14,000 healthcare workers who were then able to receive communication from program organizers including announcements of upcoming digital learning sessions and didactic materials which could be shared through the Telegram Messenger application. The program's success in reaching many HCWs in an active conflict zone highlights the value of creating pre-established virtual learning networks in high-risk countries. These networks empower response and support organizations to coordinate education and resource sharing, including psychosocial support, with local healthcare workers during emergencies.

A global strategy for prioritization of digital learning in health emergencies

As the use of digital learning in health emergencies grows, developing a framework for prioritizing countries and regions for investment in digital health education programming is critical for proactive capacity building and enhancing effectiveness of response efforts. By creating these digital learning programs in advance of a crisis, an important virtual infrastructure is developed; this results in a digitally connected network of health professionals ready to be activated and leveraged for teaching and information sharing before and during a health emergency.

Digital learning: health system assessment

With limited financial resources and attention available to develop such learning networks globally, an approach that prioritizes regions at the greatest risk of a large-scale health crisis is needed. This prioritization should be based on a recent health system assessment. Recognizing that all indices and evaluation frameworks will have some limitations, cross referencing results of multiple assessment models such as the World Health Organization Joint External Evaluation (6) (JEE) score or the Global Health Security Index (7) ranking may be of value. These assessments offer a comparative analysis of baseline health security and provide potential data to guide digital learning in health emergency priorities. Other indices that could be used include the ND GAIN Index (8) for climate vulnerability and the Fragile States Index 2024 (9). A convened workgroup of representatives of key stakeholder groups could review existing indices of health sector capacity, and specific vulnerability assessments (e.g., climate) of nations to first determine whether existing measures of health sector preparedness and capacity to respond to health emergencies sufficiently identify those regions most likely to benefit from a digital health infrastructure. After an initial review a determination should be made to proceed with use of existing health capacity or vulnerability index, or to develop a new assessment tool to rank nations according to likelihood of benefiting from a digital learning for health program.

Limitations to the use of an existing framework include a failure of the index to correctly identify a region likely to benefit from a digital learning program to provide benefit in a health emergency. In contrast, developing a new index could prove cumbersome, time-consuming, and highly specific to the subject of digital learning which could call into question the value of time and resources spent on developing another health system assessment index. These pitfalls highlight the importance of thoughtful stakeholder selection and robust discourse among stakeholders when determining whether to rely on existing health system assessments or creating a health system assessment for digital learning *de novo*.

Prioritization of regions most likely to benefit from digital learning programs

The development of a more standardized and efficient prioritization scheme could be catalyzed by request to the United Nations/World Health Organization (UN/WHO) to create such a priority list, which would be based on their assessment of indicators to assist with the prioritization of digital learning anticipatory action. Collaboration between leaders of digital learning in healthcare and the UN/WHO in identifying such a priority list might lead to a classification of priority countries and regions more specifically focused on settings whose needs and vulnerabilities may be more responsive to the benefits of digital learning networks. The prioritization scheme should be based

on an assessment that helps identify regions at increased risk of health emergencies and with resource limitations where increased investment in a virtual learning network is most likely to be of value. For example, a country or region with relatively high resources and low risk of population wide health emergency such as war or natural disaster might benefit less from development of a virtual learning network as the country would be able to mitigate the impact of the health emergency with existing resources. In contrast a country with fewer resources and greater risk of a health emergency would likely have greater benefit of implementation of a virtual learning network in the event of a health emergency providing an avenue for rapid education and information sharing among healthcare personnel.

In addition, prioritizing the delivery of digital learning and health emergency programming to high-risk countries or regions provides a more objective and need-based strategy for program development. Given limited donor funding for public health programs, using an objective approach, such as a prioritization of countries/regions by a UN/WHO led initiative, to determine areas at greatest risk can help triage digital learning resource allocation at a global level. Importantly the deployment of funds to support the development of such virtual learning networks should, ideally, be in times of stability for a country or region allowing for a methodical and controlled development of digital learning networks and programs, and not withheld to deliver only in times of crisis.

Benefits of developing virtual learning networks in settings at high risk of future health emergencies

The potential benefits of having pre-established virtual learning networks during health emergencies are many. The timeline of implementation for such programs, outside of a crisis could be as rapid as weeks to months. As observed in the Sudan program, the ability to very rapidly coordinate and deploy digital learning opportunities during a humanitarian emergency was greatly facilitated and accelerated by the presence of a pre-established continuing professional development virtual learning network, program coordinators, and subject matter experts for health worker capacity building. Potential benefits of anticipatory digital learning communities to enhance country readiness include:

1 **Familiarity with the Learning Platform**: Participants already familiar with the learning delivery platform may be more inclined to participate in a program.
2 **Experienced Coordinators**: Having program coordinators already identified and experienced in producing and delivering digital education sessions to an established learning network eliminates the need to train new teams and speeds deployment of programs. Experienced coordinators would ideally have a cultural and contextual familiarity which would aid communication and foster trust among learners.
3 **Efficient Communication and Feedback**: Familiarity of the digital learning program and learning model allow for efficient communication and feedback to program leaders. This allows for rapid adaptation of program content to meet the changing needs of learners. For example, in the Sudan program an increase in home births during the early days of the war due to unsafe hospital access was quickly communicated to program

leaders, allowing for the rapid deployment of maternity care content.
4 **Rapid deployment mechanism for pre-existing guidance:** Extensive content and educational materials, such as standardized management of emergency conditions from the WHO, currently exists and its dissemination for just-in-time information sharing is accelerated when digital learning networks are in place.
5 **Improved access to psychological support:** Psychosocial support and tools such as psychological first aid resources can be more quickly brought to first contact healthcare workers with a pre-established digital learning network in place.
6 **Potential crowdsourcing health sector information**: While the focus of information movement in digital learning is typically from subject matter experts to learners, bidirectional information sharing offers a valuable opportunity for healthcare leaders. A standing network of HCW's dispersed geographically, though connected digitally, may facilitate information gathering from the health sector related to capacity and capability as well as offer just-in-time access to epidemiological data which may inform response to health emergencies.
7 **Agile platform able to expand and contract to meet need of the crisis**: Based as an online community reaching participants through individual devices, this virtual network has the ability to adapt its scope to meet the need of a given crisis. Programs may be limited in focus on individual professional groups or communities or expanded across multiple communities and professional groups.
8 **Decreased Cost**: Once a virtual learning network is established, there is little cost in deploying new information or programs over the existing network. Cost would be limited to the time of coordinators and experts involved and related to the use of cellular or Wi-Fi data.

Another general benefit of developing virtual learning networks irrespective of predetermined level of risk is the potential to rapidly and broadly expand local networks by connecting with diaspora who are culturally and contextually familiar with the setting. These diaspora experts can participate as program developers and content experts, helping to overcome challenges faced by digital educators unfamiliar with the local culture or healthcare context.

Inequity in access to digital technology

Finally, an important consideration is incorporating strategies to overcome the digital divide (10) in education, especially for HCWs in low and middle-income countries and conflict zones. Understanding the availability and accessibility of the telecommunications infrastructure and resources is an essential step in establishing digital learning programs. Ensuring access to internet and technology equipment for individuals or groups of learners is critical to address inequities in digital learning. Where gaps in technological resources and infrastructure exist programs should be designed to function within existing capabilities (i.e., using cellular data and relying on low bandwidth platforms) and include pathways for expanding and adapting programs when infrastructure growth allows. This ability to

adapt programing based on technological resources and limitations will be key to maximizing sustainability of such programs.

Conclusion

With an increasing role in responding to health emergencies, digital learning has demonstrated success in several recent capacity-strengthening programs targeting learners based in environments experiencing complex humanitarian emergencies. Experience from these programs highlights the value of pre-established, virtual learning networks composed of culturally competent and context-aware experts. These experiences suggest that advance development of virtual learning networks in settings at high risk of future health emergencies can enhance system response capacity.

A global strategy based on health security, or other relevant vulnerability assessments to identify and prioritize settings in greatest need of health emergency virtual learning networks, using a combination of objective tools may provide a viable framework for organizations, donors, and digital learning leaders. Such a framework should be developed with an intent to identify countries or regions most likely to benefit from the value provided by a digital learning infrastructure. Prioritization of regions of greatest need could help providers of education and training to strengthen humanitarian response efforts to shift from a reactive to a proactive, more anticipatory planning model, building capacity for populations at risk of future health emergencies.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Author contributions

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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WHO public health laboratories webinar series – an online platform to disseminate testing recommendations and best practices during health emergencies

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Laboratories play a central role in managing public health emergencies. The COVID-19 pandemic imposed unique challenges on global laboratory systems, including testing protocol uncertainties, supply shortages, rapid need for information dissemination, and disruptions to traditional training methods. In response, the WHO established the Public Health Laboratories (PHL) knowledge sharing webinar series whose goals were to respond to the increased demand in up-to-date and reliable information, which WHO is in a unique position to provide. It also aimed to enhance peer-to-peer exchanges across laboratories. This article outlines the PHL webinar series delivery format and presents how the webinar series was received and perceived by participants and how it evolved to support the response to other health emergencies. Contents of the knowledge sharing sessions, as well as attendance, participants' satisfaction and application of learning were monitored over time using registration forms, satisfaction polls, an annual survey and focus group discussions. From May 2020 to December 2023, 48 sessions attracted 58,688 registrations from 204 countries and territories. Thirty-five sessions featured presentations of WHO guidance, tools or documents and 39 sessions featured country experience sharing. Initially focused on COVID-19, the series became a tool to rapidly disseminate guidance and best practices during new health emergencies and to address cross-cutting topics relevant to the laboratory workforce. Feedback data shows participants found the webinars very useful (86% respondents), reporting knowledge gains in biosafety, quality management, and laboratory practices. The series facilitated knowledge application, with foreseen changes in workplace procedures and training activities (43% respondents). Barriers such as resource limitations, additional training needs, and connectivity issues were frequently identified. Evidence that this knowledge was subsequently applied by participants, such as through changes in workflow, onwards training events and procedural changes further reinforces the efficacy with which the series was able support the laboratory workforce globally in addressing challenges of the COVID-19 pandemic and other health emergencies. The series utilized sessions on cross-cutting topics to run routinely and to keep a high level of engagement with laboratory professionals globally. This enabled it to act as an adaptable tool that was leveraged effectively and quickly during health emergencies for just-in-time learning.

Introduction

Laboratories play a central role in public health emergency management, delivering diagnostic services that guide the appropriate clinical management of patients, enable disease surveillance, including detection and confirmation of communicable disease outbreaks, and provide data to inform public health interventions. However, the delivery of timely and appropriate laboratory services of high quality is dependent on various factors specific to a country's context including resource availability (i.e., testing protocols, supplies, infrastructure, trained workforce) and scientific evidence (i.e., who should be tested, when, and how) and can be impacted by the nature of each emergency (1, 2).

In the context of the COVID-19 pandemic, laboratory systems globally faced an unprecedented number of new challenges in the delivery of laboratory services for this unprecedented and rapidly evolving public health emergency (1). Key questions such as who (i.e., asymptomatic versus asymptomatic) and how to test (molecular versus serological tests, protocols, biosafety measures, etc.) were problematic due to an initial lack of information about disease transmission, and an influx of new diagnostic tests being brought to market with sometimes limited performance data (3). Challenges such as supply shortages, personnel shortages, and fear among health and laboratory workers added to a critical need for timely information dissemination and exchange which was further disrupted by travel restrictions and border closures preventing traditional face-to-face training and laboratory visits (4).

The use of virtual learning has significantly increased in recent years with development of communication technologies and has been widely applied for health topics, such as through the ECHO model (5) established in 2003 to strengthen health workers continuing professional development and capacity building.

It was in this health emergency context and leveraging the increasing digital learning environment opportunities that the Public Health Laboratories (PHL) webinar series was established by the Public Health Laboratory Strengthening Unit at WHO Headquarters (Lyon office), the WHO Regional Office for Africa (AFRO), and the WHO Regional Office for the Eastern Mediterranean (EMRO). Initially designed to support national reference laboratories performing SARS-CoV-2 testing across the African (AFR) and Eastern Mediterranean (EMR) regions, the webinar series was developed with the goals of enhancing WHO guidance and best practices dissemination by communicating with key laboratory stakeholders at country level and enhancing knowledge sharing and peer-to-peer exchanges across laboratories in these regions. In line with the COVID-19 health emergency, it prioritized topics to support laboratories in establishing and scaling up quality and timely testing in a safe manner. However, the audience quickly grew as the series gained interest and support from all WHO regional offices and became relevant to many subnational laboratories and other global laboratory stakeholders. In an effort to strengthen the monitoring and evaluation of the series, WHO engaged with Project ECHO at the University of New Mexico, an initiative established in 2003 to strengthen health worker continuing professional development and capacity building through an "all teach, all learn" tele-mentoring approach (6–8).

In this article we outline the PHL webinar series delivery format and present how the webinar series was received and perceived by participants contributing to the increasing evidence on the added value of e-learning platforms for continuous education and just-on-time learning in health emergencies. We highlight that the series not only met its initial goals to rapidly disseminate information and encourage knowledge exchange among WHO Member States during the COVID-19 pandemic, but also established an enduring channel for multidirectional communication and learning between WHO offices, Member States, and other global laboratory stakeholders. Its sustained relevance demonstrates its potential as a valuable resource for future health emergencies.

Materials and methods

Ninety-minute webinar sessions were conducted approximately every 2 to 4 weeks. Learning sessions typically included presentations by speakers from WHO headquarters or regional offices on featured WHO guidance, followed by experience sharing from invited speakers from one to three countries. Webinars were delivered primarily in English, with occasional country presentations made in French or Spanish. Live interpretation was provided with several languages added gradually to ultimately offer six languages: English, French, Spanish, Portuguese, Russian and Arabic. At the end of each webinar a designated questions and answers (Q&A) period allowed questions from participants to be relayed to speakers. Additional elements were sometimes integrated such as technical polling questions to enhance interactions with the participants and as an information gathering tool for WHO.

Invitations were disseminated within regional networks, by independent sharing between colleagues ("word of mouth") and eventually through a registrant database whereby new invitations would be sent to all registrants of previous sessions. A one-page summary covering the highlights of the event, links to the Q&A, recordings of the session, speakers' PowerPoint presentations, and other relevant documentation were emailed to participants, generally in the week following the webinar. This document was made available in English and French for most sessions from 2021 onwards, with a version in Russian being added in the second half of 2022.

Data collection

All data collection tools utilized in this study are provided as Supplementary materials. Data was collected from session agendas and Zoom registration forms. Additional monitoring and evaluation tools were also applied including satisfaction polls, an annual survey, and focus group discussions to provide additional user feedback (Table 1). Information on the frequency and timeframe with which these tools were applied is presented in Table 1.

Data collection tool	Frequency	Timeframe
Session agenda	Every session	May 2020 – December 2023
Registration	Every session	May 2020 – December 2023
Satisfaction polls	14 sessions	June 2022 – December 2023
Annual survey	Once	September 2021 – September 2023 (covering 22 sessions)
Focus groups	Once (1 in English and 1 in French)	September 2021 – December 2023

Zoom registration enabled the collection of demographics for the registrants of each session and contained the registrants' name, email, city, country, gender, preferred language (among those offered), profession/role, health system level of work, suggestions, and any pressing questions (Supplementary material 1). Of note, registrant affiliation data (profession/role and health system level of work) only started being collected through the registration form from February 2022 onwards (Session 28).

Satisfaction polls started in June 2022 (session 33) and included four questions about session relevance to the participant's work, the usefulness of examples and information shared, commitments to taking action based on session learnings, and the likelihood of recommending the learning series to a colleague (Supplementary material 2). The satisfaction poll was launched in the last few minutes of the online webinar sessions, in English, with live simultaneous interpretation into Arabic, French, Portuguese, Russian, and Spanish.

An annual survey including 13 questions solicited feedback about attendance, barriers to participation, useful webinar elements, knowledge acquired, knowledge application and barriers, and the likelihood of recommending the series to a colleague (Supplementary material 3). This data was collected and managed using REDCap (Research Electronic Data Capture), a secure web-based software platform designed to support data capture for research studies (9). In November 2022, an invitation email containing a link to the survey was sent to anyone who had registered for one or more of the PHL webinar sessions since September 2021. The survey was made available in Arabic, English, French, Portuguese, Russian and Spanish.

On the annual survey, respondents were asked if they would agree to be contacted to provide further feedback about the webinars in a more workshop-style setting. A sample of those who responded positively was invited by email to participate in a virtual (Zoom) focus group discussion – the sample considered the gender and region of respondents to maintain general attendance diversity and representativeness. One discussion was conducted in English, and a second discussion was held in French. Discussions followed a semi-structured guide with questions and prompts focused on session improvements and practice change (Supplementary material 4).

Data analysis

Frequencies and other descriptive statistics were calculated for annual survey variables as appropriate using R (10) and RStudio (11). Focus group discussions were recorded, transcribed, and systematically analyzed using principles of content analysis to identify key concepts (12). Transcripts were analyzed in their original language (English or French), and example quotes presented in the findings

section were translated into English when necessary. NVivo software was used for qualitative analysis of focus group transcripts and open-ended recommendations captured in the annual survey (13).
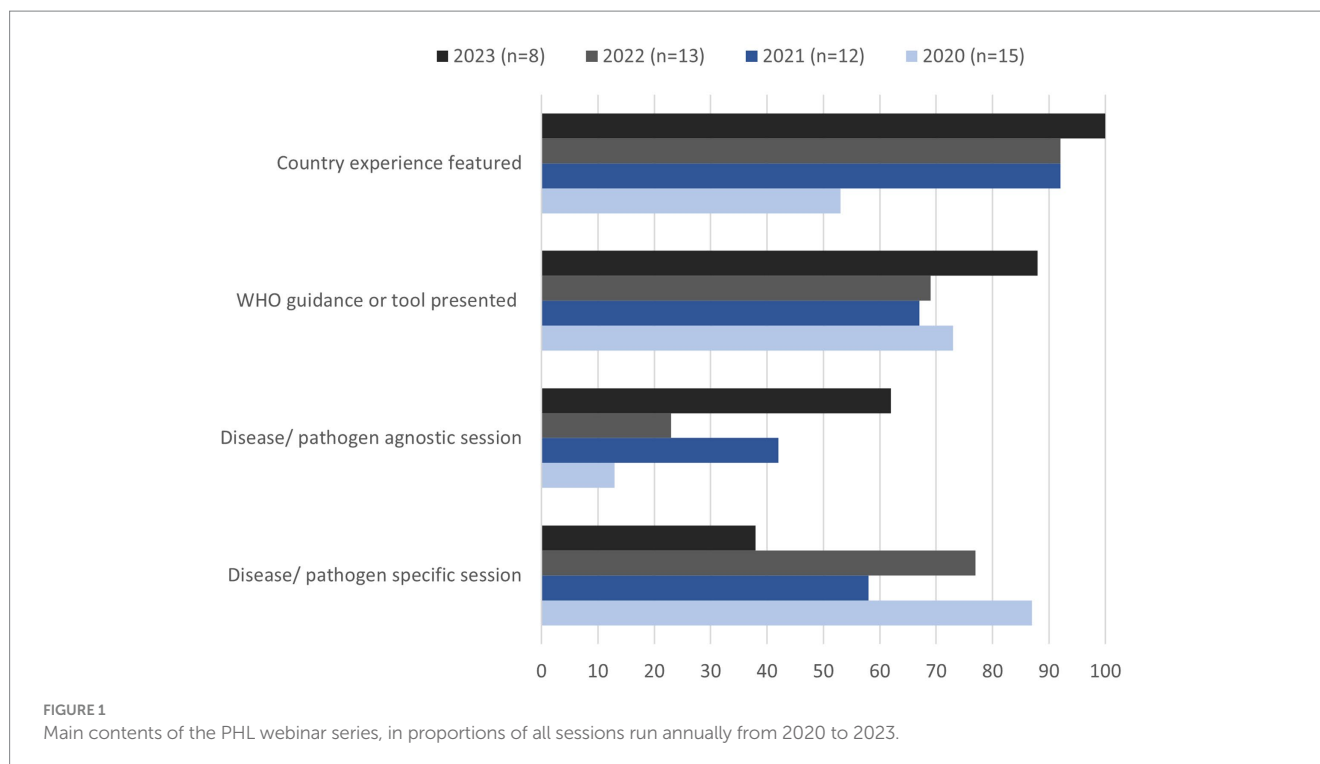
Results

Summary of sessions

Between May 2020 and December 2023, a total of 48 webinar sessions were conducted. A cumulative 58,688 registrations were received from 204 countries and territories, with 24,261 attendances. The median attendance was 504, ranging from 91 to 1,558 participants. Annual median attendance was 185 in 2020, 655 in 2021, 507 in 2022 and 588 in 2023. The top three most attended sessions were those on mpox viral disease ($n = 1,558$ participants), Laboratory Management/ General management processes ($n = 1,238$ participants) and Biosafety Risk Assessment tools and processes ($n = 1,124$ participants).

The two primary forms of knowledge-sharing and information dissemination used were presentations of WHO guidance, tools or documents (35 sessions) and country experience sharing (39 sessions). In each session featuring country experience sharing, panelists from one to three countries were invited to participate. In total, panelists from 45 countries presented during at least one session. All WHO regions (17) were represented with experience sharing from 16 countries from the African region, six for the Eastern Mediterranean region, 11 from the European region, five from the region of the Americas, three from the South-East Asian region and four from the Western Pacific region. Presentations by countries were primarily given in English, however three presentations were delivered in French and two in Spanish.

Most of the sessions delivered in the first 2 years of the series related to SARS-CoV-2 diagnosis (24/32), with 67% over the entirety of the webinar sessions (32/48) dedicated to the disease (Figure 1). From September 2021 onwards, cross-cutting pathogen-agnostic sessions began and included topics such as biosafety, laboratory and emergency management processes, quality management systems and communication for laboratory stakeholders.

Additional diversification of topics included pathogen-specific sessions on diseases other than COVID-19. This included seven webinars on diagnostics for specific diseases including mpox, Sudan virus disease, HIV, acute hepatitis, leptospirosis, and diphtheria. During these sessions information delivered included raising awareness of new WHO guidance publications, epidemiological updates of recent outbreaks, recommendations on best-practice testing methods, the use of new or innovative technologies, or regulatory requirements.

FIGURE 1
Main contents of the PHL webinar series, in proportions of all sessions run annually from 2020 to 2023.

Registrant profiles

From the 33 webinars for which this information was available (March 2021–December 2023, $N = 52,494$), 62% of registrants were female, 36% male, 1% preferred not to say, and 0.1% identified as non-binary. Fifty-six percent of individuals ($n = 19,656$) registered for more than one webinar, with one individual registering for 37 sessions. Moreover, from the 560 respondents to the 2022 annual survey, 65% of respondents reported attending between one and five sessions, 25% attended between six and 10 sessions and 11% more than 10 sessions.

Since February 2022 (session 28), demographic data from 35,827 registrants indicated that 47% described their role as laboratory personnel, 11% as researcher, 8% as technical officer, 7% as a public health official, 7% as consultant, 6% as program manager, 4% as medical care provider, 3% as student and 7% as other. Of those who answered the optional question about the level of health system in which they worked ($N = 26,080$), the majority (55%) reported working at national level, 26% at subnational level, 12% at other levels such as in international organizations and/or humanitarian organizations and for 8% the question was left blank or marked non-applicable.

The majority of registrants were from the Western Pacific region (29%), followed by the African region (21%), European region (20%), South-East Asia region (15%), Eastern Mediterranean region (10%) and the Region of the Americas (6%). Overall, 204 countries and territories were represented among participants, with the five most represented countries being Philippines, Indonesia, Ukraine, Nigeria and India.

Reception and perception of the series by participants

From satisfaction polls' respondents ($N = 3,126$), over 80% indicated that the webinars were either very relevant or extremely relevant to their work. In terms of usefulness, most respondents rated the webinars as being very useful (86%), and less than 1% of respondents stating they had not been useful to them. During focus group discussions, nine out of 16 focus group participants mentioned interest and relevance of a particular topic to their work being the primary motivation for joining the webinars with one participant mentioning that the topics were critical for her as a trained biologist working at a national public health laboratory.

Annual survey respondents ($N = 560$) indicated a wide range of areas in which they gained new knowledge or skills, with the top selected areas (indicated by more than 60% of respondents) including biosafety and biosecurity, quality management systems, and general laboratory practice and testing methods. Other popular areas of learning (indicated by more than 30% of respondents) included surveillance, emergency management and response, laboratory information systems, management and leadership, communication, workforce training, or research (Figure 2).

According to annual survey respondents, the most helpful elements of the webinar series were learning the latest technical developments (83% rated it as very helpful, $n = 466$) and hearing experiences from other countries (81% rated it as very helpful, $n = 453$). Links to WHO documents and learning from peers were also among the topmost helpful elements, selected as very helpful by 75% ($n = 420$) and 73% ($n = 408$) of respondents, respectively. In focus group discussions, session content that was cross-cutting and pathogen-agnostic was identified among the most helpful, including biosafety, biosecurity and biological risk assessments (4 of 16 participants), laboratory management skills (3 participants) and leadership and communication skills (one participant). Two participants also highlighted sessions featuring guidance on specific disease testing as the most helpful for them.

In terms of likelihood of recommending the webinars to colleagues, using a Likert scale of 1- not at all likely to 10- extremely likely, 83% of respondents in session satisfaction polls ($n = 2,977$) rated their answer
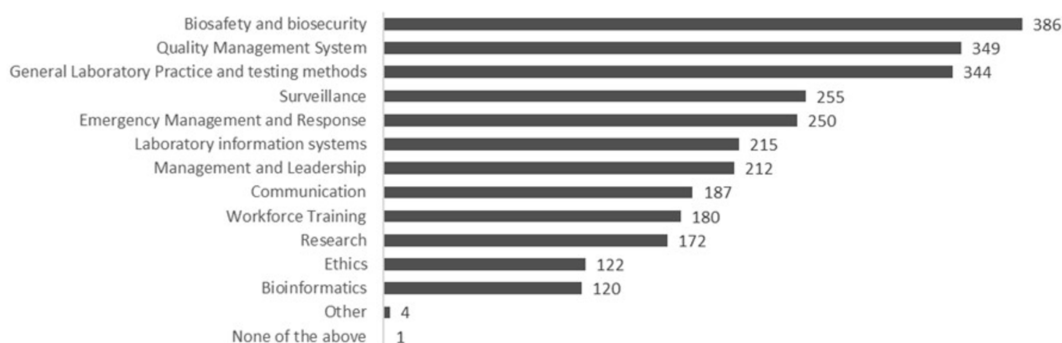
FIGURE 2
Areas of new knowledge learnings or skills for participants (annual survey, N = 560 respondents).

FIGURE 3
Ways participants planned to use learnings (annual survey, N = 560).

as equal or higher than 8. The annual survey also showed a high likelihood of recommending the webinar to a colleague, with more than 50% of respondents (n = 290) selecting 10, extremely likely to recommend, and 87% (n = 481) of respondents' rating 8 or above.

Knowledge application and best-practice implementation

In satisfaction polls (N = 3,126), participants indicated they intended to apply the knowledge or products obtained from the webinar series by sharing information or products with colleagues (32%), looking up additional information (25%), improving a process in their workplace (24%) or improving the way that they worked (17%). During the annual survey, respondents also mentioned the intention to use information to change laboratory procedures and practices (43% of respondents) or guidelines, protocols or policies (38% of respondents) (Figure 3). In focus groups, concrete examples were shared of how the best-practices were applied in practice (Table 2). In the annual survey (N = 560), challenges to applying knowledge or implementing the best-practices shared were also identified, with the top three barriers including a lack of resources (46%), need for more specific training (40%), and lack of time (30%). Other less common barriers included a misalignment between best practices shared and the guidance provided from the government, no opportunities for application, and lack of support from supervisors or co-workers (Figure 4).

During the focus groups (N = 16), participants shared additionally that challenges related to supply chain logistics prevented best-practice implementation. For example, one participant said: "We wanted to (…) make the tests faster during COVID. We procured the [reagent] dispenser, but (…) procurement and delivery took so long that when we got it, there was not so many new cases anymore." Two participants shared that the cost of implementation of certain practices was a barrier. Other issues mentioned by a single participant were lack of decision-making power, lack of enforcement from different levels, a need to reinforce awareness, and general resistance to change.

Engagement with the webinar series

In the annual survey (N = 560), the greatest challenges reported in engaging with the sessions were the time of day in which they were held (56%) and internet connection issues (31%). Other less common obstacles were topic irrelevance (15%), language availability (7%), length of session (7%), log-in logistics (5%), and software issues (3%). However, 84% of respondents reported watching one or more session recordings.

Out of 560 total respondents, 137 shared recommendations for improving engagement with the webinar series (Table 3). The majority of suggestions related to changes in session logistics (69 mentions). Other recommendations included addressing language issues, for example through subtitle use (10 mentions), improving accessibility of finding webinar products online like recordings (five mentions), having longer sessions (three mentions) and having more time for discussion (three mentions). Outside of logistical concerns, recommendations included proposals of activities complementary to

TABLE 2 Knowledge application themes from focus groups (16 participants).

Knowledge application*	Number of participants	Number of quotes	Example quote
Implemented procedures based on risk assessment	4	10	"We were worried about how the RDT test can be managed. (…) after the training organized by the WHO, (…) we have learned about the RDT management. It can be done in a simple way. So I think it also decreased our burden."
Increased awareness and understanding of potential risks	3	4	"We encountered many suspected cases of monkeypox. Although it was negative, but the webinar sessions kept me informed and aware about this outbreak."
Training	3	4	"(…) what I was able to change after attending this webinar series. (…) among the trainings I conducted during the pandemic, I included IPC measures, quality assurance, and quality control measures."
Shared with colleagues	3	4	"All sessions were very informative, and I have also shared my experience with my staff."
Improved laboratory management skills	3	3	"I had tried autocratic management, where (…) I decide everything, and after the training, I discovered that (…) each management style must be adapted according to the context. (…) it allowed me to take into account what the staff says (…) the staff is satisfied with the approach I have toward them."
Informed national protocols	2	2	"These series have brought me a lot, a lot of help, even with advice to the Ministry of Public Health of our country so that there is an elaboration of a national grouping on biosafety"
Adapted for other contexts	1	1	"One of the series I enjoyed so much was about SARS-Cov-2, (…) it has not only helped us in COVID-19 management of SARS-CoV-2 (…) the information we learned some time back is being helpful even right now where we are battling with Ebola."

*Supplementary material 5 outlines the definitions of knowledge application themes.

FIGURE 4
Knowledge application barriers (annual survey, N = 560).
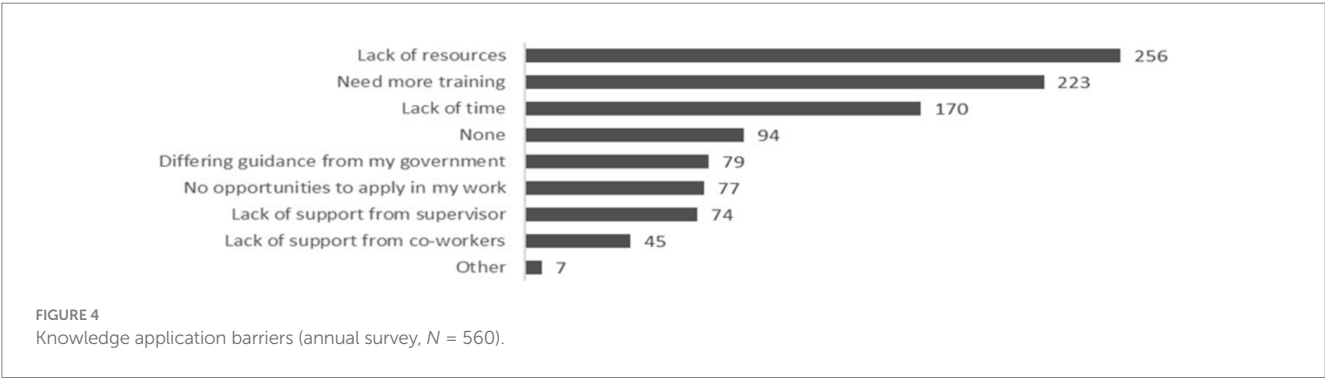
the webinar sessions (29 suggestions), including activities that were practical and hands-on (11 mentions) or involved face-to-face events/trainings (six mentions). Respondents also frequently provided suggestions of future webinar topics they would like to engage with (28 suggestions) with laboratory management and training themes most frequently mentioned (nine mentions).

In focus group discussions (N = 16), nine participants identified similar recommendations for improving webinar engagement with the most common suggestions mentioning changing the session time. However, given the diversity in time zones, the discussion quickly evolved to participants agreeing and acknowledging time zones for a program with a global reach is a great challenge "The time issue is a little bit complicated. So, my other friend in Nigeria wants it at 8:00. In my country, it will be around 5:00. Another wants it at night. (…) So I think it's a commitment."

Discussion

The results of this study add to a growing body of evidence indicating that accessible, learner-centric virtual learning on a global scale can alleviate severe health worker shortages and improve access to updated guidelines and best practices (20, 21). The WHO PHL webinar series provides a unique example of how such a virtual learning model could be leveraged for the education of thousands of laboratory workers and related personnel, providing rapid capacity building and technical support to improve laboratory quality, safety and reliability, particularly in the response to the COVID-19 pandemic.

The rapid growth and expansion of the WHO PHL webinar series in the first year of the COVID-19 pandemic, disseminated through regional networks of webinar invitations and subsequently word of mouth, highlights the demand for such a broadly accessible

TABLE 3 Recommendations for improved session engagement (137 annual survey respondents).

Area for improvement	Number of mentions	Example suggestion
Logistics (session time, language issues, recordings accessibility, and others)	69	"Scheduled time is mid-day and difficult to reserve when also often other work-related activities are scheduled at the same time. Maybe several sessions for different time zones during beginning or end of work day." "English subtitles because sometimes I wish to understand the speakers more but I cannot because of the different accent."
Develop complimentary activities	29	"Inviting participants for hands on practical" "There is need to set up an award for participants by organizing a virtual expo where participants can showcase what they have acquired or learnt from the webinar series. This will encourage as many people to participate as possible, consequently leading to knowledge spread far and wide."
Future topics requests	28	"Molecular techniques in details especially RT-PCR and the how to validate regents using different type of technique." "More topics on laboratory quality control, such as preparation of primers, optional time for each section"
Certificate requests	15	"Most people need certificates of participation"
More guidance or reference materials	12	"Providing more technical documents that are accessible"
Implement knowledge assessments	8	"It might be good to have a post-test after the webinar to make it more effective"
Engage specific stakeholders	3	"Include some speakers from different countries, like Asian countries

knowledge sharing platform. The breadth of session topics and presentations and diverse global participation demonstrates the extraordinary reach of the PHL webinar series. It exemplifies the unique convening power of WHO in bringing together global subject-matter experts in a timely manner to enhance the dissemination of WHO guidance and laboratory best practices for a wide range of diseases to a cross- disciplinary audience. This was facilitated by a webinar format that prioritized accessibility and inclusivity, featuring case presentations from 45 countries including 22 from low- and lower-middle-income countries and interpretation into various languages. Additionally, session recordings, summaries, Q&As and links to other relevant materials provided opportunities for laboratory professionals and other health workers facing issues like connectivity and timing challenges to access the learning opportunities of the initiative.

Participant feedback through satisfaction polls, annual survey and focus groups provided insight into the webinars' effectiveness at enhancing knowledge-sharing specific to laboratory personnel, which represented almost half of all participants. High relevance ratings and repeated indication that participants would recommend the series to colleagues demonstrated that the PHL webinar series' addressed the professional needs of the public health laboratory workforce. This relevance was enhanced by mechanisms allowing participants to ask questions ahead of and during each session, ensuring participants concerns and knowledge gaps were addressed and enabling suggestions for future session topics. This flexibility ensured just-in-time learning, responding to emerging needs such as new SARS-CoV-2 variants and the need to monitor their spread to inform public health recommendations and interventions or address knowledge gaps expressed by participants such as risk management for SARS-CoV-2 testing, which in turn triggered dedicated biosafety sessions, among others. Evidence that this knowledge was subsequently applied by participants, such as through changes in workflow, onwards training events and procedural changes further reinforces the efficacy

with which the series was able to make tangible impact at the laboratory level.

While the webinar series was successful in achieving relevant knowledge dissemination, application and exchange, persistent barriers toward implementing changes were also highlighted. These included insufficient resources and time, the need for more workplace support, and additional training requirements. Connectivity issues also posed participation challenges, common in underserved areas (14–16). Importantly, while the series proved effective at disseminating best practices broadly, participant feedback suggested a continued need for in-person training which stresses that such a series does not replace face-to-face and hands-on learning for laboratory professionals in the technical environment. The series delivery model, with short sessions, large attendance, and simultaneous interpretation, limits interactions among participants, restricting them to text exchange over the chat function of the webinar platform, and limiting the delivery of sessions focusing on problem solving (eg. PCR results interpretation and troubleshooting). These findings provide essential information for WHO to be able to develop future activities to reduce knowledge gaps and better support the laboratory workforce in truly effective, practical implementation of best practices. Recommendations from webinar participants have prompted both WHO and UNM ECHO to reflect on the format of delivery of their webinar series and consider future adaptations to further increase accessibility of the information shared. Additional barriers that were reported such as the lack of resources to implement change continues to be addressed through capacity strengthening initiatives of WHO and other partners, through the national action plans for health security and International Health Regulations (IHR) capacity strengthening (17, 18), the Pandemic Fund initiative which has identified surveillance, laboratory systems and health workforce as its three programmatic priorities (19) and advocacy efforts for stronger laboratories and laboratory systems at the national and subnational level.

A critical limitation of this study is inconsistent data collection at the outset of the series and the low response rate to the annual survey, impeding the ability to generalize findings. Results from different data collection instruments may be biased toward recurring participants during those timeframes. Nevertheless, quantitative and qualitative results show compelling evidence of knowledge acquisition, practice change, and session satisfaction within the study sample. It also provides insights on potential improvements as the webinar continues to be implemented.

Finally, the WHO webinar series successfully integrated topics beyond COVID-19, addressing knowledge gaps for other high priority diseases and cross-cutting laboratory topics. Subjects like laboratory biosafety or quality management that would previously have been delivered using face-to-face trainings could now rapidly reach a broader and more diverse audience through the webinar series. For example, the webinar session on biosafety (session 26) engaged 1,124 individuals from 118 countries. The series also supported emergency responses, such as the Public Health Emergency of International Concern (PHEIC) for mpox in July 2022, with a dedicated session attended by over 1,500 participants from 145 countries, one of the most attended sessions. Similar sessions followed outbreaks of Sudan virus disease (Uganda, November 2022), acute viral hepatitis (June 2022), and diphtheria (Nigeria, July 2023), proving the series to be a flexible tool for WHO to address long-term capacity building and support emergency response efforts.

In conclusion, the WHO Public Health Laboratories' webinar series successfully achieved its primary goals, which included amplifying the dissemination of WHO guidance and best practices by engaging with key laboratory stakeholders worldwide. It aimed to bolster knowledge sharing, facilitate peer-to-peer interactions among laboratories, and enrich WHO's insights into the prevailing knowledge deficits and obstacles to implementing guidance and best practices.

The webinar series succeeded in not only supporting the laboratory workforce in addressing challenges of the COVID-19 pandemic but was also successfully leveraged to support learning on cross-cutting laboratory topics and outbreak response for other epidemic and pandemic prone diseases. This success was possible because the series was implemented continuously, alternating cross-cutting topics and rapidly addressing new health emergencies. This approach allowed for the reactivation of an essential and relevant contingent of the global laboratory workforce in a timely manner, facilitating just-in-time learning for a more effective response to regional and global health emergencies. A similar approach may be utilized by WHO and technical agencies in other areas of work related to health emergencies.

Implementing stronger monitoring and evaluation mechanisms was essential for assessing the quality and delivery of the webinar series and its usefulness for participants. Evaluating its impact is crucial to justify resource allocation and drive continuous improvement, leading to greater impact and more effective support for the laboratory workforce and stakeholders who provide essential health services globally. Through the ongoing PHL webinar series, WHO will continue to utilize its unique convening power, inviting world class laboratory and diagnostic experts to help improve access to, and dissemination of, quality guidance and best-practices for the laboratory workforce globally.

Data availability statement

The datasets presented in this article are not readily available because requests to access data will be evaluated according to the ethics guidelines and should be directed to the corresponding author. Requests to access the datasets should be directed to Céline Barnadas, barnadasc@who.int.

Ethics statement

This study involved minimal risk to human subjects and the requirement of ethical approval was waived by the University of New Mexico Institutional Review Board (IRB) (Ref: 20-469) and the WHO Research Ethics Review Committee. The study was conducted in accordance with institutional requirements, and participants provided consent to participate in the study.

Author contributions

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2024.1462756/full#supplementary-material

Check for updates

The evolutionary journey to a new normal for learning and capacity building of healthcare workers to prepare and respond to health emergencies across Africa

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Background: Faced with the COVID-19 mobility restrictions, the WHO AFRO EPR program pioneered a collaborative initiative with Project ECHO to virtually educate health workers across Africa at scale. This initiative has evolved into a transformative learning journey. This paper aims to present the lessons learned.

Results: From April 2020 to February 2024, 287 virtual learning sessions were conducted with over 125,816 attendances from 173 countries and regions. This marked a significant increase compared to pre-pandemic face-to-face training, which targeted fewer than 2,000 participants annually. Survey responses ($n = 43,221$) indicated high relevance and applicability, with 97% of respondents planning to use the information in their work and 89% finding the sessions very or extremely relevant. Self-reported knowledge levels increased from 28 to 74% post-session.

Discussion: Integrating digital learning into WHO AFRO's education and training toolkit has facilitated immediate emergency responses and enhanced long-term resilience, adaptability, and equity among healthcare workers, especially in under-resourced regions. This initiative has reached more health professionals than pre-pandemic in-person training, facilitating more equitable access to essential knowledge and best practices.

Conclusion: The WHO AFRO and Project ECHO partnership navigated a variety of challenges, while establishing a paradigm shift in learning strategies. Emphasizing a digital learning first approach, while retaining in-person elements, this collaborative initiative offers insights for future healthcare education, highlighting adaptability, cost-efficiency, equity, and new technologies in addressing global health challenges. However, to sustain this momentum and further expand access to critical knowledge, stakeholders must commit to continued investment in digital learning infrastructure, training, and technology.

KEYWORDS

health emergencies, capacity building, learning interventions, health information, just-in-time learning, knowledge dissemination

1 Introduction

The onset of the COVID-19 pandemic led to unprecedented disruptions in global health systems, prompting an urgent reevaluation of the methods used to train healthcare workers (1). Traditional in person training methods were not possible to implement due to travel restrictions and there was a need for rapid, widespread dissemination of the latest health guidance and practices. In response to these challenges, the World Health Organization Regional Office for Africa (WHO AFRO) in partnership with Project ECHO hosted by the University of New Mexico (UNM) and the ECHO India Trust, embarked on an innovative initiative to train health workers across Africa through synchronous virtual learning approaches. This venture, initially a temporary solution to the pandemic's constraints, has since matured into a transformative journey of healthcare worker continuing professional development in Africa and marks a significant evolution in educational methodologies, especially in the face of health emergencies like the COVID-19 pandemic, to enhance the preparedness, response, and resilience of healthcare professionals across the continent (2).

Prior to the pandemic, the capacity of the WHO AFRO Emergency Preparedness and Response (3) Learning and Capacity Building Unit for health worker training was limited by logistical challenges and resource constraints, particularly in low-resource settings (4). Traditional in-person workshops and training sessions, though effective, could only reach a limited number of healthcare professionals due to costs, geographical limitations, and the time required to organize and conduct such events. The WHO AFRO Emergency Preparedness and Response (EPR) team typically managed about 30 face-to-face regional trainings annually, engaging 1,500–2,000 participants in total each year.

With the advent of the COVID-19 pandemic, there was a critical need to quickly scale up education and training opportunities and adapt to the constraints imposed by the crisis (5–8). The collaboration between WHO AFRO and Project ECHO transformed this challenge into an opportunity to redesign the learning model. This shift not only aimed to address the immediate needs of the pandemic, but also to lay the groundwork for a more resilient learning system capable of addressing future health emergencies (9). The transition to virtual learning platforms facilitated a dramatic increase in the scope and scale of training efforts (10–15).

This paper argues that the collaboration between WHO AFRO and Project ECHO, initially necessitated by the mobility restrictions and other challenges of the pandemic, has led to a paradigm shift in learning strategies. This shift has broadened the portfolio of learning approaches, placing a greater emphasis on digital learning—both synchronous and asynchronous—while still maintaining a modest component of in-person learning where appropriate. Beyond merely responding to immediate health emergencies, this hybrid learning model equips healthcare workers for a future that demands greater resilience, adaptability, and equity.

2 Materials and methods

2.1 Clinic design, content, and promotion

From March 2020 until February 2024, WHO AFRO and Project ECHO hosted over 287 digital learning sessions, including six emergency-response series and two non-emergency series (Table 1).

The structure of WHO/ECHO learning sessions varied based on content. Some were open information sessions, while others included case presentations and experience sharing, primarily targeting clinicians. Additionally, virtual community of practice (VCoP) sessions catered to smaller groups of specialized health professionals needing specific skills or guidelines due to the public health climate in their country or region. Each learning session was live-interpreted and recorded in English, French, and Portuguese to maximize reach and accessibility. ECHO staff and WHO program facilitators met weekly to plan and ensure session quality by optimizing slide decks, camera views, and sound quality. Session recordings were publicly available for asynchronous learning to accommodate busy health professionals.

2.2. Data collection and analysis

2.2.1 Cross sectional analysis

This study used cross-sectional and retroactive pre-post designs. Cross-sectional data were collected to assess participation using demographic variables collected via Zoom™ registration. A retroactive pre-post design was employed to evaluate participants' self-reported changes in knowledge or skills, with participants reflecting on their levels before and after the intervention. The latter aimed to provide a more accurate assessment of perceived changes, especially since participants may not have been aware of how much they didn't know before participating in the digital learning sessions. We used a voluntary response sample since the surveys were open to all participants.

Each series used Zoom™ registration questions to gather demographic information about participants, tailored to the specific needs of the program teams. Consistent registration variables included email, country or region, and profession. Zoom™ registration and attendance reports were merged as needed, and session duplicates were removed based on email addresses.

We collected feedback after each session using an anonymous online survey via REDCap (Research Electronic Data Capture) electronic data capture tools hosted at the UNM. REDCap is a secure, web-based software platform designed to support data capture for research studies (16). REDCap surveys included 13 items on one screen, primarily with multiple choice questions (one response option enforced and non-applicable present as appropriate). Once respondents clicked the submit button, they could no longer edit their answers. Survey links were emailed to participants after each session, and completion was linked to a digital certificate of participation as an incentive to increase response rates. Surveys generally closed between 3–4 weeks after each session. This online survey is offered to all international

TABLE 1 Summary of WHO Afro series names and characteristics.

WHO AFRO series name	Emergency response or not	# of sessions	Feedback survey response rate	Session time frame
WHO AFRO IDSR	Emergency	78	6.6%	October 2020–January 2023
WHO AFRO COVID-19 WEBINARS	Emergency	42	30.1%	May 2020–March 2022
WHO AFRO Miscellaneous Emergency	Emergency	41	Survey data not available	February 2021–June 2023
WHO AFRO Pediatric and Adolescent HIV	Non-emergency	29	18.4%	October 2020–October 2023
WHO AFRO Miscellaneous Non-emergency	Non-emergency	23	Survey data not available	June 2020–July 2023
WHO AFRO LAB VCoP	Emergency	14	14.7%	February–October 2021
WHO AFRO ICAN/ACDC IPC	Emergency	12	Survey data not available	July 2022–August 2022
WHO AFRO AVoHC-SURGE	Emergency	7	17.4%	December 2022–May 2023

ECHO programs that would like to deploy it. It is an overall assessment that uses CDC-recommended tools. It was designed following the CDC's program evaluation framework's structured and systematic steps, including engaging stakeholders, focusing on the evaluation, ensuring data quality, and guaranteeing that the survey is aligned with general program goals and stakeholder needs [17].

Feedback survey questions included session satisfaction indicators (e.g., whether participants would recommend the session to a colleague), relevance to their work, and knowledge and application outcomes, such as retrospective pre-post knowledge about the session topic, and whether participants would use what they learned in their work. Having been successfully employed in international programs across diverse geographies for over 3 years, the survey has demonstrated its capacity to provide valuable, actionable feedback for program improvement. This long-standing use across various contexts attests to its value and adaptability in capturing meaningful insights.

The evaluation of the programs using Zoom™ registration and REDCap surveys has been approved by the UNM IRB under protocol number 20-469. Per the IRB requirements, surveys included a consent document and a consent question in the introduction. Datasets with personal identifiers were stored in encrypted folders, and only study members listed in the protocol had access. We have reported survey information according to the CHERRIES statement [21].

2.2.2. Cost analysis

Training cost estimate data was collected and analyzed from budget lines, training records, and the interpretation dashboard to assess cost differences between physical and virtual training modalities. The estimated average cost per session and daily cost per participant for virtual training were calculated using expenditure records, interpretation records, and Zoom™ attendance reports. Trends over time were analyzed to identify patterns or changes in attendance and costs associated with both physical and virtual training.

We used descriptive statistics to calculate the number of attendances (unique to each session) the number of attendees (unique to each series) and their respective country counts. For post-session feedback surveys, we focused on the three emergency-response series with the highest response rates, calculated based on the number of submitted survey entries divided by total attendance (Table 1). Descriptive statistics were used to analyze session relevance and application of learnings, and the Wilcoxon rank sum test was used for paired data analysis of pre-and post-session knowledge levels. We reviewed all submissions, even if the responses to specific questions were missing. Given that feedback surveys were anonymous, we could not fully deduplicate the datasets. However, 93% of the WHO COVID-19 Webinar survey respondents, 97% of WHO AVoCH -SURGE Webinars, and 96% of WHO LAB Virtual Community of Practice (VCoP) sessions, shared their emails at the end of the survey to receive certificates. Based on those, we identified and excluded duplicate entries before conducting statistical analysis. Respectively, for the three programs outlined above, we excluded 7% of the records for the first two (393 out of 5,382 and 34 out of 466) and 6% (8/140) for the last. This analysis was conducted using R [18], RStudio [19], and the MASS package [20].

2.3. Data limitations

Since 2020, there has been significant variation in questions and response choices between learning sessions, limiting the ability to compare across sessions and series. However, we were able to analyze three WHO/ECHO Series attendance/registration reports and feedback surveys with the highest response rates over the last 4 years. These included WHO COVID-19 Webinars, WHO AVoCH -SURGE Webinars, and WHO LAB Virtual Community of Practice (VCoP) Sessions. As outlined previously, given that feedback surveys were anonymous, we could not deduplicate the dataset fully. VCoP sessions, targeting specific learners, often had fewer attendances than webinars, but featured higher engagement through smaller interactive group discussion. Finally, these results are based on a sample with potential bias due to low response rates.

3 Results

3.1 Participant survey

WHO AFRO and Project ECHO hosted six emergency-response series and two public health topical learning series from March 2020 to February 2024, with a total of 125,816 participants from 173 countries. Participants from the 54 African countries totaled 100,053, with 79.5% (79,542 participants) from the 47 WHO AFRO countries. Nigeria had the highest number of participants (20,555), followed by the Democratic Republic of Congo (11,572) and Ghana (6,292; Figure 1).

Pre-post retrospective knowledge of the session topic was measured in post-session surveys with before and after questions for respondents to subjectively rate their knowledge. The paired data for the three series outlined above showed that before the webinars 29.4% of participants considered themselves "Not at all/slightly knowledgeable," 24.9% as "Very knowledgeable," and 4.5% as "Extremely knowledgeable." However, post-webinar assessments revealed a significant increase in knowledge levels: only 1.7% remained in the "Not at all/slightly knowledgeable" category, while 64.2% were now "Very knowledgeable," and 18.7% were "Extremely knowledgeable." The p-value is <0.001, indicating a statistically significant improvement. These results were consistent across all topics (Table 2).

Participants expressed varying perceptions of the learning session's relevance to their work, however, more than 85% found the learning sessions to be very or extremely relevant independent of the series. For those, the Lab Virtual Community of Practice (VCoP) training had the highest ratings for relevance to participant's work (94.3%). AVoCH_SURGE and COVID-19 learning series had similar relevance ratings, respectively 87.3 and 88.7% (Figure 2).

For WHO AFRO LAB VCoP sessions, WHO AFRO AVoHC-SURGE Webinars, and COVID-19 webinars, participants were asked how they planned to use what they learned. Sharing learnings with colleagues was the most common option selected by 30.6% from the WHO AFRO LAB VCoP, 25.8% from WHO AFRO AVoHC-SURGE, and 25.8% from COVID-19 webinars (Figure 3).

3.2 Training cost estimation

3.2.1 In-person training cost estimate (2018–2019)

Between 2018 and 2019, WHO AFRO EPR conducted five in-person training sessions focused on Integrated Disease Surveillance and Response (IDSR), each lasting an average of 5.5 days, plus two travel days. These training sessions averaged 28.6 participants each. The financial commitment was substantial, with total expenditures amounting to $444,471. Individual training event costs ranged from $37,860 to $135,000. The direct cost to the organization ranged from $440 to $757 per participant per day, averaging $612 daily ($76.5 per hour) per participant, or $3,266 per participant for the 5.5-day training.

3.2.2 Virtual training cost estimate (2021–2023)

To adapt to new norms and reduce costs, WHO AFRO EPR transitioned to virtual training from 2021 through 2023. This change dramatically reduced the cost per participant to between $3 and $4 per hour and significantly increased accessibility. Consequently, average attendance surged to 404 participants per learning session. This marked increase highlights the scalability and cost-efficiency of virtual training, proving it to be a formidable alternative to traditional in-person learning sessions. This model was particularly beneficial to participants in regions where access to such training was previously limited or non-existent.

4 Discussion

4.1 Democratizing access to WHO technical expertise

The virtual learning approach expanded access to learning and enhanced the preparedness, response, and resilience of healthcare professionals across the continent, marking a significant evolution in educational methodologies during global health emergencies. Before COVID-19, face-to-face training aimed to disseminate WHO AFRO EPR's technical expertise, but reached only a select group (~2,000 per year) who could overcome logistical, geographic, and financial challenges. The shift to virtual learning democratized access by greatly reducing these barriers (22, 23); only a Wi-Fi or data-connected device was required. From 2020–2023, there were 125,816 attendances from 173 countries and regions, over 15 times the pre-COVID-19 pandemic in-person rate. This increase was primarily due to African participation, with 79.52% (100,053) of participants joining from the 47 WHO AFRO member states.

4.2 Cost- and time-efficient approach

The increased participation in WHO AFRO webinars, as outlined in the results section, is directly related to the cost and time efficiency of these learning opportunities being virtual. Virtual platforms eliminate geographical barriers, enabling healthcare professionals to access crucial health information globally without costly and time-consuming travel, and without requiring participants to leave their work posts. Traditional in-person training programs entail significant expenditures, including travel, accommodation, venue rentals, and printed materials. The significant cost savings from reduced travel and accommodation expenses allow the WHO AFRO to allocate resources more efficiently, thereby expanding the reach and frequency of their virtual learning sessions.

Additionally, virtual learning facilitates the rapid and widespread dissemination of up-to-date health information and training, crucial in emergencies like the COVID-19 pandemic. The scalability of virtual platforms enables WHO to reach a larger audience without the logistical challenges of in-person training sessions. This efficiency not only lowers per-participant costs, but
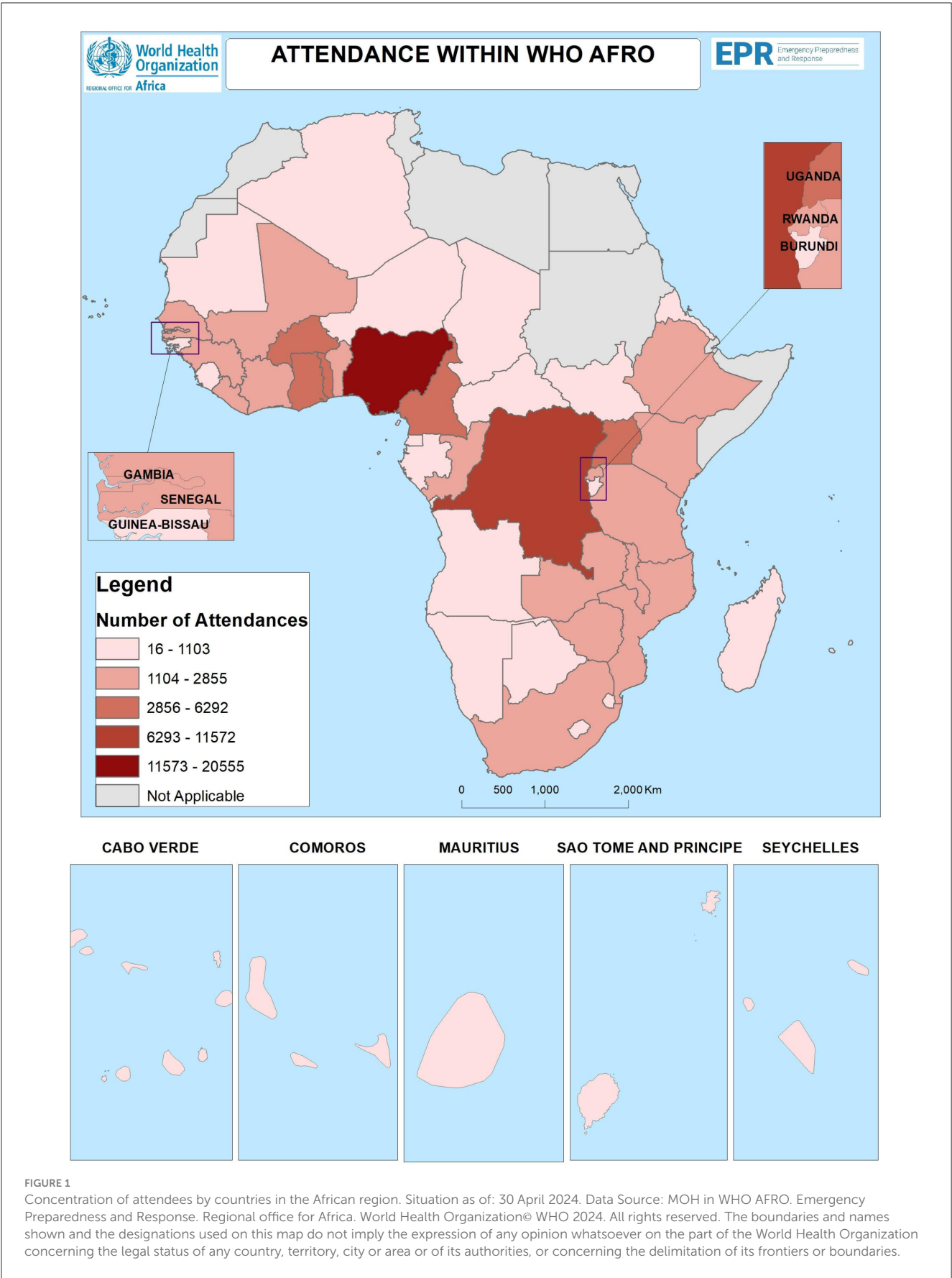
FIGURE 1
Concentration of attendees by countries in the African region. Situation as of: 30 April 2024. Data Source: MOH in WHO AFRO. Emergency Preparedness and Response. Regional office for Africa. World Health Organization© WHO 2024. All rights reserved. The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

TABLE 2 Distribution of attendees by knowledge and topics.

Topic	Number (N)	Category	Pre training	Post training
General	5,350	Not at all/slightly knowledgeable	29.4	1.7*
		Moderately knowledgeable	41.2	15.4
		Very knowledgeable	24.9	64.2
		Extremely knowledgeable	4.5	18.7
COVID-19	4,789	Not at all/slightly knowledgeable	26.9	1.8*
		Moderately Knowledgeable	43.3	13.2
		Very knowledgeable	25.1	66.6
		Extremely knowledgeable	4.7	18.4
AVoHC	430	Not at all/slightly knowledgeable	46.7	0.7*
		Moderately knowledgeable	27.4	32.3
		Very knowledgeable	23	47.9
		Extremely knowledgeable	2.8	19.1
Lab	131	Not at all/slightly knowledgeable	63.4	0.8*
		Moderately knowledgeable	9.9	42.7
		Very knowledgeable	22.1	31.3
		Extremely knowledgeable	4.6	25.2

*p value < 0.001.

FIGURE 2
Distribution of attendees by perceived relevance of training session on their work.
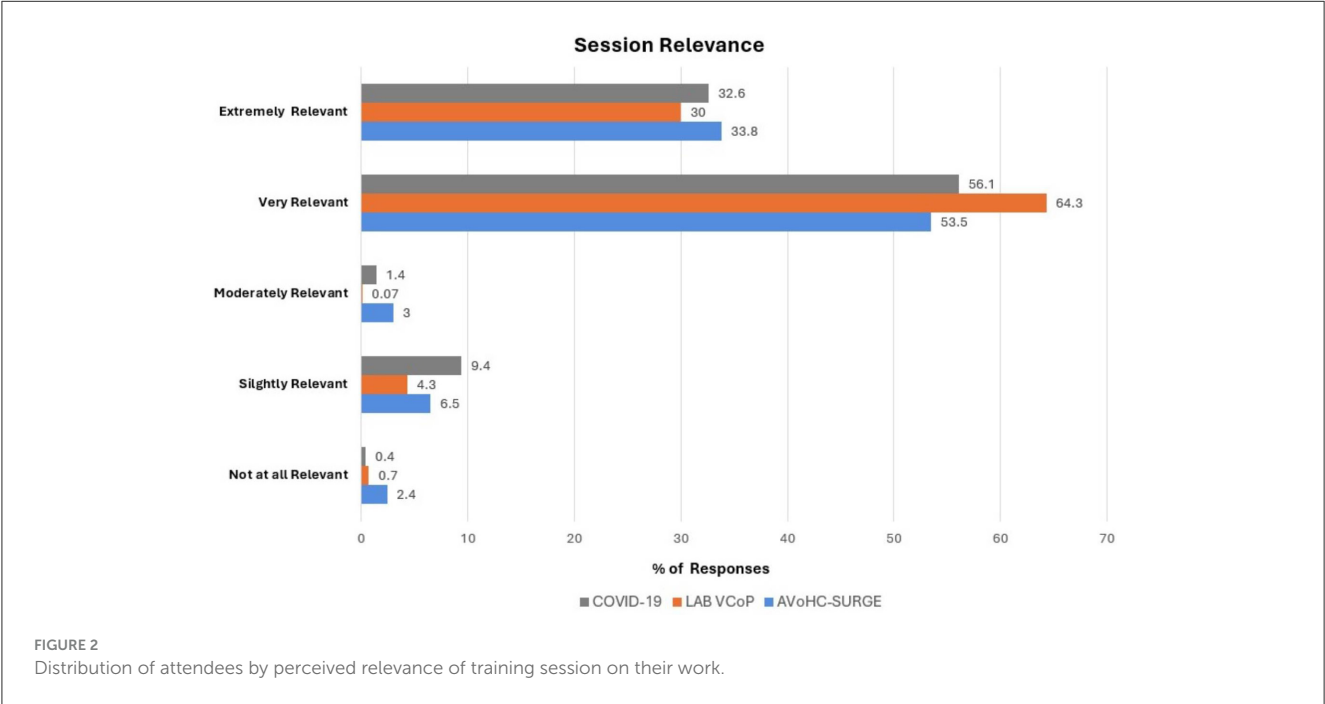
also accelerates the process of knowledge and best practice transfer, ensuring healthcare workers worldwide are well-equipped with the latest guidelines and practices. Consequently, virtual learning enhances WHO's capacity to improve global health outcomes in a cost-effective and timely manner. This collective enhancement of knowledge and best practices directly contributes to improved health outcomes globally (14, 24), demonstrating how the cost and time efficiency of virtual learning fosters increased participation and amplifies its impact.

4.3 Bidirectional learning

Bidirectional learning, the cornerstone of WHO AFRO EPR's learning strategy, has transformed knowledge sharing and action-taking through dynamic exchanges via Q&A sessions and participant feedback. By using feedback to identify learning needs, we have tailored our learning programs to address specific gaps and challenges, ensuring the content remains relevant and impactful. Real-time feedback has allowed us to swiftly revise
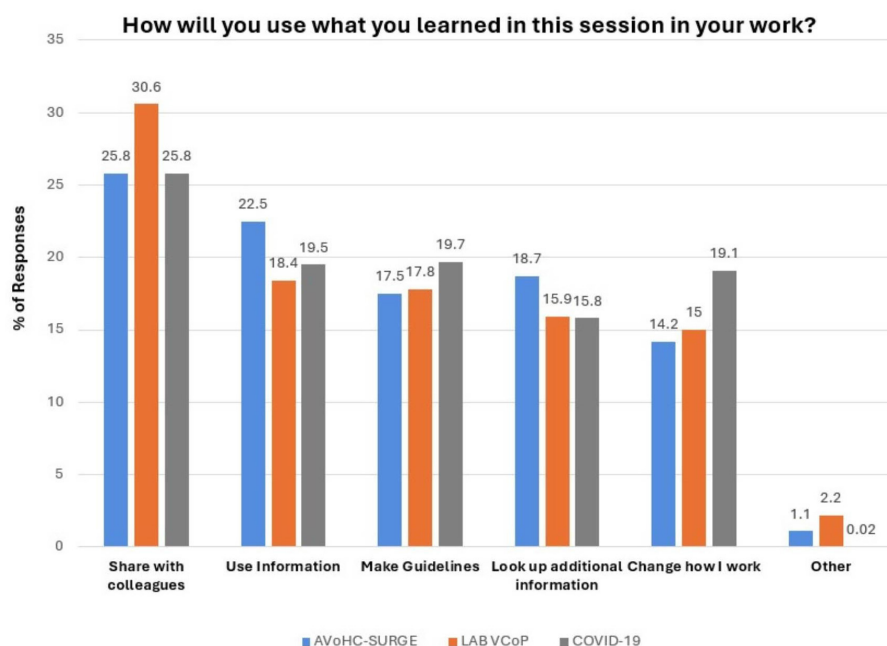
session content, keeping our learning content practical and current. Digital learning sessions have broadened participation, bringing in diverse perspectives that enrich the learning experience and foster a holistic approach to health emergency preparedness and response. For instance, the IDSR VCoP was developed in response to participant expressed needs and feedback, exemplifying the impact of bidirectional learning.

4.4 Call for an evidence-based approach to digital learning

In collaboration with WHO AFRO EPR, Project ECHO teams at the UNM ECHO Institute and the ECHO India Trust applied insights from more than 15 years of experience implementing the evidence-based Project ECHO case-based tele-mentoring model to the webinar format. Virtual learning sessions also routinely employed other adult learning best practices, such as polling and ample Q&A to maximize interactivity (25, 26). Now that the initial pandemic response has waned, there is an opportunity to assess gaps in the evidence (27).

First, there is a need to standardize participant and feedback data collection to enable more cross-program analysis. The reduced financial and personal-life burdens (e.g. time away from family and the need to secure childcare while traveling) of virtual options suggest that the virtual learning sessions are more accessible and convenient to women and early-career professionals from a wider variety of healthcare professions (28). However, analysis of categories such as participant gender, career level, and professional category is currently limited due to incomplete or inconsistent data

collection. More in-depth post-session and longitudinal evaluation is needed to better understand the impact programs have on practice change.

Second, further research is needed to determine the optimal dose, including frequency and duration of digital learning sessions, to maximize learning outcomes, equity, and resource utilization. Questions include whether biweekly sessions are as effective as weekly or monthly ones, how one-time learning sessions or limited series webinars compare to ongoing virtual communities of practice, and which learning competencies and outcomes are best suited for virtual vs. in-person learning. Identifying barriers to accessing learning opportunities and implementing learnings is also essential. While professional experience suggests a balance between virtual asynchronous, virtual synchronous, and in-person synchronous learning is important, there is limited peer-reviewed data on tailoring these approaches to specific learning objectives.

Third, research into the cost-effectiveness of digital learning initiatives, considering time, financial, and carbon emissions costs, is necessary (29–31). While there is some data on cost-effectiveness from the implementer perspective, there is limited information on the cost-effectiveness for participants and health systems when virtual learning outcomes are linked to patient outcomes and cost-savings. The negative impact of carbon emissions on the climate crisis increases the importance of measuring and factoring in carbon emission costs to the cost of education and training opportunities. In-person learning opportunities are associated with higher carbon emissions due to participant air and ground travel (which accounts for 4–5% of global emissions annually), short-term accommodations, and single-use items like conference booklets, lanyards, posters, and beverage containers (32). While some data

supports virtual learning as a lower-emission option, the specific emission impact of these programs remains unknown.

4.5 Implications of the study: a new normal in learning

The COVID-19 pandemic necessitated a rapid switch to an exclusively digital learning program, democratizing access to WHO technical expertise and allowing broader participation from diverse geographies. Participant feedback data shows that these early digital learning initiatives extended beyond achieving scale and increasing equity of access to just-in-time learning to also achieving significant impact.

While the evidence base for virtual learning is still being built, this paper advocates not for a "digital-only" future, but a "digital-first" new normal. In this digital-first approach, trainers prioritize digital learning when appropriate while utilizing a variety of tools (asynchronous online courses, webinars, virtual face-to-face, in-person). This hybrid approach leverages a diverse learning ecosystem offering a flexible and dynamic experience. Travel for in-person training would be reserved for specific, targeted objectives and may be preceded by prerequisite virtual engagements and/or followed by ongoing virtual learning opportunities.

The pandemic highlighted the importance of leveraging emerging technology to build and maintain effective learning programs. The new normal retains the spirit of innovation from early COVID-19 virtual learning, embracing the latest technologies and methodologies, including artificial intelligence and adult learning theory, and can also be useful for future pandemics (33, 34).

The new normal seeks to integrate digital learning into standard practices without compromising the efficiency, greater reach and increased equity of access achieved during the pandemic. Training sessions can be planned and implemented rapidly to disseminate information quickly to a diverse audience. This approach embraces quality improvement by integrating lessons learned from after-action reviews, providing consistent training on digital platforms, and securing increased financial and human resources for virtual learning.

5 Conclusion

The partnership between WHO AFRO EPR and Project ECHO not only helped navigate the challenges posed by COVID-19, but also laid the groundwork for a robust "new normal" in health workforce education, training, and continuing professional development. The new normal demonstrates that virtual training can facilitate substantial knowledge acquisition among a broad audience at a global level. This innovative learning approach, combined with the ECHO "all teach, all learn" case-based learning model and informed by continuous assessments, ensures ongoing preparedness and offers valuable lessons for future healthcare education endeavors. As the COVID-19 response evolves, the initiative's focus on democratizing knowledge through interactive and accessible learning sessions continues to empower public health leaders and frontline health

workers, offering them more equitable access to lifesaving knowledge and best practices.

The collaboration between WHO AFRO EPR and Project ECHO represents a significant advancement in healthcare education, setting a precedent for future continuing professional development programs. By leveraging digital technology and fostering an "all-teach, all-learn" model, this initiative has not only responded adeptly to the immediate needs catalyzed by the COVID-19 pandemic, but has also laid the groundwork for a more resilient, inclusive, and effective approach to healthcare worker education and training worldwide. To sustain this momentum and further expand access to critical health knowledge, stakeholders—including governments, donors, and health institutions—must commit to continued investment in digital learning infrastructure, training, and technology.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by University of New Mexico Institutional Review Board (IRB) as exempt (Ref: 20-469). The studies were conducted in accordance with the local legislation and institutional requirements. The ethics committee/institutional review board waived the requirement of written informed consent for participation from the participants or the participants' legal guardians/next of kin because oral consent was obtained and recorded.

Author contributions

BB: Conceptualization, Supervision, Writing – original draft. FM: Conceptualization, Methodology, Writing – original draft. AA: Data curation, Project administration, Writing – original draft. JO: Conceptualization, Visualization, Writing – original draft. HU: Writing – original draft. GB: Writing – review & editing. AB: Data curation, Formal analysis, Methodology, Writing – original draft. LB: Project administration, Writing – original draft. SM: Data curation, Methodology, Writing – original draft. SN: Writing – original draft. AG: Writing – review & editing. BS: Conceptualization, Funding acquisition, Supervision, Writing – original draft.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Co-creation of staff training to address health-related social needs in emergencies

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Background: Health-related social needs (HRSN), such as housing and transportation barriers, contribute to poor health outcomes and increased healthcare costs. Patient navigators help connect patients to community resources, but workforce training gaps are a challenge. The Strengthening Peer AHC Navigation (SPAN) study aimed to enhance navigation training during the COVID-19 Public Health Emergency.

Methods: Using a stakeholder-driven peer planning approach, SPAN co-developed a quality improvement plan for patient navigation training. Training focused on housing and transportation navigation and included didactic sessions, hands-on case studies, and biweekly expert consultations. Self-efficacy surveys measured navigator confidence pre- and post-training, and changes in navigation case resolution rates were assessed.

Results: Seventeen navigators participated in training. Self-efficacy scores improved, particularly in housing and transportation navigation. Resolved navigation cases increased by 29% ($p = 0.001$) over 6 months post-training. Participants reported increased confidence, knowledge, and empathy for patients with HRSN.

Conclusion: The SPAN peer planning model successfully developed and implemented an adaptive navigation training program, improving navigator confidence and patient outcomes. Findings highlight the value of stakeholder-driven training and ongoing expert support in strengthening the social needs workforce. Further research should explore sustainable models for workforce development in healthcare settings.

KEYWORDS

adaptive training, patient navigation, health related social needs, public health emergency, AHC model

Introduction

Health-related social needs (HRSN) including food insecurity, housing instability, transportation, and difficulty paying bills are associated with a range of poor health outcomes, increased healthcare utilization and cost (1–6). HRSN represent a health equity issue with a disproportionate burden on under, and uninsured, minority patients (2). These patients often seek care in Emergency Departments (EDs) due to insufficient access to healthcare coupled with their HRSN and other risk factors (2). To address HRSN, and improve healthcare utilization and cost, patient navigators play a pivotal role often serving

as link workers who provide patient education and facilitate a connection to community resources to address identified HRSN (1, 6). The largest test of HRSN programs with link workers in the US was the CMS Accountable Health Communities Model (AHC) which tested systematic HRSN screening, referral, patient navigation (Assistance Track) and community engagement (Alignment Track) for Medicare, Medicaid and dually covered beneficiaries (7). In Assistance, screening via the AHC screening tool, referral to community organizations and patient navigation was conducted using a randomized controlled trial design (RCT) (2, 8). Alignment added community advisory boards and continuous quality improvement, with the goal of aligning community resources to resolve HRSNs but was not an RCT. In both Tracks, Bridge Organizations (BO) served as the anchor or hub and led Model activities with clinical delivery sites (hospital emergency departments, labor and delivery departments and ambulatory clinics). BO were a range of organization types including health systems, public health, academic and non-profit organizations. 28 BOs supported 186 screeners and 159 navigators employed by the grant. "More than 1 million (1,114,099) unique beneficiaries were screened between May 2018 and January 2023. Of those, 18% (204,447) were eligible for navigation services (one or more core HRSNs and two or more self-reported ED visits in the 12 months prior to their screening)" (9). The AHC Model required implementation strategies be used by BOs and included a mixed methods evaluation by the external evaluator for the overall Model. BO staff training was a requirement for patient navigators; however, BOs were able to develop and implement their own training programs, leading to potential variability in content, modality, and overall quality of the workforce training provided (10, 11). The National Academies of Sciences, Engineering, and Medicine (NASEM) report on addressing HRSN in healthcare settings also indicated there is a current lack of data on the type of staff serving as link workers, and the workforce training that they may have received specific to assessing and addressing HRSN in the US (12). In short, to successfully connect patients to community resources, patient navigators require education and training that is often beyond the scope of existing community health worker (CHW) or patient navigator training programs in the United States.

The public health emergency (PHE) caused by the novel Coronavirus (COVID-19) represented a pivotal time for healthcare, HRSN, and patient navigators serving as the link between patients and community resources. While initially disrupting and reducing healthcare and ED utilization, as the pandemic progressed, EDs again became a focal point of patient contact with some studies noting rebounds in ED visits particularly for minority African American patients by April to May 2020 in safety net hospitals (13). Patient navigators working in healthcare settings, including EDs, were sometimes removed from working in person on patient units during the pandemic to reduce unnecessary contact and disease spread. In addition, HRSN increased substantially during the pandemic, especially food insecurity, housing instability and transportation needs (14–16). This enormous increase in need was coupled with strains on available community resources such as food pantries, housing assistance programs, and even public transit agencies who reduced or shifted their operations in response to the pandemic (17, 18). Many community agencies, and even local government funded

programs dealt with challenges from reduced revenue resulting in difficulty maintaining operations at pre-pandemic levels (18). In short, the PHE created a challenging and dynamic situation where more patients needed support for HRSN but faced reduced access to both healthcare and community resources. This was coupled with reduced access to patient navigators who were often forced to work remotely and had to find innovative ways to continue to provide their education and facilitation services to patients. Little is currently known about patient navigator training programs for HRSN in the US, and even less is known about how programs were created or adapted for the PHE to respond to evolving patient and navigator needs and rapidly changing availability of community resources.

The Strengthening Peer AHC Navigation (SPAN) study, was conceptualized to structure technical assistance to AHC BO and CDS who had identified gaps in the implementation of the AHC Model, particularly within their provision of patient navigation services (19). Using an integrated framework blending the Consolidated Framework for Implementation Research, Intervention Mapping, and the Expert Recommendations for Implementing Change compilation (ERIC), a comprehensive technical assistance protocol was created to help Bridge Organizations improve delivery of the AHC Model (20–22). Using these three implementation science frameworks, SPAN applied four succinct steps, assessment, planning, implementation with technical assistance, and evaluation. A mixed methods assessment was conducted to understand baseline implementation processes, identified needs, and readiness for change and results have been previously reported (7, 19). Briefly, SPAN's assessment found specific workforce training gaps for navigators in the AHC Model, including patient engagement, communication, knowledge, and boundary spanning skills needed to successfully connect patients to community resources, particularly for housing and transportation needs (7, 23). Our objective in this study is to describe the pilot test of the SPAN peer planning process and the development and implementation of a quality improvement plan focused on patient navigation training and workforce development for HRSN during the PHE at one AHC BO and CDS located in Houston, Texas.

Setting

The BO and partnering clinical delivery sites in this study were in the AHC Model Assistance Track in Houston, Texas. They had previously co-created the implementation strategy for AHC (1). The SPAN stakeholder and peer planning method used in this study was to co-create a quality improvement (QI) plan during implementation of the AHC Model to enhance navigation service delivery. The QI plan included adaptive booster training for HRSN patient navigation for housing instability and transportation needs during the PHE which were identified as a key gap area in our largest partnering safety net hospital system's existing emergency room patient navigation program. The patient navigation program in this study had been operating for more than 20 years using CHWs as patient navigators. Navigators and Managers were Texas certified CHWs and received regular continuing education as required to maintain Texas certification (24). CHW certification in Texas is a generalist model with a set of eight core competencies (24, 25). As part of our AHC Model implementation, AHC assigned navigators received Model specific training prior to

implementation which included both didactic and hands-on training in HRSN, screening, referral and navigation. Navigation training included active listening, action planning and behavior change techniques including role modeling and vicarious reinforcement (1). Our present study included these same staff and added the new components described in this study as co-created booster training. Our goal was for 100% of the existing AHC team members to participate in this study and to use the SPAN framework to co-create the quality improvement plan.
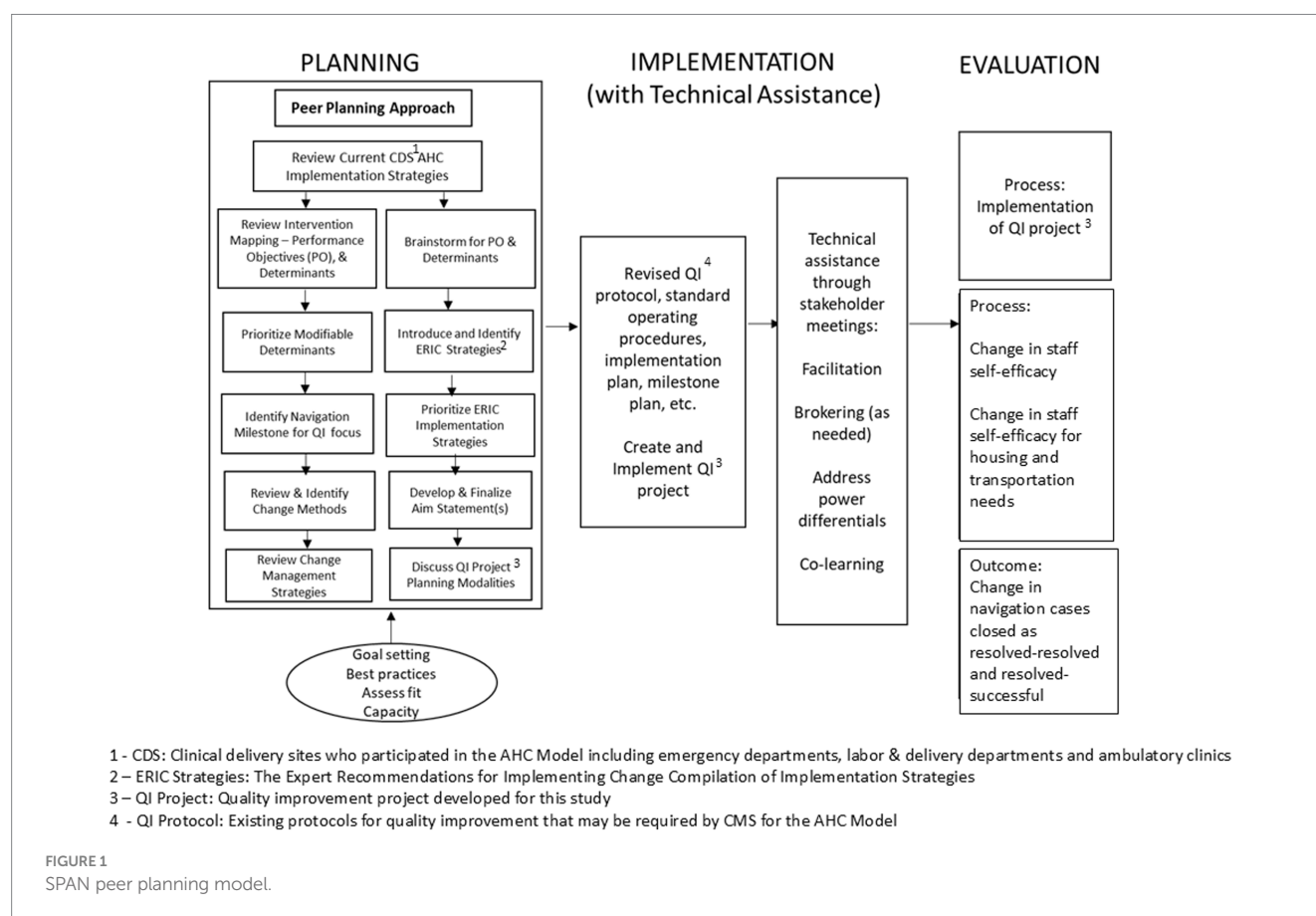
Methods

Peer planning method

The study was reviewed by the UTHealth IRB, protocol number HSC-SPH-20-0152. It was approved exempt. The peer planning approach for this study is shown in Figure 1. Briefly, the SPAN assessment and results have been reported elsewhere (7, 19). Our focus in this study was on pilot testing the SPAN model for peer planning, quality improvement and evaluation of impact on navigation milestones at one Bridge Organization in the AHC Model as shown in the Figure. SPAN is a triple loop learning model where organizations participate as co-creators through structured processes, and the technical assistance team as facilitators seek to shift not only organizational processes for navigation, but also their approaches to learning (26).

Stakeholder committee meetings

As described in (19), a stakeholder committee was comprised of representatives including hospital, Bridge Organization, and research staff. The stakeholder committee was officially formed from an email invitation to all staff or leadership listed in the AHC Model implementation plan (required documentation) with an overview document describing the study and how to accept participation (via email confirmation). The history of the AHC project, objectives of the study, and purpose for future stakeholder and intervention mapping (IM) sessions was also shared with the team. The research team held a discussion to establish terms of the committee including meeting norms, vision, roles and responsibilities, decision-making processes and communication plans. As determined collectively, all decisions made by the stakeholder committee would be made via consensus with the use of voting and discussion following Robert's Rules of Order. Finally, the committee was asked to input into the next meeting's agenda. As part of every stakeholder meeting the team was asked if anyone else should join the committee to ensure all stakeholders were represented. Meetings were recorded and notes were taken by an assigned staff member during each meeting to create meeting minutes.

The second stakeholder meeting was held 2 weeks after the first meeting. Minutes from the previous meeting were reviewed and approved by the committee. A summary of results from the mixed

FIGURE 1
SPAN peer planning model.

methods assessment of current implementation strategies was presented to the committee. First baseline data on current implementation was reviewed, including: rates of HRSN screening, positives for HRSN, navigation acceptance rates and HRSN resolution from navigation services. Next, preliminary interview themes around barriers and facilitators to AHC Model implementation were checked to validate findings. Lastly, the process maps of current workflows for screening, referral and navigation were reviewed and edited to ensure accuracy. Since the IM peer planning sessions were scheduled to occur in the middle of the four stakeholder meetings, the structure and expectations were given for the planning sessions during this stakeholder meeting.

Intervention mapping peer planning sessions

Prior to IM planning sessions, the research team gathered data from the SPAN assessment step (19) on the existing implementation process components and met and discussed the components that may be ready for enhancement or improvement, mapped the components to the theories underlying what would determine a change, and linked it to the ERIC strategies for consistency in terminology, understanding, and replicability.

Three, three-hour, IM Adapt peer planning meetings were held via WebEx. In the first meeting, the final interview themes and updated process map from the mixed assessment were first reviewed with the committee. The interview themes were linked to specific CFIR constructs and informed conversations about quality improvement opportunities. In addition, the research team reviewed current implementation strategies with the AHC clinical delivery site. In the second and third meeting, three separate breakout rooms for implementers (navigation staff/CHWs), managers, and leadership/IT staff were created. IM Adapt was used during the meeting to review current implementation strategies and barriers and facilitators in the AHC implementation (Meeting #2), brainstorm performance objectives and determinants (Meeting #3), and identify potential implementation strategies for performance objectives and determinants using the ERIC compilation (Meeting #3) (27). Each breakout room had an assigned facilitator who used open-ended questions to brainstorm performance objectives, determinants and implementation strategies. The key questions brainstormed were: Who are the implementers? What do they need to do? These first two questions represent performance objectives. Why would they do it? This question represents determinants. How should they do it? Is it feasible? These questions represent implementation strategies and change management. Responses from each of the breakout rooms' participants were entered real-time into jamboard and an Excel spreadsheet (see Supplementary material) that was compiled by the research team into a single document for review and approval at a subsequent stakeholder meeting.

The result of these IM planning sessions process was a Quality Improvement Project template (see Supplementary material) with a theoretical foundation for success as shown by the equation below.

Performance Objectives + Determinants + ERIC Strategies = Quality Improvement Project Components.

An anonymous survey was emailed to the stakeholder committee members following the third and final peer planning session to give stakeholders the opportunity to prioritize the QI components identified during the planning sessions.

The third and fourth stakeholder meetings were held after the IM peer planning sessions. The QI components generated from the IM planning sessions and research team meeting were reviewed and summarized by the research team for the stakeholder committee. The research team facilitated discussion amongst the committee to ensure the performance objectives, determinants and ERIC strategies accurately represented the stakeholder's perspectives. The committee then held a discussion to prioritize areas identified for potential quality improvement and change management strategies. During the fourth and final stakeholder meeting, an overview of designing a QI aim statement was provided and the team drafted the QI aim statement for their project. Finally, change management strategies were reviewed and linked to the implementation of the QI project. A smaller QI working group was formed from the stakeholder committee to develop the QI plan.

Co-creation of quality improvement plan

To co-create a quality improvement plan, 5 h-long meetings were held via WebEx with the quality improvement working group. The first of QI team meeting began with a review of the QI Aim statement, determinants and change method to determine where the participants wanted to focus the QI plan. JamBoard was used during the discussion to provide a visual aid of how the change methods corresponded to the determinants being considered for the QI Project.

The second meeting began by reviewing the project QI aims and outcome. QI project planning began with the stakeholder committee and research team discussing possible training options for navigation staff. Consideration was given to the current training schedule for the navigation staff to ensure the additional training did not overburden the staff.

Having established the training constraints of the navigation staff, during the third QI project planning meeting, the research team was able to draft several training options with accompanying budgets for the stakeholder committee to review. The committee and research team discussed the pros and cons of each training option. Questions were generated from the stakeholder committee regarding the flexibility of the training options for the research team to take back to the training vendors.

During the fourth QI project planning meeting, the stakeholder committee and research team discussed the desired level of specificity and delivery method of navigation case management support complete with a demonstration. The QI Project evaluation was discussed, and QI charter protocol reviewed during the meeting. Lastly, the committee and research team finalized the QI project's budget for submission to the selected vendors.

The final QI project planning meeting was used to review the finalized QI plan, QI project budget, and QI evaluation plan. Having gotten the approval from the stakeholders, research team, vendors and CMS, this was the final meeting before the launch of the QI project. This meeting was a time for managers to ask any lingering logistic questions and confirm the training's scheduled dates.

Training development

Once the committee settled on the QI plan of additional intensive training around the identified problem areas of housing and transportation navigation, the research team set out to compile a list of reputable vendors with subject matter expertise in the identified areas. The research team reviewed established collaborative connections and relationships with community organizations to identify potential partners. After fielding the potential partners for participation interest and time and resource availability to provide adequate training within the parameters of the project, two partners, one specializing in housing navigation and the other specializing in transportation navigation, with frontline experience were selected.

Once selected, the research team worked with vendors to develop and tailor content for training sessions to ensure synchronization with the prioritized determinants, strategies, and desired outcomes. Training sessions were then delivered in person and via WebEx.

Evaluation

Psychosocial outcomes were assessed at baseline and following training. Perceived self-efficacy was measured using a previously validated 12-item self-efficacy questionnaire (SE-12, Axboe et al. (32)) programmed in Qualtrics. The final item of the SE-12 was used as two separate statements with one word added for grammatical clarity to assess changes in navigation to housing and transportation resources, resulting in a 13-item survey (see Table 1, results). Navigators and managers were asked questions on the training curriculum and its impact on their knowledge, confidence, empathy for patient needs, optimism and relevance to their position in REDCap (see Figure 2, Results). Data on a selected client navigation outcome was used to assess the change in the number of navigation cases resolved from baseline (1 year) to 6 months post-training. The AHC Model navigation outcomes were Resolved: Resolved (beneficiaries' need had been met), Resolved: Successful (the patient contacted the agency, and their need was believed possible to be addressed within 6 months), Unresolved: Unavailable (no community resource available to address the need for more than 6 months), Unresolved: Attempt Failed (the navigator made three unsuccessful outreach attempts to the beneficiary). The outcome measure for this study was a navigation case status of Resolved: Resolved or Resolved: Successful. A paired t-test was used to assess change from baseline.

Results

Representatives agreeing to participate in the stakeholder committee included executive leadership from the hospital ER navigation program (n = 2), Directors and Managers from the ER navigation program (n = 3), front-line patient navigators from the ER navigation program (n = 1), leadership, and staff from the AHC Bridge Organization (principal investigator, project manager; n = 2). Faculty and students with expertise in mixed methods and quality improvement led the meetings as external facilitators. A total of eight people comprised the stakeholder committee with 100% of the AHC

team participating. In addition, the training developed in the study was open to all navigators and managers working at the partnering health system. An additional nine staff participated in training.

Intervention mapping peer planning sessions

The performance objectives, determinants and ERIC implementation strategies brainstormed and prioritized by the team for the QI plan are shown in Table 2. The team decided to focus on the patient navigator and navigator manager roles for QI. Knowledge, self-efficacy, and outcome expectations were the selected behavioral determinants based on barriers identified in the assessment and stakeholder/planning meetings. ERIC implementation strategies were selected from the repository to match the prioritized determinants.

Co-creation of quality improvement plan

The co-created QI plan focused on resolved navigation cases as the main outcome for QI. Three specific aims for training were developed to increase resolution of HRSN. 1) Conduct ongoing training focused on discussion, facilitation, active learning, consciousness raising, and technical assistance/capacity building to improve the knowledge of AHC navigators about housing and transportation resources in the City of Houston/Harris County to increase our percentage of resolved-successful navigation cases. 2) Conduct ongoing training focused on tailoring, modeling, participation, monitoring and feedback, and skill building/guided practice to improve the self-efficacy of AHC navigators to navigate patients to housing and transportation resources in the City of Houston/Harris County to increase our percentage of resolved-successful navigation cases. 3) Conduct ongoing training focused on elaboration and cues to action to improve the outcome expectations of AHC navigators to navigate patients to housing and transportation resources in the City of Houston/Harris County to increase our percentage of resolved-successful navigation cases.

Implementation of didactic and hands-on training for navigation staff

The training curriculum included active learning, consciousness raising, elaboration, cues to action, tailoring, modeling, participation, monitoring and feedback, and skill building/guided practice to improve the knowledge, self-efficacy and outcome expectations of AHC navigators and managers to navigate patients to housing and transportation resources and to meet the specific aims from the QI plan. The training began with a half-day workshop for navigators focused on didactic training for skill-building. A total of 23 navigators attended. The workshop covered the following topics: diverse transportation navigation strategies and review of custom-tailored resources for transportation along with interactive exercises including case studies. Housing training included a demonstration of available resources, tips/tricks to navigation, and applied practice through case

TABLE 1 Self-efficacy survey results and baseline and post-training.

Self-efficacy Survey Item	Baseline		Post-Training		Difference
How certain are you that you are able to successfully ….	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	Median
1. Identify the issues the patient wishes to address during the conversation?	8.0 (2.09)	8.5 (4.0)	8.5 (2.07)	9.5 (3.0)	1.0
2. Make an agenda/plan for the conversation with the patient?	6.5 (2.66)	6.0 (4.0)	8.5 (2.35)	9.5 (2.0)	3.5
3. Urge the patient to expand on his or her problems/worries?	6.7 (1.97)	6.0 (3.0)	8.7 (1.97)	9.5 (2.0)	3.5
4. Listen attentively without interrupting or changing the focus?	8.8 (2.00)	10.0 (1.0)	9.2 (2.04)	10 (0)	0
5. Encourage the patient to express thoughts and feelings?	7.8 (1.94)	8.5 (3.0)	8.8 (1.47)	9.5 (3.0)	1.0
6. Structure the conversation with the patient?	7.7 (2.07)	7.5 (4.0)	8.0 (2.76)	9 (3.0)	2.5
7. Demonstrate appropriate non-verbal behavior (eye contact, facial expressions, placement, posture and voicing)?	8.2 (1.94)	8.5 (3.0)	9.2 (1.79)	10 (2.0)	1.5
8. Show empathy (acknowledge the patient's views and feelings)?	8.4 (1.97)	9.0 (2.0)	8.5 (2.51)	9.5 (3.0)	0.5
9. Clarify what the patient knows in order to communicate the right amount of information?	8.2 (2.07)	9.0 (3.0)	8.7 (2.34)	10 (1.0)	1.0
10. Check patient's understanding of the information given?	8.3 (1.97)	9.0 (3.0)	9.0 (2.00)	10 (1.0)	1.0
11. Make a plan based on shared decisions between you and the patient?	8.2 (1.94)	8.5 (3.0)	9.0 (2.00)	9.5 (1.0)	1.0
12. Navigate the client to helpful [transportation*] resources?	6.2 (3.55)	6.0 (5.0)	8.7 (1.97)	10 (2.0)	4.0
13. Navigate the client to helpful [housing*] resources?	6.0 (3.61)	5.0 (5.0)	8.7 (1.97)	9.5 (2.0)	4.5

*Added word for grammatical clarity. Growth in self-efficacy in navigating patients with housing and/or transportation HRSN specifically was the area with the largest improvement post-training (4-point increase), followed by urging the patient to expand on their concerns, structuring the conversation, and making a plan (see green boxes).

studies. A panel of community members with lived experience who have successfully navigated the system also presented their keys to success and challenges they encountered. Upon completion of the initial training, navigators were provided with necessary resources, including updated community resource directories. After training, they also met with the contractors biweekly for 6 months to collaboratively discuss, and problem solve challenging navigation cases with expert support, allowing for adaptive training and skill-building over time. A guidebook with challenging cases and proposed solutions was also developed to enhance skills practice and sustainability going forward. In addition, the contractors provided a monthly update on the capacity of each available community organization to resolve needs.

Evaluation

23 navigators or managers completed the self-efficacy survey at baseline, 17 staff completed training and six completed the post-training survey (35% response overall). The six completing the post-training survey were all AHC staff and stakeholder committee members (75% response of those actively engaged in SPAN). Navigator self-efficacy results for those who completed both pre-post-surveys are shown in Table 1. The median change in SE score from baseline to post-training was 15 points, trending to an increase in self-efficacy. For individual items, all staff reported increases to conduct navigation activities assessed except for listening attentively which had a median score at baseline of 10 (highest). Growth in self-efficacy in navigating patients with housing and/or transportation HRSN specifically was the area with the largest improvement post-training (4-point increase), followed by urging the patient to expand on their concerns, structuring the conversation, and making a plan (see green boxes Table 1). As shown in Figure 2, 100% of survey respondents strongly agreed that the training had increased their knowledge and empathy for patients with housing and transportation needs. 100% strongly agreed the training was relevant to their job. 80% strongly agreed that the training increased their confidence, knowledge, and optimism to navigate patients overall and for these needs. The number of navigation cases with HRSNs coded as resolved during the baseline year (August 2020–August 2021) was an average of 758 cases per month. The number of navigation cases coded as resolved during the post-training period (Sept 2021-February 2022) was an average of 975 cases per month, an increase of 29% of cases resolved per month ($p = 0.001$).

TABLE 2 Prioritized performance objectives, determinants and ERIC implementation strategies from the IM Planning Sessions.

Implementor	QI Performance Objectives	Prioritized Determinants	Current Barriers	ERIC Strategies Selected
Patient Navigator	1. Attend program training 2. Complete navigation process post-training: Review priority list and work on patients based on that timeline. Review community resources with patient, what resources were sent, gather what resources patient may need and provide new resources as needed, use RedCap scripting, and document all encounters 3. Become an expert with knowledge of local housing and transportation resources	Community resource knowledge Self-efficacy and skills to engage beneficiaries, assess and address concerns and needs Outcome expectations	Fear of being able to engage beneficiaries to talk about their needs. Knowledge of community resources Level of motivational interviewing skills	19. Intervene with Patients to Enhance Navigation process 23. Provide Ongoing Consultation 31. Capture and Share Local knowledge 32. Engage Community Resources
Navigation Manager	1. Support a culture of training by co-creating QI training plan and requiring staff to participate in continuing education 2. Support staff by participating in training to become a team of experts in housing and transportation community resources 3. Meet weekly with team to address goals, problems, and solutions 4. Proactively identify navigation roadblocks and solutions (e.g., patient rush off phone, set a plan to talk/identify barriers to talking/better time to call)	Budget/resources Self-efficacy Outcome expectations	Self-efficacy Time/effort	7. Provide Local Technical Assistance 20. Develop Educational Materials 21. Distribute Educational Materials 24. Conduct Ongoing Training

Discussion

The SPAN peer planning process piloted in this study led to the creation and implementation of a quality improvement plan and booster training for patient navigators and managers for HRSN navigation, with a particular focus on housing and transportation. As shown in the results, we found directional increases in navigator self-efficacy post-training, though due to limited sample size we were not able to test this change statistically. Due to the PHE, we used an online survey, yielding a response rate of 35% overall and 75% for staff actively engaged in SPAN. While lower than pre-PHE survey response rates, recent studies have shown similar PHE response rates (28, 29). We recommend readers interpret the survey results accordingly. The number of resolved HRSN cases over the following 6 months increased significantly from the baseline period. To our knowledge, this is the first study to report on methods for creating and implementing adaptive navigator training for certified CHWs working as professional patient navigators and managers specifically for HRSN in the hospital setting. Previous studies of HRSN navigation

included peer to peer and student models (30, 31). These are similar to the Texas CHW generalist certification in competencies covered (30, 31). Our assessment indicated that additional training was needed for housing and transportation navigation. We found that providing adaptive and just in time training was helpful (26). Using peer planning and co-creation to identify specific skills foci for training with the front-live staff allowed for the creation of detailed learning objectives. In addition, the use of the bi-weekly meetings with housing and transportation experts provided the opportunity for adaptive and ongoing learning (26). While not specifically measured in this study, we found anecdotally that the time needed to support navigators decreased over time in these meetings which we hypothesize was due to increased self-efficacy. In the future, it would be helpful to measure this specifically. In addition, providing navigation services during the evolving PHE was challenging, even when using a structured approach to increase workforce and organizational capacity. Some factors that impact HRSN resolution are beyond the control of health systems, staff, facilitators and external experts. We found ongoing changes in community resource availability due to the PHE and had to

FIGURE 2
Percent agreement with survey items assessed.
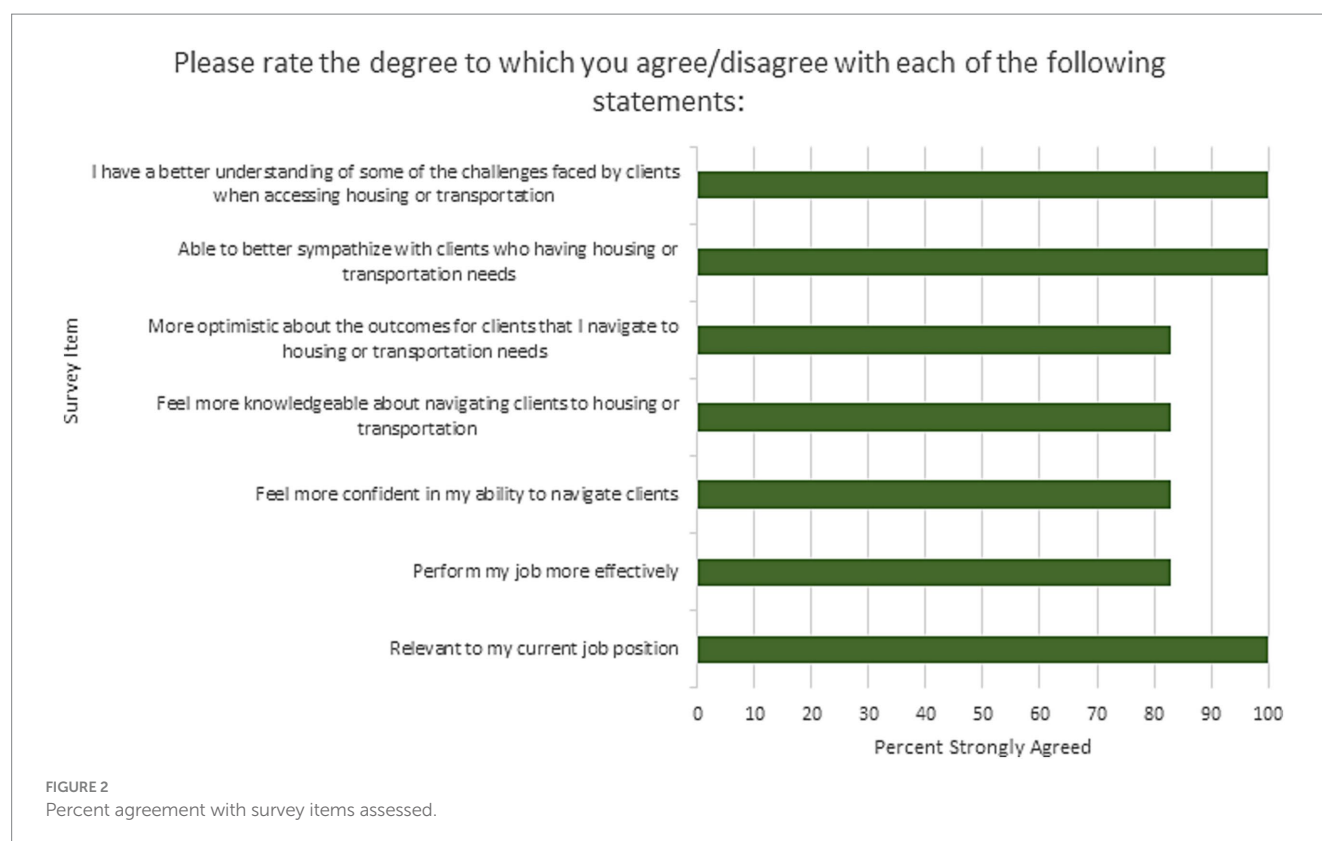
regularly update the community resource directory for accuracy. At the policy level, Houston's implementation of the end of the eviction moratorium created challenges to housing resolution with large increases in need coupled with dwindling housing availability. Another challenge to HRSN navigator workforce development in the US is that all States all have different credentialling requirements, and there is no national body focused on the development of the HRSN workforce, particularly for link workers. These challenges highlight the impact of policy and the need for a systems approach that is integrated from the front-line to policy to support HRSN resolution.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Committee for the Protection of Humans Subjects at UTHealth Science Center at Houston. The studies were conducted in accordance with the local legislation and institutional requirements. The ethics committee/institutional review board waived the requirement of written informed consent for participation from the participants or the participants' legal guardians/next of kin because study was reviewed and determined exempt.

Author contributions

LH: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing. GF: Data curation, Formal analysis, Investigation, Supervision, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Gen AI was used in the creation of this manuscript.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2025.1441368/full#supplementary-material

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