# Trainings for Infectious Disease Outbreaks and Other Emergencies in Low and Middle Income Country Settings: a Systematic Literature Review

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## Tables and Figures

***Executive Summary***

*Background* As part of the Global Health Security Agenda, the U.S. Centers for Disease Control and Prevention awarded a grant to the Center for Humanitarian Health at the Johns Hopkins Bloomberg School of Public Health to, among other things, conduct a systematic review of literature on trainings on infectious disease outbreak (and other emergencies) response, including implementation, evaluation, curriculum and recommendations.

*Methods* The literature review searched three databases—Scopus, EmBase, and PubMed—using four "concepts" (each concept combining controlled vocabulary and key words): "rapid response", "preparedness", "training" and "infectious disease." The publication date range was from January 1, 2000 to February 1, 2018. Articles included peer-reviewed journals and gray literature sources focusing on training implementation, training evaluation, training curriculum, and training recommendations. A total of 10,555 articles were included for title and abstract review; 225 articles were selected for full-text review, and 160 articles were selected for full-text data extraction and analysis.

*Results* Most of the 160 publications came from and/or were focused on high-income or upper-middle income countries. These articles differed in significant respects—in training content, format, and evaluation methodologies to name only a few—from the much smaller number of publications that focused on lower-middle and low-income countries. While infectious diseases with pandemic potential threaten all countries, our review found that high income and upper-middle income countries tended to focus training efforts more on complex emergencies, bioterrorism, and mass casualty incidents than on infectious disease outbreaks. In lower-middle and low income countries, on the other hand, infectious disease was the predominant focus of training implementation. As content focus differed, so too did training formats and methods, with more extensive and complex simulations and interactive exercises being used in locations with more resources.

Regardless of training format, content, or duration, adequate evaluation of the training is essential. A key best practice and recommendation from the evaluations literature was the need to establish a list of key outcomes, competencies and skills that would be tested in the evaluation process for prior to conducting the training. While pre-post evaluations provide the benefit of measuring improvement from baseline, post-only evaluation methods were helpful in acquiring feedback which would allow for improved training development. Out of 83 evaluation articles, 15 recommended the need for re-

trainings to retain key objectives just as knowledge of the specific issue, participant confidence, familiarity with protocol, and efficiency. Re-training intervals should be considered in the context of how frequently the participants are applying the knowledge or skills emphasized in the training in conjunction with the participants baseline level of knowledge prior to a training.

The most effective curricula involve a combination of didactic lectures and interactive exercises, with drills and simulation thought to be the most effective method of learning, although also the most logistically complicated and resource intensive. Curricula should be tailored to the location and background of the learners, and there should be a method of assessment to ensure the efficacy of the curricula. A key training recommendation calls for the development of comprehensive, competency-based, multidisciplinary training programs that are easily adaptable for specific disasters and have clear outcomes that can be assessed and evaluated.

*Conclusions* Among our key findings are that there is a dearth of publications originating from and/or focusing on lower-middle income and low income countries. This is significant as one of the primary goals of the GHSA is to increase in-country capacity in LMIC settings to be able to respond to epidemics.[61] While it is not necessarily the case that a lack of publications on trainings means that such trainings are not taking place, limited documentation raises a concern both about the quality and standardization of such trainings and the extent to which lessons learned are being shared.

As to the trainings themselves, the evidence suggests that the most effective trainings include a combination of didactic instruction and hands-on practice and exercises, and that the training is of sufficient duration (including re-training) to allow for in-depth learning. While the metric of what is "sufficient duration" may vary, the literature supports trainings that cover multiple days, providing opportunity for learning of content knowledge, practice of skills, and evaluation of both knowledge and skills. Effective trainings also must include robust evaluation methods to measure both knowledge and skills acquisition. These evaluation methods may vary but, ideally, they should include some measure of baseline and endline knowledge and skills, which favors a pre-post evaluation approach (as opposed to post-only methods). Finally, attention needs to be given to the implementation and sustainability of rapid response training in low-resource settings. Methods that include virtual emergency departments and online modules offer promise for application in low-resource and rural settings, though proper evaluation and more research is needed to assess their effectiveness.

## A. Introduction

In 2012, the US Centers for Disease Control and Prevention (CDC) identified five "top global infectious disease threats" that it was watching that year: avian influenza A (H5N1), cholera, poliomyelitis (polio), enterovirus-71 (EV-71), and extensively drug-resistant tuberculosis (XDR-TB), noting that "fortunately, the majority of outbreaks remain localized, and the global spread of a truly novel pathogen is rare."[40] In 2013, the CDC listed expanded to include the Middle East Respiratory Syndrome Coronavirus (MERS-CoV) and Avian influenza A (H7N9); the epidemiology of both of these disease threats was "not well understood" and H7N9, in particular, due to its "presumed lack of pre-existing immunity among humans, could lead to a global pandemic."[40]

Five years later, in 2017, CDC updated its list of top global infectious disease threats. These included the two subtypes of avian influenza A viruses (H5N1 and H7N9) and cholera, but now also included three types of vector-borne diseases that had caused large outbreaks since 2013 (yellow fever, chikungunya, and Zika virus) and, perhaps most significantly, Ebola virus disease (EVD). Up until 2014, outbreaks of EVD had been localized in sub-Saharan Africa but, in March 2014, a broader outbreak was confirmed in Guinea, which quickly spread to neighboring Sierra Leone, Liberia, and Nigeria.[41] By March 2016, the outbreak in West Africa grew to be "the largest EVD outbreak ever recorded," with a total of 28,646 documented cases and 11,323 deaths in 6 West African countries, 3 cases in Europe, and 4 cases in the United States, including one death.[41]

In February 2014, just weeks before the Ebola outbreak, the Global Health Security Agenda (GHSA) had been launched as a partnership of governments, international organizations, and non-governmental organizations (NGOs). Its goals were to advance compliance with the World Health Organization's (WHO) International Health Regulations, the World Organization of Animal Health's (OIE) Performance of Veterinary Service Pathway, and other global health security frameworks.[61] The GHSA partnership, which included more than 60 countries as of January 2018 "*acknowledges the essential need for a multilateral and multi-sectoral approach to strengthen both the global capacity and nations' capacity to prevent, detect, and respond to infectious diseases threats whether naturally occurring, deliberate or accidental—capacity that once established would mitigate the devastating effects of Ebola, MERS, other highly pathogenic infectious diseases, and bioterrorism event*."[61]

The GHSA commits support for 11 GHSA Action Packages with a three-pronged approach to Prevent, Detect, and Respond to infectious disease threats. As part of the action packages to detect disease threats, the GHSA commits to developing a workforce including physicians, veterinarians, biostatisticians, laboratory scientists, and epidemiologists; as part of the response action packages, is a commitment to "maintaining trained, functioning, multi-sectoral rapid response teams[i] and 'real-time' biosurveillance laboratory networks and information systems and trained Emergency Operation Center (EOC) staff capable of activating a coordinated emergency response."[37] Supporting this need for a well-trained workforce, the Global Health Risk Framework Commission stated that "Resilient health systems must have well-trained health workers and community participation to build public trust and provide culturally appropriate services…There is no question that the world will face pandemics in the future; the only question is the level of national and global preparedness and response."[63]

As part of the GHSA, CDC awarded a grant to the Center for Humanitarian Health (CHH) at the Johns Hopkins Bloomberg School of Public Health to support a variety of capacity-building efforts for rapid response to outbreaks in low- and middle-income settings (LMICs). As part of this grant, a CHH team conducted a systematic review of literature on trainings on infectious disease outbreak (and other emergencies) response, including implementation, evaluation, curriculum, and recommendations.

This report presents results of that review conducted in 2018. While the primary focus is on rapid response trainings for infectious disease outbreaks in LMICs, the review expands this focus in three ways: First, though rapid response trainings are designed to prepare teams for a response within 24 hours, the training for such a response can take place over a longer period of time, including a year or more for some professional training, though it might also include highly-condensed "just-in-time" training in the context of an acute emergency. Second, though infectious disease outbreaks are the focus, also included are bioterrorism events and complex emergencies, where outbreaks may occur but in conjunction with other health threats, including conflict, displacement, inadequate shelter, and food and medical shortages. Third, though the focus is on training for LMICs, we felt it was important to examine literature from high-income countries as well. This was based in part on the dearth of articles

[i] "Rapid response teams" are defined as "rostered, trained, multidisciplinary teams able to deploy to a public health emergency in any part of the country within 24 hours to investigate and characterize the epidemic, evaluate patients, collect clinical specimens, oversee containment measures, and communicate with public health authorities" (CDC, 2018).

on trainings in LMIC settings, but also because we felt that findings from high-income countries can provide insights and suggestions for adaptation of training implementation and training evaluation to low and middle-income country settings.

## B. Methods

*B.1. Data Sources and Key Words*

The literature review was conducted by searching three academic databases—Scopus, EmBase, and PubMed—using four "concepts" (each concept combining controlled vocabulary and key words): "rapid response", "preparedness", "training" and "infectious disease." These search terms were chosen in order to identify literature on trainings to improve responses to infectious disease outbreaks, mass casualty incidents (MCIs), bioterrorism events, and complex humanitarian emergencies.[ii]

*B.2. Inclusion and Exclusion Criteria*

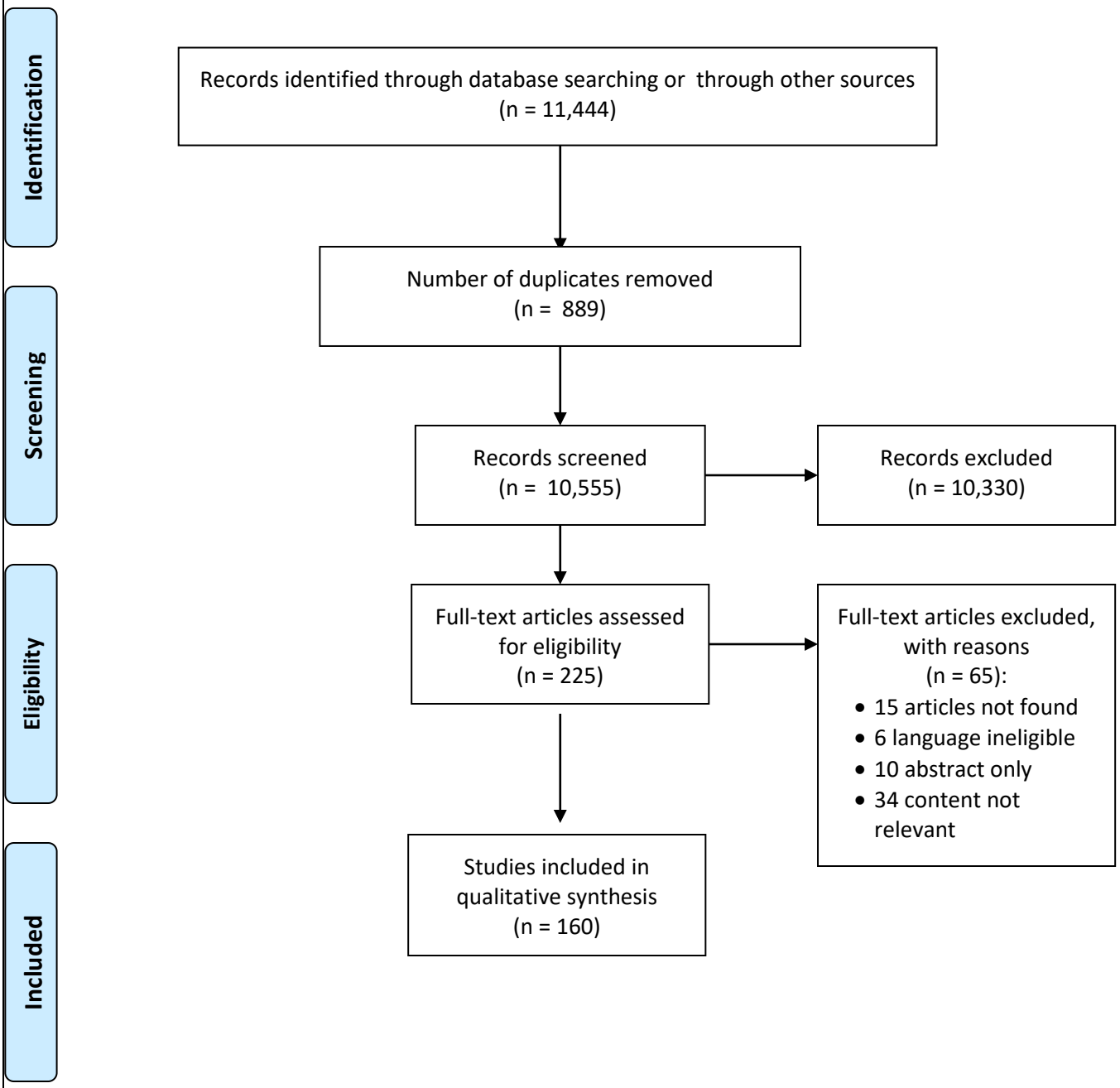
Articles in English, French and Spanish languages were deemed eligible for inclusion. The publication date range was from January 1, 2000 to February 1, 2018. Articles could be from peer-reviewed journals or from gray literature sources. In terms of types of articles, we chose to include four main types: training implementation, training evaluation, training curriculum, training recommendations, as well as systematic literature reviews of trainings or training methods. We also chose to include articles about training implementation, evaluation, curriculum, and recommendations in all countries regardless of income-level (Low, Middle or High) on the assumption that results and findings could be potentially adapted for different contexts.

*B.3. Electronic Search Strategies*

Adopting a Boolean logic framework, we searched for the overlap among the four specified concepts, which yielded an initial 11,444 articles for screening using the systematic review software, Covidence. Out of the original 11,444 articles, 889 were removed as duplicates. This left 10,555 articles to be included in the title review screening. Two reviewers independently read each title and, in more than 450 cases the abstracts as well. If the reviews were concordant to include or exclude, those decisions were final; in the event of a non-concordant review (there were 279 of these), a third reviewer rendered a final decision. This process resulted in 225 studies to be included for full-text review, of which 65 articles were removed during the data extraction process, leaving 160 articles to be selected for full-text data extraction and analysis.

[ii] Initially, it was envisioned to undertake an "all hazards" approach to the literature review on rapid response training. This proved infeasible due to the total number of initial records (nearly 30,000) and deemed beyond the scope of the project, whose focus was primarily on trainings to support response to infectious disease outbreaks, and other emergencies in which infectious disease outbreaks were likely to occur.

**Figure 1: Literature Search Flow Diagram**[1]




[1] *Flow Diagram Design from:* Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

*B.4. Data Extraction*

The reviewers extracted information from each of the 160 eligible articles, using an 18-item form, which included (1) journal or publication; (2) title; (3) author(s); (4) year of publication; (5) region of article focus (based on the World Health Organization's regional groupings—AFRO, AMRO, EMRO, EURO, SEARO, and WPRO); (6) country in which the training or evaluation occurred, (7) country income-level (Low, Middle, High); (8) type of article (training implementation, training evaluation, training curriculum, training recommendations, and systematic literature review); (9) training content (Ebola, mass casualty incident, bioterrorism, etc.; (10) training format (in-person, online, mixed); (11) training audience (health departments, nurses, pediatricians, etc.); (12) training method(s) (lecture, simulation, exercise, etc); (13) training length; (14) evaluation method(s) (pre-post testing, case-control, etc.); (15) evaluation length; (16) evaluation description; (17) outcomes; and (18) key findings.

## C. Results: General

*C.1. Characteristics of Included Articles*

From an initial list of 11,444 articles, the review team selected 160 for full-text review and data abstraction. The data abstraction forms included 18 items as noted in the Methods section above. General results described in this section focus on four of these items: region of focus, income-level of country/region of focus, year of publication, and type of article (see Table 2). Subsequent results sections focus on the four main types of articles about trainings (implementation, evaluation, curriculum, and recommendations); each of these, in turn, will present the findings in respect to the additional items in the data abstraction form that are relevant to particular types of article. Thus, the results from the training implementation articles (n=39) focus on training content, format, audience, method(s), length, outcomes and key findings. Results from the training evaluation articles (n=83) include these items but add evaluation method(s), description, and length. Results from the training curriculum articles (n=20) focus primarily on content, audience, methods, and key findings. Results from the training recommendation articles (n=18) focus primarily on training content as well as training and evaluation methods. The systematic literature articles on trainings (n=3) will be discussed in various sections as they pertain to implementation, evaluation, curriculum and/or recommendations.

*C.2 Region of Focus*

The regional categories were based on the WHO's regional groupings (WHO, 2018): African Region (AFRO), Region of the Americas (AMRO), Eastern Mediterranean Region (EMRO), European Region (EURO), South-East Asia Region (SEARO), and Western Pacific Region (WPRO). As noted in Table 1 below, 108 of the included 165 articles focused on the Region of the Americas, with another 27 focusing on the European Region, and 18 focusing on the African Region. The remaining 12 articles focused on the Western Pacific Region (4), the South-East Asia Region (3), and the Eastern Mediterranean Region (1). Four articles spanned multiple regions, in various combinations.

***Table 1. Characteristics of Included Articles (N=160)***

| *Characteristic* | *Category/Level* | *Number (%)* |
|---|---|---|
| Region of Focus* | Region of the Americas (AMRO) | 104 |
| | African Region (AFRO) | 17 |
| | Eastern Mediterranean Region (EMRO) | 1 |
| | European Region (EURO) | 27 |
| | South-East Asia Region (SEARO) | 2 |
| | Western Pacific Region (WPRO) | 4 |
| | Multiple Regions | 5 |
| Income-level of Focal Country/Region** | High-Income | 124 |
| | Upper-Middle-Income | 4 |
| | Lower-Middle-Income | 4 |
| | Low-Income | 13 |
| | Mixed/Multiple | 15 |
| Year of Publication*** | 2000-2004 | 9 |
| | 2005-2009 | 60 |
| | 2010-2014 | 42 |
| | 2015-2018 | 49 |
| Type of Article | Training Implementation | 38 |
| | Training Evaluation | 83 |
| | Training Curriculum | 21 |
| | Training Recommendations | 15 |
| | Literature Reviews on Training | 3 |

* The abbreviations for the WHO regions are the names of the regional offices (RO) [Accessed from: http://www.who.int/about/regions/en/]
** WHO member states are grouped into 4 income groups based on World Bank income classification of economies for the fiscal year [Accessed from: http://www.who.int/healthinfo/global_burden_disease/definition_regions/en/]
*** Year of publication is aggregated in five-year intervals, with the exception of the 2015-2018 interval, which reflects publications in three full years (2105-2017) and two months of 2018.

*C.3. Income-Level of Focal Country/Region*

In terms of the income-level of the focal countries and/or regions, 124 articles focused on high-income countries, reflecting the predominance of AMRO and EURO in the literature. A total of 13 articles focused on low-income countries, while an additional 8 focused on either upper-middle income countries (4) or lower-middle income countries (4). Another 15 articles focused on multiple countries from different income-levels.

Table 2 below shows the individual countries, grouped by WHO region, that were named as a focal country in one or more of the included articles. The names of these focal countries (in bold) are followed by the number of articles in which these countries are referenced in the context of rapid response

training implementation, evaluation, curriculum, or recommendations. While the United States of America (USA) stands out dramatically above all other countries in being referenced in 99 articles, AMRO includes only 4 countries in total, counting the USA. AFRO, by contrast, includes 25 countries though many are referenced in article focusing on multiple African countries. EURO includes 11 countries, with references in 27 articles.

***Table 2. WHO Regional Groupings and Individual Countries (Included Countries in Bold)***

| | |
|---|---|
| AMRO (n=104) | Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, Bolivia, Brazil, **Canada**, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, **Guatemala**, Guyana, **Haiti (2)**, Honduras, Jamaica, **Mexico**, Nicaragua, Panama, Paraguay, Peru, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, **United States of America (99)**, Uruguay, Venezuela. |
| AFRO (n=17) | Algeria, Angola, **Benin**, Botswana, **Burkina Faso**, Burundi, **Cameroon, Cape Verde**, Central African Republic, Chad, Comoros, Congo, Côte d'Ivoire, **Democratic Republic of the Congo**, Equatorial Guinea, **Eritrea**, **Ethiopia**, Gabon, **Gambia, Ghana, Guinea, Guinea-Bissau**, Kenya**, Lesotho**, **Liberia (2)**, Madagascar, **Malawi, Mali, Mauritania**, Mauritius, Mozambique, Namibia, **Niger**, **Nigeria**, Rwanda, Sao Tome and Principe, **Senegal**, Seychelles, **Sierra Leone (3)**, **South Africa**, South Sudan, Swaziland, **Togo**, **Uganda**, **Tanzania**, **Zambia**, Zimbabwe. |
| EMRO (n=1) | Afghanistan, Bahrain, Djibouti, Egypt, Iran (Islamic Republic of), Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, **Pakistan**, Qatar, **Saudi Arabia**, Somalia, Sudan, Syrian Arab Republic, Tunisia, United Arab Emirates, Yemen. |
| EURO (n=27) | Albania, Andorra, Armenia, Austria, Azerbaijan, Belarus, Belgium, **Bosnia and Herzegovina (2)**, Bulgaria, **Croatia**, Cyprus, Czech Republic, Denmark, Estonia, Finland, **France**, Georgia, **Germany**, **Greece**, Hungary, Iceland, Ireland, **Israel (3)**, **Italy (5)**, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Luxembourg, Malta, Monaco, Montenegro, **Netherlands**, **Norway**, Poland, Portugal, Republic of Moldova, Romania, Russian Federation, San Marino, Serbia, Slovakia, Slovenia, Spain, **Sweden (2)**, Switzerland, Tajikistan, The former Yugoslav Republic of Macedonia, Turkey, Turkmenistan, Ukraine, **United Kingdom of Great Britain and Northern Ireland (3)**, Uzbekistan. |
| SEARO (n=2) | Bangladesh, Bhutan, Democratic People's Republic of Korea (North Korea), **India**, Indonesia, Maldives, Myanmar, Nepal, Sri Lanka, **Thailand**, Timor-Leste. |
| WPRO (n=4) | **Australia**, Brunei Darussalam, Cambodia, **China**, Cook Islands, Fiji, **Japan (2)**, Kiribati Lao People's Democratic Republic, Malaysia, Marshall Islands, Micronesia, Mongolia, Nauru, New Zealand, Niue, Palau, Papua New Guinea, Philippines, Republic of Korea (South Korea), Samoa, Singapore, Solomon Islands, Tonga, Tuvalu, Vanuatu, Viet Nam. |
| Note: Countries in **Bold** are those named as a focal country in one or more of the included articles. The country might have been the single focus of an article or could have been included in an article focusing on multiple countries. The number following the name of the country represents the number of different articles in which the country is referenced as a focal point (usually the location of a training implementation or evaluation, or the location of the authors reporting on training curricula or training recommendations). | |

*C.4. Year of Publication*

Table 1 above presents the year of publication in three five-year intervals—2000-2004, 2005-2009, 2010-2014—with one interval, 2015-2018, that includes three full years plus the first two months of 2018. While there is general rise in the number of publications over time—from an average of 1.8 publications per year in 2000-2004, to 17 publications per year in 2015-2017 (counting only full years)—there appears to be a surge in publications from 2005-2009 (12.2 publications per year) followed by a decline from 2010-2014 (8.6 publications per year), then an increase again in 2015-2017. Given that the 165 selected articles do not include all articles from the initial list, it would be unwise to draw overly broad conclusions, though Morris (2003) notes an increased level of research and scholarship after the 2001 anthrax attacks in the United States. The 2015-2017 increase in publications per year occurred after the 2014 Ebola outbreak which suggests a similar increase in research and publication following this globally significant event (Cruz-Calderón, 2015).

*C.5. Type of Article*

As noted previously, the literature review focused on trainings to improve responses to infectious disease outbreaks, MCIs, bioterrorism events, and complex humanitarian emergencies. To further classify the types of articles on training, in the process of the initial title and abstract review, four main categories were identified: training implementation, evaluation, curriculum and recommendations. Of these, the final list of articles for full-text review included 38 articles on training implementation, 83 articles on training evaluations, 21 articles on training curriculum, and 15 articles on training recommendations. More detailed results on these different types of articles are presented in separate sections that follow.

## D. Results: Training Implementation

### *D.1. Overview*

The articles classified as "training implementation" were ones that primarily described the process by which a training, or series of trainings, took place. While some of these articles may have included a brief description of how the training was evaluated, or what sort of curriculum was used, or what recommendations might follow, the primary focus was on how the trainings were implemented. Our review identified 38 articles that described the implementation of rapid response training curricula (Table 4).

The majority of training implementation articles described trainings that took place in high-income countries (n=24, 64%),[14,65,69,70,102,109,115,118,129,131,133,135,138,148,154,155,158,162-166,171] including 23 in the USA.[5,14,65,69,70,102,109,115,118,129,131,135,138,148,154,155,158,162-166] Most of the remaining articles described trainings implemented in low-income countries (n=8),[52,77,92,98,107,117,137,152] including five in in West Africa.[52,77,92,98,107] Duration of trainings ranged from two-day exercises to two-year field epidemiology and laboratory training programs. Most trainings were less than one week in duration (n=21),[52,65,69,77,92,93,99,109,110,115,128,129,133,135,137,148,152,154,158,163,168] while the longest training programs were primarily those incorporated into medical school or field epidemiology programs, rather than those tailored as continuing education modules for health professionals. Infectious disease response was the most common content theme across trainings, and some articles focusing on specific diseases such as Ebola,[52,77,98,115] smallpox,[168] tuberculosis, and polio.[110] Health professionals were the largest target audience type (n=30)[5,52,65,69,70,77,92,93,98,99,107,110,113,115,117,118,124,128,135,137,148,152,154,155,158,162,164-166,168] as compared to students(n=8).[102,109,129,131,133,138,163,171] Key characteristics of the 38 training implementation articles are summarized in Table 3 below.

***Table 3: Characteristics of Training Implementation Articles (n=38)***

| *Characteristic* | *Category/Level* | *Number (%)* |
|---|---|---|
| Region of Focus | Region of the Americas (AMRO) | 26 |
| | African Region (AFRO) | 8 |
| | European Region (EURO) | 2 |
| | South-East Asia Region (SEARO) | 1 |
| | Multiple Regions | 1 |
| Income-level of Focal Country/Region | High-Income | 24 |
| | Upper-Middle-Income | 1 |
| | Lower-Middle-Income | 1 |
| | Low-Income | 8 |
| | Mixed/Multiple | 4 |
| Year of Publication | 2000-2004 | 2 |
| | 2005-2009 | 11 |
| | 2010-2014 | 14 |
| | 2015-2018 | 11 |
| Content Topic | All Hazards | 2 |
| | Bioterrorism | 3 |
| | Cholera | 2 |
| | Complex Emergency | 3 |
| | Ebola | 4 |
| | Infectious Disease | 10 |
| | Mass Casualty Incident | 9 |
| | Polio | 1 |
| | Public Health Emergency | 1 |
| | Reproductive Health | 1 |
| | Smallpox | 1 |
| | Tuberculosis | 1 |
| Training Format | In-person | 25 |
| | Online | 4 |
| | Mixed | 7 |
| | Not Specified or Applicable | 2 |
| Training Method | Exercise | 7 |
| | Instruction | 6 |
| | Mixed Methods | 21 |
| | Not Specified | 3 |
| | Not Applicable | 1 |

***D.2. Key Focus and Findings***

Below are some of the key focus areas and findings from the articles on rapid response training implementation. There were substantial differences, for example, between the high-income and upper-middle income countries, on the one hand, and low-income and lower-middle income countries, on the other hand, in terms of training content, format, methods, target audience, and duration. These differences are presented below along with insights derived from the articles about training implementation process.

1. *Training Content*: Of the 25 trainings implemented in high- and upper-middle income countries, more than half (n=14) focused on complex emergencies, bioterrorism, and mass casualty incidents.[5,65,69,70,129,131,135,155,158,162,165,171] Of the nine trainings implemented in low- and lower-middle income countries,[92, 52,77,98,107,117,128,137,152] eight of the trainings were related to responding to infectious disease outbreaks.[52,77,98,107,117,128,137,152] Nine articles describe trainings that should be incorporated into broader curricula and materials that have been developed and that may be useful in other rapid response events.[77,99,102,118,133,137,163-165] Pfenninger et al. outline a 14-module disaster education training course, including experiential learning, which can be adapted for basic medical student disaster education. Rajasingham et al. discuss the development of train-the-trainer materials for cholera outbreak response, which were originally designed to train community health workers in Haiti to respond to the 2010-2011 cholera outbreak.

2. *Training Format and Methods*: For the purposes of this review, the training methods were categorized as Exercise, Instruction, or Mixed Method. An Exercise was any training that included an interactive component where the trainee practiced a skill during a simulated event. The exercise could be referred to as a "tabletop exercise," which means trainees participated in a simulated event in a classroom-like setting, or exercises could be much more complex. For example, the Field Epidemiology Training Program was categorized as an exercise in this review, as FETP trainees gain extensive hands-on field experience. Implementation articles categorized with the "Instruction" training format included trainings that were lecture-based rather than experiential-based. Finally, "Mixed Method" included trainings that combined Exercises with Instruction. Most articles in the Implementation category used a Mixed Method (n=21) for training. A higher proportion of trainings in high- and upper-middle income countries included online components (9 of 25, 36%)[69,118,148,155,162-166] compared to trainings that took place in low- and lower-middle income countries (1 of 9, 11%).[77] A total of 22 articles describe training

methods or formats that authors argue may be useful in future trainings, such as online formats, and propose different approaches to established methods.[65,69,70,109,110,113,115,117,124,128,129,131,135,138,152,154,155,158,162,166,168] These articles include Rega et al., which outlines an approach to a semester-long pandemic preparedness and response exercise, Heinrichs et al. (2008), which outlines a tool to train healthcare teams in virtual environments, and Lescano et al., which contrasts FETP-type training with an alternative method using short, locally tailored training courses to build outbreak response capacity in the Americas.

3. *Target Audience*: Articles on trainings implemented in high- and upper-middle income countries targeted students (n=8)[102,109,129,131,133,138,163,171] and health professionals such as clinicians, first responders, or epidemiologists (n=17).[5,65,69,70,110,115,118,135,148,154,155,158,162,164-166,168] In low- and lower-middle income countries, target audiences included clinicians, hospital staff, and laboratory scientists, but notably did not include students. Six articles described the number of people trained and how they have used their skills to help address public health issues.[14,52,98,107,148,171] For example, Lubogo et al. and Mutabaruka et al. discuss the Epidemiology Network and Field Epidemiology Training Program in countries in East and West Africa.

4. *Training Duration*: In high- and upper-middle income countries, training duration ranged from one day to several months. Evans et al. describe a complex humanitarian emergency certificate for Master of Public Health students at the Rollins School of Public Health that consists of two foundational courses, one advanced course, and six electives, and participation in a field practicum or several simulation exercises. Parrish et al. describe a bioterrorism training aimed at medical students that took place in 18 hours over four days. In low- and lower-middle income countries, training duration ranged from two days to two years. Ntahobakurira et al. describe in-person training of health professionals in Rwanda through a two-year field epidemiology and laboratory training program. Jones-Konneh et al. describe in-person training of health care workers in Sierra Leone, which provided two tiers of training based on the experience of the trainees. Clinicians without experience in infection prevention and control (IPC) or personal protective equipment (PPE) received three days of clinical IPC training and two days of simulated patient exercises at a mock Ebola treatment unit (ETU). Clinicians with IPC and PPE experience received one day of clinical IPC training and two days of simulated patient exercises at a mock ETU.

***Table 4: Training Implementation Articles: Topics, Methods, and Key Focus and/or Findings (n=38)***

| *Citation* | *Training Topic* | *Training Method(s)* | *Key Focus and/or Findings* |
|---|---|---|---|
| Abraham et al. (2012)[5] | Bioterrorism | Exercise (Tabletop) | Presents five realistic preparedness tabletop scenarios for rural health professionals. |
| Andress (2003)[14] | Smallpox | Exercise (Tabletop) | Exercises involving community to proactively plan a mass vaccination response to a smallpox threat. |
| Evans et al. (2016)[52] | Complex Emergency | Exercise; Instruction (Lecture) | University-based focus on emergency response training for undergraduate students and continuing professionals. |
| Grant et al. (2007)[65] | Mass Casualty Incident | Exercise (Simulation); Instruction (Lecture, Hands-on) | When conducting a joint exercise with civilian and military responders, pretraining is key for familiarity with different terminology, equipment, and systems. |
| Heinrichs et al. (2010)[69] | Mass Casualty Incident | Exercise (online Virtual Emergency Department (VED) simulation) | Case studies of online training with virtual reality simulation systems for health care teams working in high-stress environments. |
| Heinrichs et al. (2008)[70] | Mass Casualty Incident | Instruction (online); Exercise (Simulation Virtual Emergency Department (VED)) | Virtual emergency department simulations provide practice opportunities to staff working in rural or isolated areas. |
| Jones-Konneh et al. (2017)[77] | Ebola Virus | Exercise (Skill stations, Simulation); Instruction (Lecture) | National Ebola Training Academy was established to provide modules and realistic simulations for frontline health workers in Ebola treatment centers. |
| Leow et al. (2012)[92] | Mass Casualty Incident | Exercise (Tabletop); Instruction (Lecture) | Tabletop exercises to review triage and trauma principles. An example of a low-cost MCI tabletop exercise is the Emergo Train System. |
| Lescano et al. (2007)[93] | Infectious Disease | Instruction (Lectures, readings, case studies/group work) | In-person instruction offered upon request from host country that uses lectures, readings, case studies, and group work to provide steps to enhance preparedness for future epidemics. |
| Logue et al. (2017)[98] | Ebola Virus | Exercise (demonstration and practice); Instruction (Lecture, eLearning module) | e-learning module also used as a refresher training for volunteers deploying to do lab work in Ebola treatment units. |
| Lubogo et al. (2014)[99] | Ebola Virus | Not Specified | Professional training program emphasizing the one health approach in solving public health issues. |
| May et al. (2007)[102] | Infectious Disease | Exercise (Simulation); Instruction (Lecture) | It is recommended that a three-hour simulation-based workshop on outbreak preparedness be incorporated into medical education curricula. |
| Monday et al. (2011)[107] | Infectious Disease | Exercise (field practice and experience); Instruction (Lectures) | FETP and FELTP programs provide ideal platforms to integrate the One Health approach. |

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| Morrison et al. (2010)[109] | Public Health Emergency | Exercise (Simulation) | This public health emergency preparedness simulation exercise of infectious disease outbreaks can be a useful learning strategy at other educational institutions and can be easily replicated. |
| Moulsdale et al. (2014)[110] | Poliovirus | Exercise (Tabletop exercise) | Countries that participated in the exercises are generally prepared for potential poliovirus introduction, and the exercises helped identify strengths and weaknesses in preparedness. |
| Mutabaruka et al. (2011)[113] | Infectious Disease | Exercise (In-the-field mentored training); Instruction (Lecture) | Description, structure and achievements of the West African Field Epidemiology and Laboratory Training Program (FELTP). |
| Narra et al. (2017)[115] | Ebola Virus | Exercise (Clinical simulation); Instruction (Lecture) | Safety principles and practices for health workers caring for Ebola-infected patients. In-person instruction course was turned into a web-based toolkit. |
| Nsubuga et al. (2011)[117] | Infectious Disease | Exercise (Field experience); Instruction (Lecture) | Development and implementation of an 8-step, standardized process to establish FELTPs in sub-Saharan Africa. |
| Ntahobakurira et al. (2011)[118] | Infectious Disease | Exercise (Field experience); Instruction (Lecture) | Description, structure and achievements of Rwanda's FELTP. |
| Otto et al. (2011)[124] | Infectious Disease | Exercise (Tabletop); Instruction (Course, Workshop) | Description of training initiatives and lessons learned by the Armed Forces Health Surveillance Center, Division of Global Emerging Infections Surveillance and Response System (AFHSC-GEIS). |
| Pande et al. (2017)[128] | Tuberculosis | Instruction (Lecture) | Description of a smartphone application that provides clinicians with information about tuberculosis. |
| Parrish et al. (2005)[129] | Bioterrorism | Exercise (Simulation); Instruction (Lecture) | Description of a scenario-based experiential component in a course for medical students on leadership in disaster response. |
| Pattillo et al. (2003)[131] | Mass Casualty Incident | Exercise (Tabletop); Instruction (Lecture) | Describes organizational and peer support, personal skills, and connections as crucial components to developing a disaster nursing course. |
| Pfenninger et al. (2010)[133] | All Hazards | Exercise (Simulation); Instruction (Lecture) | 14-module medical disaster education course template comprising 2-hour units. |
| Pryor et al. (2006)[135] | Mass Casualty Incident | Exercise (Tabletop); Instruction (Lecture) | Tabletop exercise to increase WMD disaster and response capabilities among healthcare administrators. |
| Rajasingham et al. (2011)[137] | Cholera | Instruction (Training manual) | Train-the-trainer materials to respond to the cholera outbreak in Haiti. |

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| Rega et al. (2014)[138] | Infectious Disease | Exercise (Tabletop) | Series of lectures culminating in a 2.5-hour tabletop exercise. |
| Sisler et al. (2016)[148] | Infectious Disease | Exercise (Simulation); Instruction (Multimedia, Self-study) | Includes quick reference, one-page guides to help healthcare workers' knowledge of emerging infectious diseases. |
| Stehling-Ariza et al. (2017)[152] | Infectious Disease | Not specified | |
| Streichert et al. (2005)[154] | All Hazards | Exercise (Tabletop); Instruction (Multimedia, Self-study) | One-week course using problem-based learning to foster cross-disciplinary communication. |
| Tauxe et al. (2011)[158] | Cholera | Instruction (Lecture, Multimedia) | Train the trainer program for cholera outbreak in Haiti. |
| Waxman et al. (2017)[162] | Mass Casualty Incident | Exercise (Simulation) | Tool to use immediate bed availability as a measure of preparedness in emergency departments. |
| Weiner et al. (2006)[163] | Mass Casualty Incident | Instruction (Multimedia) | Training modules were designed using a "How People Learn" framework, which begins with a challenge, followed by questions. |
| Weiner (2006)[164] | Mass Casualty Incident | Exercise (Simulation) | Examples of low, moderate and high-fidelity simulations to address emergency preparedness and response competencies for nurses. |
| Weiner (2006)[165] | Complex Emergency | Not specified | Competency-based emergency preparedness and response education curricula for nursing students are widely available, but could be enhanced if they were provided through a centralized clearinghouse. |
| Westphal et al. (2005)[166] | Bioterrorism | Instruction (Multimedia) | A web-based interactive and user-friendly course that provides instruction in bioterrorism and emergency preparedness using real case studies. |
| Williams et al. (2017)[168] | Complex Emergency | Exercise; Instruction (Lecture, Multimedia) | Incorporates both didactic and participatory training to focus on climate change in humanitarian response training. |
| Zotti et al. (2016)[171] | Reproductive Health | Exercise (Simulation); Instruction (Self-study) | Description of online course, tools, and resources for reproductive health in emergency preparedness and response. |

## E. Results: Training Evaluation

### *E.1 Overview*

Our review identified 83 articles that were evaluations of rapid response training curricula. Articles selected for this category included some kind of structured evaluation of training impact and effectiveness, focusing on content knowledge, skills acquisition, or both. Key characteristics of the evaluation articles are summarized in Table 5 below**.**

The majority of these training evaluations were conducted in AMRO (n=58, 69%)[1-4,6,7,10,13,18-20,24,27,30,39,42,44,47,53-58,60,62,67,80-84,86-88,91,97,103,114,119,122,126,127,130,136,140,142-147,150,156,157,159,160,167] while EURO accounted for the second largest region (n=16, 18%).[8,9,16,33,51,68,72,73,78,89,90,106,108,116,132,141] The remaining evaluation articles were regionally represented in descending order: AFRO (N=5)[23,31,32,125,149], SEARO (N=1)[85], WPRO (n=2)[22,169] and EMRO (N=1)[153]. The vast majority of the evaluation articles focused on high-income county settings (n=75, 90%)[1-4,6-10,13,16,18-20,24,27,30,33,39,42,44,47,51,53-58,60,62,67,68,72,73,78,80-84,86-91,97,103,106,114,116,119,122,126,127,130,132,136,140,142-147,150,153,156,157,159,160,167,169] that included 58 articles published in the United States (n=58, 68%).[1-4,7,10,13,18-20,24,27,30,39,42,44,47,53-58,60,62,66,67,80-84,86-88,91,97,103,114,119,122,126,127,130,136,140,142-147,150,156,157,159,160,167] The remaining evaluation articles were distributed by country income level in descending order: mixed/multiple (n=3)[32,108,141], upper-middle income (n=2)[31,85], lower-middle income (n=1)[125] and low-income (n=2).[23,149]

The publication distribution by year was relatively equal in number between 2005-2009 (n=30, 35%)[1-4,6,18,22,27,31,39,44,47,57,58,81,82,88,89,97,106,116,119,132,136,140,142,143,147,156,159] and 2015-2018 (n=28, 34%)[7,16,19,23,32,33,51,53,55,56,60,67,68,78,80,85,108,125-127,130,145,146,153,160,167,169] with fewer publications between 2010-2014 (n=20, 24%)[8-10,13,30,62,72,73,83,84,86,87,90,91,103,114,122,141,144,149,157] and the fewest conducted between 2000-2004 (n=5, 5%).[20,24,42,54,150] Out of the 85 articles, mass casualty incident (n=31, 36%)[7,13,16,19,20,22,30,33,62,67,68,72,73,78,80,81,83,85,87,90,108,116,119,127,132,142,144,145,157,167,169] and bioterrorism (n=14, 16%)[1,18,24,42,54,82,88,89,97,122,140,147,156,159] training evaluations accounted for the two dominant content categories and collectively accounted for 52% of all articles.

Of the various evaluation methodologies described, the most commonly used were post-training (post-only) evaluation methodologies (n=22 26%)[6-10,13,18,27,31,55,57,60,68,85,87,97,103,114,116,140,146,149,160] and pre-post evaluation methodologies (n=32, 38%).[1-3,19,22,24,42,44,53,54,58,62,78,80,86,91,108,119,122,125-127,130,136,141,144,147,153,157,159,167] Additional methods were used including case-control (n=1, 1.1%)[16], focus

groups (n=2, 3.6%)[4,106], multiple methods/a combination of methods (n=12, 14%)[32,67,73,81,83,88,116,127,143,145,150,156], trained observers (n=8, 9%)[56,72,82,84,88,132,142,169], visual analogue scale (n=1, 1.2%)[51] and evaluation methodologies that were not specified (n=2, 2.3%).[23,33]

***Table 5: Characteristics of Training Evaluation Articles (n=83)***

| *Characteristic* | *Category/Level* | *Number (%)* |
|---|---|---|
| Region of Focus | Region of the Americas (AMRO) | 58 |
| | African Region (AFRO) | 5 |
| | Eastern Mediterranean Region (EMRO) | 1 |
| | European Region (EURO) | 16 |
| | South-East Asia Region (SEARO) | 1 |
| | Western Pacific Region (WPRO) | 2 |
| Income-level of Focal Country/Region | High-Income | 75 |
| | Upper-Middle-Income | 2 |
| | Lower-Middle-Income | 1 |
| | Low-Income | 2 |
| | Mixed/Multiple | 3 |
| Year of Publication | 2000-2004 | 5 |
| | 2005-2009 | 30 |
| | 2010-2014 | 20 |
| | 2015-2018 | 28 |
| Content Topic | All Hazards | 8 |
| | Bioterrorism | 14 |
| | Mental Health Resilience | 1 |
| | Public Health Preparedness | 1 |
| | Ebola | 7 |
| | Infectious Disease | 13 |
| | Mass Casualty Incident | 31 |
| | Influenza/Pandemic Influenza | 4 |
| | MERS | 1 |
| | Monkey Pox | 1 |
| | MRSA and Norovirus | 1 |
| | SARS | 1 |
| Evaluation Methodology | Case-Control | 1 |
| | Focus Groups | 3 |
| | Multiple Methods | 15 |
| | Not Specified | 3 |
| | Post-Only Evaluation | 22 |
| | Pre-Post Evaluation | 33 |
| | Trained Observer | 5 |
| | Visual Analogue Scale | 1 |

***E.2 Key Findings***

Below are some of the key findings from the articles on rapid response training evaluation. As with the articles on training implementation—indeed, all the articles, there were substantial differences between the high-income and upper-middle income countries, on the one hand, and low-income and lower-middle income countries, on the other hand. Out of all 83 evaluation articles, only 2 were conducted in low-income settings[23,149] and one in low-and-middle income settings.[125] In terms of content area, the low-and-middle income country context (n=3)[23,125,149], rapid response training curricula were exclusively geared towards infectious diseases including Ebola (n=2)[23,125] and unspecified infectious disease (n=1).[149] In evaluation articles conducted in high income county settings (n=75), the largest categories represented were mass casualty incidents (n=31) [7,13,16,19,20,22,30,33,62,67,68,72,73,78,80,81,83,85,87,90,108,116,119,127,132,142,144,145,157,167,169], bioterrorism (n=14) [1,18,24,42,54,82,88,89,97,122,140,147,156,159] and all hazards training evaluation (n=8).[9,39,44,47,57,58,60,126]

Out of all evaluation methodologies used in high income settings (n=75) [1-4,6-10,13,16,18-20,24,27,30,33,39,42,44,47,51,53-58,60,62,67,68,72,73,78,80-84,86-91,97,103,106,114,116,119,122,126,127,130,132,136,140,142-147,150,153,156,157,159,160,167,169], the most common evaluation methodologies were pre-post evaluations (n=32). [1-3,19,22,24,42,44,53,54,58,62,78,80,86,91,108,119,122,125-127,130,136,141,144,147,153,157,159,167] and post-training evaluation (post-only) methodologies (n=24). [6-10,13,18,27,31,55,57,60,68,85,87,97,103,114,116,140,146,149,160] Out of the evaluation articles that were from low and low-middle income country settings (n=3) [23,125,149], a post-only evaluation methodology was used (n=1)[149], pre-post methodologies were used (n=1)[215], and an evaluation methodology was not specified (n=1).[23]

1. *Pre-Post Evaluation* The most common type of evaluation method found in the literature were pre-post evaluation methodologies (n=33, 38%).[1-3,19,22,24,42,44,53,54,58,62,78,80,86,91,108,119,122,125-127,130,136,141,144,147,153,157,159,167] Pre and post-surveys, exams and assessment lists were common ways to test the effectiveness of a training on individual participants.[53,54,122,144,147,167] The use of these surveys to measure knowledge, confidence levels and skill acquisition was noted for its cost-effectiveness and transferability to lower resources settings.[3,122,167] In the use of an online gaming simulation used to evaluate readiness for bioterrorism and emergencies, both pre and post-surveys were administered to affiliates of the Minnesota School of Public Health to test specific competencies.[122] This was shown to be an easily administered evaluation methodology which could

allow for a measurable comparison of gained competencies, increased sense of confidence in responding to emergencies and elements of trainings which were not easily absorbed by participants.[122] Tauxe et al. (2011) noted that pre-post surveys helped reveal strengths and weakness in their trainings which could help establish improved versions. [158] In an emergency response and disaster medicine training drill, a group of medical students were tested with pre-post surveys to gauge changes in their ability to triage 100 inflatable mannequins in a mass casualty incident training exercise. [144]

***Table 6: Pre-Post Training Evaluation Articles: Topics, and Key Focus and/or Findings (n=32)***

| *Citation* | *Training Topic* | *Key Focus and/or Findings* |
|---|---|---|
| Abatemarto et al. (2007)[1] | Bioterrorism | Pre-test and post-test data showed statistically significant changes in knowledge about protective factors and protocol, self-perceptions of skill levels, and behaviors. |
| Ablah et al. (2007)[3] | Infectious Disease | Pre-post survey results showed significant improvements in ability to participate in rapid responses to infectious disease and ability to identify the need for surge capacity. |
| Ablah et al. (2008)[2] | Infectious Disease | Pre-post survey results showed increased knowledge in the post surveys which were administered immediately after the training. Unfortunately, improvements were not unilateral in all topical areas with awareness of zoonotic diseases standing out as the weakest category. |
| Bank & Khalil (2015)[19] | MCI | Surveys on knowledge and confidence were conducted before and after the trainings. These showed improved knowledge and confidence which was retained after 6 months of training. |
| Bartley et al. (2007)[22] | MCI | A pre and post knowledge assessment survey was developed to determine disaster plan knowledge before and after the video was watched. This study recommended the use of educational videos in disaster preparedness training. |
| Beaton & Johnson (2002)[24] | Bioterrorism | A questionnaire was developed to evaluate the effectiveness of the training based on the responses of a pilot questionnaire which helped identify specific training objectives and content areas. The questionnaire was determined to have concurrent validity and be a sufficiently sensitive measure of testing skill acquisition. |
| Buso et al. (2005)[31] | Infectious Disease | Assessments were administered before and after participation to assess skill acquisition and satisfaction levels among participants. Further epidemiology training was recommendation from participant feedback. |
| Chandler et al. (2008)[39] | All Hazards | The instructional development process included creating pre and post-test assessments which took an average of 10 minutes to complete. Results of the study indicated high levels of satisfaction with the blended training methodology. |
| Chung et al. (2004)[42] | Bioterrorism | Pre and post tests were administered after medical residents participated in a bioterrorism lecture. Participants were re-tested after 6 months to assess skill retention. This study found that providing physicians with |

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| | | bioterrorism training through simulations and access to a website did not increase preparedness. |
| Collander et al. (2008)[44] | All Hazards | Pre and post-test trainings were conducted to assess participant attitudes and skill acquisition. Post-test training scores compared to baseline showed this to be an effective method. |
| Ferranti et al. (2016)[53] | Ebola | Pre and post-test assessments were used to assess changes in confidence and knowledge retention. Surveys were linked to specific participant ID numbers and participants that made improvements were acknowledged. This methodology was found to be effective in nursing schools to provide comprehensive, rapid response trainings to infectious disease outbreaks. |
| Filoromo et al. (2003)[54] | Bioterrorism | Comparison between pre and post tests showed improvements in clinician confidence to respond to bioterrorism incidents. |
| Fox et al. (2008)[58] | All Hazards | A 10 question pre-test established baseline levels of knowledge among participants. After an 80-minute discussion and presentation, individuals were tested again for comparison to baseline. Recommended periodic re-trainings for health professionals to be sufficiently prepared for an emergency. |
| Glow et al. (2013)[62] | MCI | When participants pre and post test scores were compared, the exercise showed to increased skills and also yielded recommendations for additional periodic refresher trainings. |
| Jonson et al. (2017)[78] | MCI | Nurses that participated in the simulation exercises completed pre and post-tests. These tests showed that simulation exercises were effective, but further research is necessary to determine how often retraining should occur. |
| Kim et al. (2017)[80] | MCI | Online pre and post tests were administered to determine leadership, team development, skill acquisition and qualitative feedback. Improvements were observed in participants, but additional research is needed to demonstrate sustainability. |
| Leaming et al. (2013)[86] | Pandemic Influenza | Hospital staff took pre-post assessments to determine the effectiveness of a simulation based training. Communication and supply availability were determined to be the two weakest areas in the hospital environment. |
| Lee et al. (2014)[87] | MCI | Pre and post-test trainings were given to first responders including PCPs, police and fire trainees. While all groups saw increased knowledge, differences in the first responders' baseline knowledge affected their overall performance and the level of skill acquisition. |
| Leonard et al. (2012)[91] | Infectious Disease | Pre and post-tests scores were compared for students that participated in an infectious disease education module. Performance showed increased knowledge between the 2 tests and validated a hybrid form of teaching methods. |
| Montan et al. (2015)[108] | MCI | Brief forms were given to participants before the training was conducted and compared to post-training form scores through a coding system. This study recommended the use simulation like tools to increase the efficacy of skill retention. |
| O'Brien et al. (2009)[119] | All Hazards | Pre and post-test scores were evaluated to measure the impact of PREPARE training courses in the efficacy of disaster planning. The combined style of train-the-trainer, tabletop exercises and multimedia instruction were found to be effective. |

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| Olson et al. (2010)[122] | Bioterrorism | The effectiveness of the gaming simulation exercise was evaluated through a comparison of pre and post-test results. Results indicated that significant improvements were seen in participants. |
| Otu et al. (2016)[125] | Ebola | Pre and post-test quantitative surveys were administered to health workers to measure knowledge, attitude and practice measures. Only modest gains were measured. |
| Owens et al. (2017)[126] | All Hazards | Students completed online pre and post-tests online. This 1-day training was found to be an effective means to quickly increase capacity for a large number of people to respond to health emergencies. |
| Pate et al. (2016)[130] | Infectious Disease | Tests administered before and after the training focused on willingness to participate in the exercise, baseline level of preparedness, and the specific role of pharmacists in emergencies among pharmacy students. This study revealed that tabletop exercises may increase knowledge, skills and protocol adherence among pharmacy students. |
| Quiram et al. (2005)[136] | Infectious Disease | Seven focus areas were assessed in pre and post-test assessments to evaluate the efficacy of increasing collaborative skills in a healthcare worker audience. This multidisciplinary approach was found to be effective and dissemination to a national audience was recommended. |
| Reynolds et al. (2014)[141] | Monkeypox | Pre and test-test surveys were administered to garner both qualitative feedback from participants and to assess skill acquisition. Surveillance skills increased among healthcare workers and similar training models were recommended for resource poor settings. |
| Scott et al. (2009)[144] | MCI | Fourth year medical students were evaluated with a pre and post-test scoring system which examined students' ability to apply the training concepts. While this training was found to be effective among students, further research was recommended to identify key competencies in disaster response. |
| Silenas et al. (2008)[147] | Bioterrorism | Identical pre and post-training tests were administered to participants. Improved scores across multiple professional categories validated this form of training as an effective, low-cost means of improving multiple skills that are important in disaster response across professional disciplines. |
| Stirling et al. (2015)[153] | MERS | Surveys were given to participants beforehand to assess baseline knowledge of MERS. Additional surveys were administered periodically to measure knowledge and assess acquisition of knowledge. This was found to be effective in reducing disease transmission from healthcare workers. |
| Swartzentruber et al. (2014)[157] | MCI | Pre-post tests were administered online to assess provider knowledge, EPT skills, and confidence using a simulation. Participants scored higher after the trainings which led the study to endorse simulation. |
| Terndrup et al. (2005)[159] | Bioterrorism | Identical pre and post tests were taken before administration of the educational materials via screensaver and website deployments. There were significant increases in the post test scores and screensavers and web materials were found to be effective in knowledge acquisition. |

2. *Post-Only Evaluation* The second largest evaluation methodology category used were the post-training (post-only) methodologies without any additional evaluation (n=22, 26%)[6-10,13,18,27,31,55,57,60,68,85,87,97,103,114,116,140,146,149,160] Post-only evaluation methodologies used exams, surveys, checklists and forms the address skill acquisition, participant confidence, and gain qualitative feedback. Some studies attempted to measure preparedness through post-surveys only with no pre-survey component and interviews to determine the level of preparedness for individuals who had completed trainings.[9,160] This methodology was also cited to have serious limitations due to lack of information and research on what constitutes preparedness and how it can be measured, but was found to be effective in gaining feedback from participants on their experience with the training. [9,18] A University of Florida study attempted to evaluate the effectiveness of training emerging infectious disease researchers and one health professionals to participate in rapid responses to disease outbreaks.[160] The post-only survey methodology was helpful in identifying the participants' perceived value of including a fieldwork component in combination with online training.[160] Adini et al. (2015) noted the usefulness of the post-only evaluation in critiquing participant decision making processes, but questioned the sensitivity of this evaluation method.[7]

***Table 7: Post-Only Training Evaluation Articles: Topics, and Key Focus and/or Findings(n=20)***

| *Citation* | *Training Topic* | *Key Focus and/or Findings* |
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| Abrahamson et al. (2006)[6] | SARS | Educators reviewed post-training evaluation surveys which were filled out by participants. These surveys were meant to identify any concerns that participants had about their own preparedness, but did not assess for specific skills. |
| Adini et al. (2012)[9] | All Hazards | An evaluation tool was created through the Delphi method with a group of experts. The tool was tested in a pilot study and the results of the evaluation tool were reviewed by experts from the Ministry of Health for feedback to participants. |
| Adini et al. (2012)[8] | Influenza | A detailed check list was used to evaluate participants' perceived quality of the training on a scale from 1-6 in key content areas. This training recommended developing a more rigorous evaluation tool to determine the effectiveness of the training rather than merely reviewing how participants rated their experiences and perceived aptitudes in key content areas. |
| Aiello et al. (2011)[10] | Influenza | Feedback session surveys provided a scale from 1-5 for level of agreement with statements about training. Participants strongly agreed that they were able to more confidently respond to an influenza outbreak. |
| Andreatta et al. (2010)[13] | MCI | A post-test was administered 2 weeks are the completion of the training and participants were found to have increased levels of confidence and skill acquisition from this training. |

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| Baldwin et al. (2005)[18] | Bioterrorism | The evaluation methodology was designed to total the number of staff members that participated in the training. The training modules scored participants after completion. This study found that intranet systems were an effective way of training health department staff. |
| Brahmbhatt et al. (2009)[27] | Infectious Disease | A 36 item questionnaire was administered to determine preparedness after the training was completed. These findings underscored the necessity and effectiveness of pre-disaster training to best equip responders. |
| Dausey et al. (2007)[47] | All Hazards | Post training evaluations were conducted through after action reported which were designed to underscore lessons learned and critique the design of the table top exercise. Follow up trainings were recommended to help retain skills. |
| Foote et al. (2017)[55] | Ebola | After action reports were used to acquire qualitative data on participant feedback on specific thematic areas that were used to improve future trainings. Recommendations included the development of specific validated metrics to establish a more robust and reliable validation process. |
| Fowkes et al. (2007)[57] | All Hazards | Evaluation tools were used to collect data on participants' educational backgrounds and demographic information in addition to qualitative feedback on the quality of the trainings' content and presenters. |
| Gardner et al. (2016)[60] | All Hazards | An after-action review acquired qualitative data 1 week after training was completed. This report revealed that the most important practices to reduce among clinicians were communication lapses and inappropriate triaging of patients in medical emergencies. |
| Haverkort et al. (2016)[68] | MCI | The exercises were analyzed using an established standardized protocol known as the Protocol for Reports from Major Accidents and Disasters. This process revealed that the exercise increased the hospital's preparedness. |
| Kuhls et al. (2017)[85] | MCI | A post-training assessment was administered to assess confidence among participants to respond to MCI incidents. All participants saw improvements, but this training was found to be especially effective for nurses and active duty military. |
| Lennquist et al. (2014)[90] | MCI | After participants completed the simulation model, they were scored on the accuracy of their performance on a scale of 1 to 5. Participants were found to have increased knowledge and skills in key areas in responding to major incidents. Communication was found to be the most challenging area. |
| Livet et al. (2005)[97] | Bioterrorism | An after training evaluation methodology among public health professionals revealed that 99% of participants found the training to be useful and felt an increased level of confidence. |
| McCabe (2012)[103] | Mental Health Resilience | A post training evaluation methodology was administered to faith based groups to assess their confidence in responding to mental health issues in disaster scenarios. Confidence and attitudes were increased among participants. |
| Reid et al. (2005)[140] | Mental Health Resilience | Participants felt an increased sense of confidence in their ability to increase mental health resilience in individuals affected by |

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| | | hurricanes. This was determined through web-based surveys that assessed knowledge and skills. |
| Siddle et al. (2016)[146] | Ebola | Participants took an online web survey to assess knowledge of Ebola. This study found that disease specific training helped to increase the accuracy of participants' knowledge about infectious disease. |
| Sow et al. (2010)[149] | Infectious Disease | Health district personnel were evaluated after the training occurred in key performance areas. This training was found to be effective, but feedback was recommended for participants. Reliable communication and simplified reporting were identified as key areas for improvement. |
| Valentine et al. (2015)[160] | Infectious Disease | Post assessment surveys were administered to participants to gain feedback from the training experience in addition to key pedagogical outcomes. Confidence and skills gained were assessed and demographic information was also gathered. |

3. *Trained Observer and Other Evaluation Methodologies* Trained observers (n=5, 6%)[56,72,82,84,88,132,142,169] were used to evaluate the efficacy of training programs. In a study by Klein et al. in 2005, a group of experienced observers proved to be an effective methodology for evaluating the effectiveness of a rapid response exercise with the guidance of a pre-established evaluation protocol.[82] In a bioterrorism tabletop exercise, hospitals and health departments participated in this training which was evaluated by trained observers. [82]Each observer had extensive data collection experience and had participated in the training being utilized. [82]Throughout the training, the observers collected data which they later compiled into summary reports to present findings on the effectiveness of the training outcomes in team debriefing sessions. [82]In a study by Pelaccia et al. (2009), trained observers monitored participants to assess triage performance in a mass casualty incident training for a group of medical students and healthcare workers by creating detailed performance reports. [132]

***Table 8: Other Training Evaluation Articles: Topics, Methods, and Key Focus and/or Findings (n=10)***

| *Citation* | *Training Topic* | *Evaluation Method(s)* | *Key Focus and/or Findings* |
|---|---|---|---|
| Ablah et al. (2008)[4] | Infectious Disease | Focus Group | Training was evaluated with focus groups to discuss the usefulness of the format, ways to improve the exercises for future use and efficacy of the exercise objectives. Participants indicated that they felt more confidence in improved skill levels in each target area. |
| Adini et al. (2015)[7] | MCI | Focus Groups | The evaluation tool that was used in this training was highly informal and based off of feedback from participants in focus group style conversations concerning perceived confidence in their decision making processes during an MCI event. Future studies recommended applying this training methodology in other emergency contexts outside of MCI settings. |
| Badiali et al. (2017)[16] | MCI | Case-Control | The case and control groups were compared by differences in what percentage of at-risk patients were correctly identified for their appropriate triage categories. The group that received training correctly identified a higher percentage of at-risk patients. |
| Foote et al. (2017)[56] | Infectious Disease | Trained Observers | Trained observers used a standardized evaluation guide to assess specific skills including adherence to protocols, speed of processing patients, infection control activities and adherence to key preventative procedures. |
| Klein et al. (2005)[82] | Bioterrorism | Trained Observers | Trained observers assessed for specific competencies. Further research was recommended to develop news tools to make the trained observer evaluation process more objective. |
| Klima et al (2012)[83] | MCI | Trained Observers | Trained observers rated hospital staff performance based on communication, command structure, decontamination, staffing and patient tracking. While this training was found to be effective, communication was the most deficient area and additional training was recommended. |
| Kohlhoff et al. (2012)[84] | Pandemic Influenza | Trained Observers | The drill's ability to increase general facility preparedness was assessed with the help of trained observers who scored participants on forms. The form used by the observers was found to be effective in identifying training weaknesses and producing recommendations to improve the training. |
| Mikkelsen et al. (2008)[106] | MRSA and Norovirus | Focus Groups | Nursing students participated in focus groups after infectious disease response trainings focused on MRSA and norovirus. Feedback predominantly reflected a sentiment that simulations were effective in increasing confidence and awareness of how to respond to health emergencies. |
| Pelaccia et al. (2009)[132] | MCI | Trained Observers | Trained observers reported observations as healthcare students participated in the simulation. This exercise was found to be effective in improving triage performance and validated simulations as an effective means to train healthcare students. |

| | | | |
|---|---|---|---|
| Ruter et al. (2007)[142] | MCI | Trained Observer | A pre-established template was used to evaluate participants during the training process. Simulations were found to improve preparedness for mass casualty incidents. A logging system was recommended for identifying and improving poor performance areas. |

4. *Multiple Methods* Combined methods were found to be effective in evaluating training outcomes in studies that used more than one evaluation method (N=15, 18%).[30,32,67,73,81,83,88,116,127,143,145,150,156] Burke et al. (2014) found that using multiple methods allowed for them to acquire different kinds of information in the evaluation process.[30] This study used surveys and interviews to assess skill acquisition and improvements, but also to garner quantitative and qualitative feedback for participants.[30] Trained observers were also used to tailor the quantitative assessment of each participant and provide tailored supplemental education.[30] A study by Spinello and Fischbach (2004) used a combination of focus groups and surveys in their evaluation process.[150] The focus groups allowed for qualitative feedback from a group of undergraduate student participants while the survey helped assess quantitative aptitudes.[150] Summerhill et al. (2008) used both case-control and pre-post survey evaluations to assess the acquisition of quantitative skills for participants vs. non-participants in addition to skills acquired by participants.[156] Studies that used multiple evaluation methods were able to acquire different kinds of data for different purposes and to increase the level of certainty of a training's effectiveness.

***Table 9: Multiple Method Training Evaluation Articles: Topics, Methods, and Key Focus and/or Findings (n=16)***

| ***Citation*** | ***Training Topic*** | ***Evaluation Method(s)*** | ***Key Findings*** |
|---|---|---|---|
| Burke et al. (2014)[30] | MCI | Surveys; Interviews; Trained Observers | Participants provided both qualitative and quantitative feedback about their perceptions of the efficacy of the exercise. Trained observers also provided qualitative feedback and recommendations for participants. The study found that this exercise enhanced the participants' ability to care for children in MCI attacks. The qualitative feedback component was helpful in assessing the strengths and weaknesses of the training. |
| Caceres et al. (2017)[32] | Ebola | Pre-Post; Focus Groups | A pre-post methodology was used to compare baseline and post-training surveillance skills. A focus group was conducted to determine the quality of the content and surveillance reports used. An additional follow up assessment was conducted 6 months after the training. |

| | | | |
|---|---|---|---|
| Eardley et al. (2016)[51] | Ebola | Visual Analogue Scale; Post-Only | A visual analogue scale was used to provide a more granular gradation of skill acquisition which is similar to a Likert scale. The analysis of the post-training analysis of the results showed an increase of confidence and self-reported knowledge among 80% of participants. |
| Hannings et al. (2016)[67] | MCI | Pre-Post; Trained Observer | Pharmacy students took pre-post surveys to assess skill acquisition. These tests revealed that participants needed additional training. Trained observers also supplemented the training with personalized feedback. |
| Ingrassia et al. (2013)[72] | MCI | Trained Observers; Case-Control | Trained observers evaluated participants during the training process and assessed to assess the accuracy of clinical abilities during this process. No differences in clinical abilities were observed in the group that received training and the group that did not. This process was helpful in critiquing the training. |
| Ingrassia et al. (2010)[73] | MCI | Post-Only; Trained Observers | The training was evaluated after its completion to assess the effectiveness of clinical maneuvers, triage and radio usage. This was found to be effective in determining the efficacy of the training in combination with trained observers. |
| King et al. (2006)[81] | MCI | Post-Only; Trained Observers | Assessment cards were provided to participants to determine organizations skills, communication, treatment and general performance. This process helped identify weakest performance areas such as communication lapses and contributed to the recommendation of developing a standardized field documentation method. |
| Leiba et al. (2007)[88] | Bioterrorism | Trained Observers; Case-Control | Physicians were rated by trained observers in patient history taking, physical examination, laboratory orders and protocol adherence. Physicians who attended the lecture performed better than those who did not. This training validated the effectiveness of preparedness training in hospitals for clinicians. |
| Leiba et al. (2006)[89] | Bioterrorism | Trained Observers; Pre-Post | Trained observers judged the clinicians' accuracy in responding to patients that were suspected to have been exposed to anthrax. Physicians showed an improvement from the baseline pre-post testing process. This validated a combination of lectures and drills as an effective method for training clinicians. |
| Nambisan (2010)[114] | MCI | Post-Only; Case-Control | Students participated in an online questionnaire that was administered after the training. Students that participated in the training scored significantly better than students that did not. Online training was found to be effective, but had a high variability in how engaged participants felt. |
| Nilsson et al. (2008)[116] | MCI | Post-Only; Trained Observers | Trained observers scored participants based on managerial skills, decision making skills, and how accurately participants followed correct procedures. This came with a post-training assessment. Setting specific indicators beforehand to measure performance was key to the success of measuring efficacy. |

| | | | |
|---|---|---|---|
| Paddock et al. (2015)[127] | MCI | Trained Observer; Pre-post | Pre and post-test scores showed improvements among participants in this simulation exercise. This method was found to be a novel alternative to live instructor training. Future research recommended with a larger sample size and measures of long-term clinical performance. |
| Savoia et al. (2009)[143] | Infectious Disease | Survey; Trained Observer | An extensive survey was developed to assess leadership skills, communication, infectious disease control and prevention, and surveillance. Multiple reviewers scored these surveys and assessed performance with trained observers. This carefully constructed tool was found to effectively evaluate skill acquisition. |
| Shannon (2015)[145] | MCI | Post-Only; Trained Observers | After the completion of the response readiness course for nurses, responses were scored to assess skill acquisition. Qualitative feedback was provided to improve future trainings. |
| Spinello & Fischbach (2004)[150] | Infectious Disease | Post-Only; Focus Groups | Students completed a post-course evaluation and participated in focus groups. Feedback indicated that the simulation exercise was an effective and motivating didactic method for participants. |
| Summerhill et al. (2008)[156] | Bioterrorism | Case-Control; Pre-Post | Participants level of knowledge was superior to those in the control group. Post training assessment was conducted up to a year later which helped show that participants retained higher levels of knowledge than non-participants. Repeated trainings were recommended after 1 year. |

## F. Results: Training Curriculum

### *F.1 Overview*

A curriculum is "a complete set of learning experiences, including classroom, experiential, and self-guided, that, taken altogether, achieve a desired set of competencies."[36] Rapid response training curricula aim to provide health care providers, local officials, public health professionals, and the public, practical skills and knowledge to minimize morbidity and mortality in the event of a manmade or natural disaster, such as an infectious disease outbreak or act of bioterrorism. Our review identified 21 articles published since January 2000 that describe rapid response training curricula, among which there was wide variation in format, length, and content (see Table 10 below).

***Table 10: Characteristics of Training Curriculum Articles (n=21)***

| *Characteristic* | *Category/Level* | *Number (%)* |
|---|---|---|
| Country/region of origin: | United States | 13 |
| | United Kingdom/Europe | 6 |
| | Japan | 1 |
| | Guatemala | 1 |
| Country/region of Focus: | United States | 9 |
| | United Kingdom/Europe | 5 |
| | Japan | 1 |
| | Africa | 3 |
| | Ethiopia | |
| | Sierra Leone | |
| | Zambia | |
| | Guatemala | 1 |
| | LMICs across regions | 2 |
| Content Topic | Bioterrorism | 3 |
| | Nuclear | 1 |
| | Infectious disease outbreak | 8 |
| | Unspecified | 9 |
| Target Audience | Public health students | 3 |
| | Medical professionals | 7 |
| | Physician trainees* | 4 |
| | Government workers** | 4 |
| | Multiple or unspecified | 3 |

*includes medical students, residents and fellows.
**includes ministry of health staff, epidemiologists, local and national officials

Most training curricula studied were intended either for medical professionals, physicians in training, or public health students or professionals. One attempted to address community members as well[26], and two addressed government officials not specifically in public health.[26,49] Because several curricula were intended for students or trainees, some authors saw it as desirable to integrate disaster response training into existing educational activities. Six curricula[17,46,74,76,101,112] were thus integrated into other post-graduate training, while nine[11,21,26,49,51,71,75,94,104] of the curricula were intended as independent educational activities. One curriculum was a hybrid,[12] with an intensive component initially and the remainder integrated into trainees' regular work responsibilities. This was done in an effort not to remove trainees from their daily responsibilities, as this program was directed at workers in the ministry of health in LMICs, who might be the only people available to carry out the responsibilities of their jobs locally and could not be taken away from their jobs for an extended period.

The duration of the stand-alone training curricula varied from 3 hours to 7 weeks, with seven under 5 days in length. Four[71,76,94,104] comprised independent learning, with online lectures and discussion forums or lectures provided in digital format, without a specific recommended time frame. Some curricula included simulations or field experience, and multiple authors suggested that the most effective educational format would include hands-on drills. However, the most frequently-utilized formats were simply lectures, or a mix of lectures with practical exercises, usually in the form of "tabletop exercises," meaning students talk through scenarios or work through problems together in discussion format. The tabletop exercise format also provides a means of evaluation of students' understanding of the material. Of the few curricula that included a hands-on component, this largely consisted of specialized practical skills such as donning and doffing of personal protective equipment, rather than management of disaster response.

***Table 11: Format and Contents of Training Curricula (n=21).***

| | | |
|---|---|---|
| Instructional Method | Lecture only | 4 |
| | Lectures + classroom exercises | 10 |
| | Lectures + simulation or field experience | 3 |
| | Unspecified | 4 |
| Curriculum Format | Integrated | 5 |
| | Stand-alone | 8 |
| | Self-directed* | 2 |
| | Hybrid | 1 |
| | Unspecified | 5 |
| *Curriculum Length (Stand-alone)* | 3 hours | 1 |
| | 12 hours | 1 |
| | 1 day | 1 |
| | 2 days | 1 |
| | 3 days | 2 |
| | 4 days | 1 |
| | 5 days | 1 |
| | 7 weeks | 1 |
| | 3 months | 1 |
| | Not specified | 11 |
| Content Area | Bioterrorism | 3 |
| | Infectious disease outbreak | 8 |
| | Nuclear disaster | 1 |
| | Mass casualty | 1 |
| | Disaster response | 8 |

*online or recorded lectures on CD/DVD only

***F.2 Key Themes and Findings***

Below are some of the key themes and findings from the review of the training curriculum articles.

1) *Experiential learning.* There is increasing consensus that experiential learning methods are favorable and often required for acquisition and retention of complex knowledge and skills.[151] Moye et al. found that experiential programs were "more likely to cover a broader range of topics and to teach them more frequently compared with nonexperiential programs.[111] Thus, adopting of experiential methods was a marker for overall program intensity," which they also found correlated with program funding. Although this is the most logistically challenging learning format, it may be the most essential, even if the experiential component represents only a fraction of the curriculum. Of the curricula reviewed here, only four[76,94,101,104] are entirely lecture-based, however some research suggests that a majority of existing medical education on disaster preparedness and response does

not include an experiential component. For example, Moye et al. found that 85% of Emergency Medicine residency education on disaster response is entirely in lecture format.[111] Because of the resources needed and challenges associated with simulations and field work, many curricula are either entirely lecture based[76,94,101,104] (4 in our review) or fulfill a hands-on component through group classroom exercises[11,17,21,26,49,51,71,74,111,123] (10 in our review). Some examples of classroom exercises include:

- "a two-day, hands-on [tabletop] exercise [simulating an] anthrax attack in a small U.S. port city… Students were assigned to roles including mayor and staff, hospital administrators… police, EMS, and media representatives… Each student received only information relevant to his or her agency during the exercise, illustrating the importance of inter-agency communication in the event of an emergency."[123]
- "Two different table-top simulations were implemented. The first involved a building collapse in which students were asked to triage a total of 15 victims projected on a whiteboard. The second simulation involved a chemical accident with 150 casualties. The participants had to work out the best possible strategy that would enable the emergency departments of three virtual hospitals to cope with the massive influx of contaminated victims. For this, students were given maps and an overview of hospital resources."[74]
- "A scenario in which personnel arrive at a site and begin their activities thinking it is a normal fire or disaster, after which it is determined to be a CBRNE disaster. Participants discuss this in a group and place toy figures of emergency vehicles and squad members on a map of the site to understand the response."[11]

Three of the curricula[12,75,112] include field experience as a key component. This ranged from "field trips and seminars"[112] comprising a minimal portion of the curriculum, to a majority of time spent in the field:

> *"Residents spend about 25% of their time undergoing didactic training and the remaining 75% in the field working within the Federal Ministry of Health and Regional Health Bureaus where they investigate disease outbreaks, improve disease surveillance, respond to public health emergencies, and use health data to make recommendations on setting health policy for the nation."*[75]

The third curriculum including field experience was adapted to various countries, but generally included "weekly surveillance reports,… case investigation reports,… and outbreak investigation reports" using data gathered from local health facilities and authorities.[12]

Interestingly, three[50,111,120] of the eight authors writing about non-experiential curricula recognize the need for more experiential learning through drills and simulations. As one states, "parallel to the teaching part of the programs, there is a training part, which is necessary to fully develop competencies (knowledge, skills and abilities). Both are equally important… Exercises are of paramount importance to validate, to test, and to train the plans."[50] O'Neill suggests that drills are critical to preparedness and lectures alone are not sufficient: "Staff must be educated in the plan and rehearsed regularly through table-top and simulation drills.[120] A critique of these drills should identify weaknesses and deficiencies in the institutional plan and lead to appropriate and timely revisions that should then be re-evaluated during subsequent drills." This means drills are not only critical to learning but of utmost importance in identifying and correcting issues in the response methods. The paper continues to emphasize this point: "True readiness can only be achieved by testing and modifying these plans through integrated simulation drills and tabletop exercises."[120]

Furthermore, drills and simulations may prove to be feasible in LMICs as well, as the major resources needed for disaster simulations are personnel and time. Disaster simulation should be run with locally-available materials in order to best approximate a real disaster in the area. In fact, the Expert Panel on Bioterrorism Education for Medical Students recommends that didactic methods be used for early knowledge acquisition, but prefers experiential learning for integration of knowledge and skills.[15] An ideal curriculum would have an initial lecture component to ensure that all trainees have the same common knowledge base, but would then focus heavily on hands-on drills and simulations for consolidation of skills and reinforcement of concepts. This model was demonstrated in a few of the included curricula:

- "The program… consists of an initial 5-day workshop introducing basic epidemiology principles and importance of disease surveillance. The participants then return to their regular job sites for 5 weeks. There, they receive onsite and remote mentoring from program staff... The participants return for a second 5-day workshop to present their work and receive feedback,… then return to the field for the second 5-week field stage to put in

practice what they have learned under the guidance of the mentors and to complete… field activities."[12]

- "Each day of the two-day course was organised into reflection and action sessions. The days started with reflection sessions introducing terms, definitions, approaches, and gave time to discuss these. The afternoons were dedicated to actions: exploring ways to put concepts into practice, testing ideas, working on scenarios related to both on-going and crisis challenges, discussing and getting feedback from others within small working groups and in the plenum."[49]

2) *Integration of curriculum to trainees' existing school or work.* Although it can be argued that all members of the community should receive some level of training in disaster response, most curricula are intended for students of public health or medical professions or for professionals already working in these areas. Unless training for a specific disaster that is already underway (and only one of the articles reviewed covered this type of training[51]), including education in existing school curricula or job training requirements may be the best way to ensure consistent coverage of the subject. For these audiences, it may also represent an additional and unwelcome burden to require intensive courses outside of the regular school or job responsibilities. Seven articles[17,46,74,76,101,112,123] suggest integrating disaster training into existing educational activities. This most frequently consists of additional lecture topics, but can also encompass workshops or simulation during dedicated didactics time, on-the-job mentoring by experts in the field, or field experience relevant to one's current position (for example, investigating outbreaks in one's country while working for the ministry of health).

3) *Tailoring of curriculum to learner type and location.* Different types of learners were addressed with the curricula studied, including community members, first responders, nurses, doctors, public health professionals, government officials, and students of all types.

- "There is a need to provide detailed training to professionals already working in a particular discipline; however, it is the people who will directly encounter [the outbreak] who can benefit the most from training and will have the greatest impact on the outcome."[26]
- "Training should focus on the role of the community, since not having functioning hospitals in a major disaster is a real possibility."[94]

These learners all have different background knowledge and experience. In order to provide information that is both useful and comprehensible, curricula must be tailored to the intended audience, both in terms of content and learning style. "The delivery of information to all levels requires numerous trainers, and materials that can be delivered both to educated professionals and the general public."[26]

Disaster response may also be very different depending on local resources, culture, educational level, and infrastructure. Ideally curricula should be developed or modified in concert with local experts who can ensure content is locally relevant. One successful CDC program developed a common framework that was then tailored to each country in which it was deployed.

> "CDC staff visited each country and met with representatives of each MOH to describe the program and explore the value and feasibility of [the program]… [An] implementation workshop was held with key stakeholders from relevant ministries within the country and key nongovernmental partners. During the meeting, leaders and stakeholders discussed strategic elements of program implementation. [International] teams were often embedded within the MOH offices to facilitate planning and operation of the program."[12]

4) ***Repeat exposure to key topics.*** None of the curricula described followed up with trainees at a later date to assess retention, but evidence suggests that periodic review of educational material enhances understanding and retention of knowledge.[79] This could take the form of annual brief workshop sessions at the school or place of employment, or an annual disaster drill or simulation, for example.

- "No specific guidelines exist to define appropriate frequency of bioterrorism education, and the wide variation suggests that residency programs are still struggling to define the appropriate frequency of this important training."[111]
- "Training must be ongoing to maintain skills and to recognize that emergency preparedness, like other academic disciplines, is not static and constantly changing as new approaches and technologies are identified… It is recommended that this focused training and practice be at least on an annual basis."[94]

5) *Gaps in existing knowledge*

a) *Evaluation of efficacy***.** Thirteen[11,12,17,21,26,49,51,71,74,75,111,112,123] curricula evaluated learners through table top exercises, group problem solving, or field exercises. Of the remaining curricula, two evaluated learners through written examinations at the end of the training,[104,111] one through a final paper,[12] and one through faculty assessments of knowledge and skills.[75] Only in two instances[71,104] were the post-training evaluations compared with pre-training assessments of baseline knowledge. None followed up at any later time to assess retention of knowledge, and none assessed the ability to apply what was learned in training to real world situations. Future curricula should aim to include an assessment tool to evaluate efficacy of training.

b) *Curriculum development in LMICs.* The vast majority of training curricula studied were initiated or carried out in high income countries. Some were developed by expert agencies in high income countries working closely with officials in LMICs. However, in future, it would be ideal to see more involvement of local experts in LMICs, including training curricula developed in those countries primarily.

## G. Results: Training Recommendations

### *G.1. Overview*

Articles including recommendations specific to training content and based upon training and evaluation methods were classified as "training recommendation" articles. Our review identified 15 articles that provided recommendations for rapid response training curricula.

Of these 15 articles, about 50% of the articles were from AMRO (n=8, 53.3%), all of which were specific to the USA. The remaining seven articles were from the EURO (n=4, 26.7%), AFRO (n=2, 13.3%), and WPRO (n=1, 6.7%). The majority of articles (n=10, 66.7%) were from high income countries, with the remaining articles from mixed income (combinations of high, middle, or low income) (n=2, 13.3%), low-income (n=2, 13.3%), and upper-middle-income (n=1, 6.7%). Publication distribution was the same for 2005-2009 and 2015-2018 (each with n=6, 40%). Fewer articles were published from 2010-2015 (n=2, 13.3%), and only one article was published from 2000-2004 (n=1, 6.7%).

Training recommendation articles covered a variety of content topics, with little overlap. Articles focused on an unspecified infectious disease (n=5, 33.3%) made up ~~33%~~ of training recommendation articles. The remaining articles focused on the following topics in descending order: mass casualty incidents (n=3, 20%); Ebola (n=2, 13.3%); all hazards approach (n=1, 6.7%); bioterrorism, public health emergency (n=1, 6.7%); chemical, radiological, biological, nuclear, and explosive- CBRNe (n=1, 6.7%); infectious disease epidemics (n=1, 6.7%); and SARS (n=1, 6.7%).

More than half of the articles did not specify training format (n=9, 60%). Of those specified, the following formats were identified in descending order: mixed training formats (n=3, 20%); in-person trainings (n=2, 13.3%) and online trainings (n=1, 6.7%). Training methods were not commonly specified (n=8, 53.3%). Of those specified, simulation and tabletop exercises were most commonly employed (each with n=2, 13.3%). The remaining training methods included drill, exercise (general), and mixed (each with n=1, 6.7%).

Health professionals were the most common target audience for training recommendation articles (n=9, 60%). They were further stratified by the following designations: clinicians (n=3, 20%), public health professionals (n=2, 13.3%), first responders (n=1, 6.7%), general health professionals (n=1, 6.7%),

National Health Service employees (n=1, 6.7%), and nurses (n=1, 6.7%). Other audiences included: emergency departments (n=1, 6.7%), hospitals (n=2, 13.3%), mixed audiences (n=2, 13.3%), and unspecified audiences (n=1, 6.7%).

***Table 12: Characteristics of Training Recommendations Articles (n=15)***

| Characteristic | Category/Level | Number (%) |
|---|---|---|
| Region of Focus | Region of the Americas (AMRO) | 8 |
| | African Region (AFRO) | 2 |
| | European Region (EURO) | 4 |
| | Western Pacific Region (WPRO) | 1 |
| Income-level of Focal Country/Region | High-Income | 10 |
| | Upper-Middle-Income | 1 |
| | Low-Income | 2 |
| | Mixed/Multiple | 2 |
| Year of Publication | 2000-2004 | 1 |
| | 2005-2009 | 6 |
| | 2010-2014 | 2 |
| | 2015-2018 | 6 |
| Content Topic | All Hazards | 1 |
| | Bioterrorism; Public Health Emergency | 1 |
| | Chemical, biological, radiological, nuclear and explosive (CBRNe) emergencies | 1 |
| | Ebola | 2 |
| | Infectious Disease Epidemics | 1 |
| | Mass Casualty Incident | 3 |
| | SARS | 1 |
| | Infectious Disease | 5 |
| Training Format | In-person | 2 |
| | Online | 1 |
| | Mixed | 3 |
| | Unspecified | 9 |
| Training Method | Drill | 1 |
| | Exercise | 1 |
| | Exercise: Simulation | 2 |
| | Exercise: Tabletop | 2 |
| | Mixed | 1 |
| | Unspecified | 8 |
| Audience | Clinicians | 3 |
| | Emergency Departments | 1 |
| | First Responders | 1 |
| | Health Professionals | 1 |
| | Hospitals | 2 |

| | | |
|---|---|---|
| | Mixed | 2 |
| | National Health Service Employees | 1 |
| | Nurses | 1 |
| | Public Health Professionals | 2 |
| | Unspecified | 1 |

***G.2. Key Focus Areas and Findings***

Below are key findings from the 15 articles on training recommendations. They are divided into recommendations focusing on training content and recommendations focusing on training development and implementation.

1. *Training Content*
    a. *Unspecified Infectious Disease:* Four articles provided recommendations for unspecified infectious disease outbreak response;[25,29,34,59] three of which focused on identifying key competencies for infection prevention and control efforts.[25,29,34] Differing methodologies- including analysis by a national expert panel of first responders;[25] review and analysis of existing recommendations;[29] and a systematic review of literature, competencies, and objectives-[34] resulted in differences among the key competencies identified. Belfroid et al. identified 61 competencies across the following domains: "construction and maintenance of the outbreak preparedness plan; support for health professionals, patients and families; surge capacity; communication to the public, patients and families; coordination and collaboration; facilitators for implementation of plans; and new recommendations added.[25] Brouqui et al. segmented their recommendations for control of highly infectious pathogens by hospital department- e.g. recommendations specific to infection and control in an emergency department setting, in a pediatric setting, etc. Carrico et al. provided a list of seven competencies necessary for hospital-based healthcare workers.

        - *"Research and development of universal, bedside, reproducible, and transferable diagnostic tools are mandatory. Prompt reporting to the authorities is needed so that a rapid response can be organised. These measures should be accompanied by harmonised recommendations for the safe care of these unusual patients."*[29]

    b. *Mass Casualty Incidents:* Three articles focused on recommendations related to mass casualty incident response.[28,48,161] These recommendations were identified through multiple methods: a survey of nurse educators;[28] a questionnaire distributed to training centers;[48]

and a qualitative analysis of interviews of healthcare professionals.[161] Brannigan et al. found that training simulations were preferred over lecture, online, and video approaches for teaching mass casualty incident skills to nursing students. Walsh et al. recommends that trainings for healthcare professionals should be provided in a succinct manner to ensure that professionals are not overburdened by an unnecessary time commitment. Furthermore, trainings should be considered applicable across multiple disciplines and should be required for professionals at all levels, especially those in decision-making roles.[161] Evaluation of disaster training programs is critical to their success,[28] but experts have difficulty determining effective metrics to evaluate the effectiveness.[161]

- *"Preparedness-focused [health care coalitions] are logical forums for the education and training of a diverse subset of health care professionals, and they have already improved the capability of health care systems across the United States to respond to disasters."*[161]

c. *Ebola:* Multiple research methods were employed for identification of key recommendations from the two articles specific to Ebola response.[105,170] McQuilkin et al. summarized lessons learned from the U.S. academic medical support (AMS) provided in Liberia during the Ebola outbreak. Particularly relevant lessons learned include the need for increased collaboration between local responders and AMC professionals, and the deployment of AMC personnel with relevant experience in humanitarian and/or disaster settings.[105] Additional recommendations for collaboration were identified by Yeskey et al., who stressed the need for collaboration with stakeholders to address barriers related to responder health and the high rate of responder turnover.[170]

- *"[Academic medical support centers] have valuable resources to offer in humanitarian crises, including the ability to leverage funding and faculty members with expertise and experience in basic and clinical sciences."*[105]
- *"When the appropriate needs and resources align, AMCs, especially those with long-term relationships, can have a significant and positive impact on international humanitarian response."*[105]
- *"The first gap is the absence of a mechanism that integrates public health, medical, occupational health, and worker safety activities in a comprehensive approach that*

*incorporates key stakeholder perspectives and provides easy-to-follow risk-based guidance."*[170]

d. *All Hazards:* Claudius et al. evaluated the occurrence of medical errors during an all hazards disaster response drill to determine if the quality of patient care would be preserved during a disaster. Findings from the exercise show a lack of preparation for a disaster, evident by the increase in incomplete patient charts and overall decrease in patient care; leading to recommendations for standardized documentation and care for disaster response situations.[43]

   - *"Certainly, more standardization of documentation and care is required in the pediatric disaster setting. Prompts and algorithms have been found to improve care in areas of emergency medicine not related to mass casualty incidents."*[43]

e. *Bioterrorism; Public Health Emergency:* Lichtveld et al. implores disaster response professionals to incorporate lessons learned from the 2001 Anthrax attacks in bioterrorism training and planning efforts. One lesson learned was related to isolation procedures and the need for healthcare professionals to know when and how to implement these infection-control procedures.[95]

   - *"It is essential to know when and how to isolate or quarantine individuals or groups of people. In addition to practicing isolation procedures, public health organizations may need to direct the actions of others, such as requiring a suspected case to take body temperature twice a day…The public health and the medical community can be challenged with the need to impose restrictions on individuals while also trying to maintain necessary respect for the individual and his/her rights."*[95]

f. *Chemical, biological, radiological, nuclear and explosive (CBRNe) emergencies:* Linney et al. identified 10 key competencies to be included in future NHS training programs. These competencies are believed to provide the NHS workforce with awareness of potential threats and strategies to plan for and respond to CBRNe emergencies, manage resources, and use equipment properly.[96] Linney et al. also stresses the importance of debriefing after an emergency to identify gaps and improve planning and response efforts for future events.[96]

g. *Infectious Disease:* Reid et al. identified seven key guidelines for infectious disease response trainings: they should be competency-based, delivered through multiple formats, include skill-building, evidence based, provided by experts, evaluated, and should have a record keeping system built-in. The importance of evaluation was stressed, as training programs should be periodically evaluated to ensure that they are meeting the identified outcomes.[139] In terms of infectious disease epidemics, Lucey et al. recommends that "one health" be implemented in healthcare professional educational programs to ensure that the workforce can assess problems holistically.

| **Box 1: Guidelines for collaborative training efforts[139]** |
|---|
| 1. The training should be competency based<br>2. The training delivery methodology should be blended<br>3. The training should include skills-building opportunities<br>4. The training should be based on the best science available<br>5. The training should be delivered by subject matter experts and experienced trainers<br>6. The training should have evaluation criteria that were consistently used for evaluating content and delivery programs<br>7. Participant records should be kept in an accessible format |

h. *SARS:* Chan et al. tested modular nursing practice to determine if this approach would reduce the incidence of cross-transmission of infection in hospital settings. Increased patient and family education and awareness, healthcare worker hand washing, and increased focus on continuity of care were observed- but there was no observed decrease in cross-transmission with the modular nursing approach.[38]

- *"a supportive environment for nurses' sense of control over work demands is important to professional and personal growth and to humanistic care practices including good infection control."*[38]
- *"the clinical importance of continuity of care should be highlighted even in acute settings with high nurse-patient ratio. The long-entrenched culture of collegiality supports teamwork and ward efficiency, but geographical separation in a general ward setting would not support it."*[38]

2. *Training development and implementation*

a. *Standardization of methodology, definitions, and terminology:* Carrico et al. suggested standardizing elements of training programs across disciplines. Additionally, rapid response training programs should be competency based, as this is considered to be most effective in preparing healthcare workers to respond to disasters.[139]

- *"Ensuring that every hospital-based health care worker is competent to prevent infection transmission is an essential element for daily practice as well as during times of emergency. The competencies and terminal objectives can be used as a step toward ensuring the readiness of hospital-based health care workforce."*[34]
- *"Staff and advisors understood at the outset that the training had to conform to the developing trend in training in public health: the identification and use of recognized competency domains and the competencies within them. Conforming to this national movement (and established practice) would provide many benefits, including standardization, measurement of effectiveness, accountability and greater utility/applicability for organizations outside the FCPHP, including other national training centers, state agencies, and universities."*[139]

b. *Coordination between and among health professionals and stakeholders:* Three articles emphasized the need for increased coordination between healthcare workers (across multiple disciplines) and stakeholders (at all levels) to ensure disaster response plans are comprehensive and address multiple components of response.[25,161,170] Successful integration across disciplines and among stakeholders can be illustrated by the cooperation between AMC and local responders during the Ebola outbreak- where the AMCs provided local responders with subject matter experts and the necessary personal protective equipment (PPE) to respond to the 2014 Ebola outbreak effectively.[105]

- *"Working in coordination with other NGOs and stakeholders who are involved in the response is vital to avoid duplication or confusion. This collaboration can best be accomplished by integrating into the framework set out by national or international leaders (e.g., members of the local ministry of health or personnel from the U.S. National Disaster Management System)."*[105]

c. *Training of healthcare professionals across disciplines* Two articles specify the need to train all designated healthcare professionals across multiple disciplines.[25,170] Linney et al.

recognizes that training needs differ for different types of healthcare workers and suggests that healthcare workers are broken up into groups, based on their roles, for additional training after the initial, standardized rapid response training.[96] The concept of specialized training is supported by three other articles that explain rapid response training implementation is dependent on the audience and oftentimes also varies based on the subject, or type of incident healthcare workers are being trained to respond to.[29,34,48] Finally, rapid response training programs should be periodically evaluated to determine their effectiveness.[34,139]

- *"As the IPC competencies are translated and disseminated into educational programs and curricula, these training materials must be validated through a structured evaluation process that includes measurement of the behavioral change in the practice setting. In this way, educational content can be standardized to ensure maximum effectiveness."*[34]
- *"Each curriculum contained specific training outcomes and learning objectives that were competency based as the basis for evaluation."*[139]

d. *Cross-disciplinary training programs:* Multiple articles identified the need for rapid response training implementation across disciplines.[25,170] Lucey et al suggests that educational training programs take a one health approach in training as this approach is thought to help healthcare professionals understand "why epidemics occur when and where they do, and also how to respond, mitigate, and sometimes prevent them."[100] Walsh et al. emphasizes the need for risk reduction training programs to be incorporated into the curricula of all health professional schools.

- *"As the global population of both humans and animals grows in size, density, and proximity, the predictable potential effects of pan-epidemics could be devastating to human, animal, and environmental health. One Health can help provide an effective international antidote to such pan-epidemics."*[100]
- *"Ultimately, a system is needed that better enables the ongoing integration of disaster-preparedness education and training into the health care professions and facilitates the sharing of knowledge and expertise among HCCs across the country."*[161]

e. *Professional training programs* Brouqui et al. emphasizes the need for specialized training for health professionals responding to disasters.[29] Effective responders should know their role when responding to disasters, and be equipped with the competencies necessary to respond effectively.[95] Two articles call for an increase in training and structural implementations to prepare for disasters in hospital settings.[29,34] Of these articles, Carrico et al. specifies that these implementations should include methods to identify the knowledge and skills needed by healthcare workers responsible for responding to disasters, which are agreed upon by multiple stakeholders and regularly re-evaluated.[34] Furthermore, healthcare professionals should be trained in protection and control measures to ensure their health and safety during disaster response efforts.[25,170]

- *"Infection control, worker safety, and emergency management professionals need to be better connected to manage resources, consolidate guidance, and protect worker health and safety. End-users also require a mechanism to contribute to the development of local practice and policy and into the guidance issued by federal agencies."*[170]

f. *Training Methods:* A mixed methodology approach is recommended for rapid response training curricula.[139] Furthermore, this approach should place an emphasis on skill-building opportunities.[139] Simulation trainings and exercises were identified as the most effective rapid response training method for teaching the majority of skills needed for effective mass casualty event response.[28] Reid et al. suggests that all trainings be delivered by subject matter experts to ensure proper training content, but Brannigan et al. explains that subject experts are not always available to provide rapid response trainings in an educational setting.

- *"Staff and advisors were in agreement that the most effective training would be live-interactive workshops delivered on-site to the participants. However, to the extent practicable, distance learning technologies would be used prior to the on- site session to allow participants to obtain basic knowledge about the topic area to enhance the workshop learning experience… It was agreed that each of the on-site trainings should have activities that allowed the participants to practice and demonstrate the skills learned didactically."*[139]

- "*Based on findings of this study, nurse educators view simulation as an effective method for teaching MCI- preparedness skills. When compared to lecture, online education, and information transfer via video/CD, respondents indicated that simulation was the best method to teach most skills."*[28]

g. *Continuity of care:* Brouqui et al. emphasizes the need for the standardization of protocols for patients affected by disasters, to ensure their quality and continuity of care. For example, networks of care should be established and transmission reduction measures should be implemented across disciplines during infectious disease outbreaks.[29] Claudius et al. highlights the current deficiencies in the documentation and quality of care provided to pediatric patients, and stresses the need to develop guidelines for the standardization of care.[43] Furthermore, healthcare professionals should ensure that patient records are stored in an accessible format so multiple healthcare professionals are able to access patient information during disaster response.[139] Finally, additional research is needed for the development of universal and reproducible diagnostic tools for highly infectious pathogens.[29]

- *"These measures should be accompanied by harmonised recommendations for the safe care of these unusual patients.…Networking for the standardisation of procedures and the management of these patients is mandatory."*[29]
- *"In our institution, we have developed a number of complaint-based documentation and order sheets that include prompts and dosing suggestions for the most common mass casualty situations as a response to the findings of this study. However, a more streamlined approach that reaches all hospitals and all providers is currently one of our greatest needs in pediatric disaster medicine."*[43]
- *"Research and development of universal, bedside, reproducible, and transferable diagnostic tools are mandatory."*[29]

***Table 13: Training Recommendation Articles: Content Topics and Key Findings (n=15)***

| Citation | Content Topic | Key Findings |
|---|---|---|
| Belfroid et al. (2017)[25] | Infectious Disease | Experts selected 10 key recommendations essential for outbreak preparedness. |
| Brannigan et al. (2006)[28] | MCI | Nurse educators viewed simulation trainings as the most effective method for teaching necessary skills for mass casualty incidents. |
| Brouqui et al. (2009)[29] | Infectious Disease | Special infection prevention and control training should be offered to emergency department teams. |
| Carrico et al. (2009)[34] | Infectious Disease | Six key competencies were identified and further stratified by healthcare workers' role. |
| Chan et al. (2008)[38] | SARS | Modular nursing could be more effective than convention task-focused nursing during outbreak response, but additional research and long-term implementation are needed. |
| Claudius et al. (2008)[43] | All Hazards | Standardization of documentation and care is needed in the pediatric disaster setting to reduce documentation breakdown during response. |
| Delooz et al. (2007)[48] | MCI | Prehospital medical care and management were identified as priority training objectives for disaster medicine response to mass casualty incidents. |
| Froeschl et al. (2016)[59] | Infectious Disease | Identification of likely pathogen outbreaks by region can ensure proper distribution of scarce resources, increase laboratory capacity, and inform response planning efforts in LMICs. |
| Lichtveld et al. (2002)[95] | Bioterrorism; Public health emergency | Three competencies were identified as necessary for public health professionals to leverage existing legal and political policies and create lasting change. |
| Linney et al. (2011)[96] | Chemical, biological, radiological, nuclear and explosive (CBRNe) emergencies | Experts generated ten core training competencies designed to properly prepare healthcare works to respond to acute CBRNe exposures in a hospital setting. |
| Lucey et al. (2017)[100] | Infectious Disease/ Epidemics | The concept of one health should be incorporated into medical education curricula to promote collaboration between the U.S. and international organizations that have a one health approach. |
| McQuilkin et al. (2017)[105] | Ebola | Academic medical centers can provide LMICs with the necessary expertise and supplies to properly respond to epidemics, but this coordination should be properly planned and implemented to ensure that it does not hinder response. |
| Reid et al. (2014)[139] | Infectious Disease | The Center for Public Health Preparedness implements seven guidelines for effective training principles and practices for the public health workforce. |

| | | |
|---|---|---|
| Walsh et al. (2015)[161] | MCI | Disaster preparedness-focused healthcare coalitions can increase the capacity of the healthcare system and healthcare workers but need stakeholder support and engagement. |
| Yeskey et al. (2017)[170] | Ebola | There are currently no sustained training programs for infectious disease outbreak response, potentially due to an overall lack in funding, complacency, or disease-specific trainings that are not easily adaptable. |

## H. Discussion and Conclusions

### *H1. Overview*

This section summarizes and discusses some of the key findings from each of the four main types of articles (training implementation, training evaluation, training curriculum, and training recommendations). The section also offers some conclusions, with a particular focus on what insights this systematic review might offer to those tasked with conducting rapid response training for infectious disease outbreak in LMICs.

It is a general finding, across all types of articles, that most of the 160 publications came from and/or were focused on high-income or upper-middle income countries and that these differed in significant respects—in training content, format, and evaluation methodologies to name only a few—from the much smaller number of publications that focused on lower-middle and low-income countries. This disparity could be due to the fact that our search was limited to English, French and Spanish language publications.

Despite the disparities between higher income and lower income countries, it is our view that these differences are instructive, both in terms of what they say about the different levels of resources available, but also in terms of providing insights as to how best practices might be shared more broadly, despite the challenges faced in low resource settings.

### *H2. Training Implementation and Evaluation*

As noted, while infectious diseases with pandemic potential threaten all countries, our review found that high income and upper-middle income countries tended to focus training efforts more on complex emergencies, bioterrorism, and mass casualty incidents than on infectious disease outbreaks. In lower-middle and low income countries, on the other hand, infectious disease was the predominant focus of training implementation. As content focus differed, so too did training formats and methods, with more extensive and complex simulations and interactive exercises being used in locations with more resources. In terms of formats, training formats that have been implemented in high- and upper-middle income countries, such as virtual emergency departments and online modules, may also be highly useful in low-resource or rural settings.

Sustainability may be a crucial aspect to consider for organizations seeking to implement trainings, if local ownership of future trainings is a desired endpoint. In the training implementation literature, sustainability focused on fiscal questions, particularly in trainings implemented in in low-income countries. Five of the seven articles that cited the Field Epidemiology Training Programs (FETP) and Field Epidemiology and Laboratory Training Programs (FELTP) expressed concern about the programs' long-term sustainability.[93,124,107,113,117] To address this concern, Rwanda, Uganda, Zimbabwe, and West African FELTP programs proposed a diversification of funding sources,[07,113,117] and Lescano et al. present alternative trainings to FETPs in the Americas that are more cost-effective and shorter in duration.

Regardless of training format, content, or duration, adequate evaluation of the training is essential. A key best practice and recommendation from the evaluations literature was the need to establish a list of key outcomes, competencies and skills that would be tested in the evaluation process for prior to conducting the training.[8,82,116,143,169] This process can guide both the establishment of key competencies that evaluators can assess from participants, and the feedback that the administrators would like to receive from participants. While establishing a clear set of criteria to assess for in a survey was found to be effective when used in conjunction with trained observers, establishing structured, pre-set criteria for trained observers to score participants against was found to be a key best practice in limiting bias and more accurately measuring skill acquisition.[82,116,143] While pre-post evaluations provide the benefit of measuring improvement from baseline, post-only evaluation methods were helpful in acquiring feedback which would allow for improved training development.[9,18]

Out of the 83 evaluation articles, 15 recommended the need for re-trainings to retain key objectives just as knowledge of the specific issue, participant confidence, familiarity with protocol, and efficiency.[19,62] Studies varied in how often they recommended periodic re-trainings, but several tested skills after 6 months or 1 year.[2,156] Summerhill et al. (2008) recommended that skill retention began to decline after 1 year and that participants could benefit from refresher trainings.[156] Bank and Khalil (2016) cited that skills and confidence levels were retained by participants 6 months after the initial training and that these participants did not yet need a follow up training.[19] Ablah et al. (2008) noted that participants were able to retain information 8 months after the training period, but credited this to participants reporting that they used their acquired knowledge at least one time per week.[2] This finding suggests that re-training intervals should be considered in the context of how frequently the participants are

applying the knowledge or skills emphasized in the training in conjunction with the participants baseline level of knowledge prior to a training.[2,153]

### *H.3 Training Curriculum and Recommendations*

Rapid response training curricula have been developed and studied mostly in high income countries but increasingly in LMICs, usually in partnership with established international agencies. They vary widely in format, with some integrated into existing school or job training curricula and others provided as independent workshops, most of which are relatively short in duration, generally under 5 days. The most effective curricula involve a combination of didactic lectures and interactive exercises, with drills and simulation thought to be the most effective method of learning, although also the most logistically complicated and resource intensive. Curricula should be tailored to the location and background of the learners, and there should be a method of assessment to ensure the efficacy of the curricula.

A key training recommendation calls for the development of comprehensive,[34,96,170] competency-based,[139] multidisciplinary training programs[25,170] that are easily adaptable for specific disasters[2,4,6] and have clear outcomes that can be assessed and evaluated.[34,139] Having a comprehensive training program could improve response efforts in LMICs because it will increase their capacity through the transfer of knowledge needed to respond to a variety of disasters and emergencies. Additionally, an established training program will not be affected by fluctuations in disaster funding[170] thus ensuring that limited resources remain on current, pervasive health problems in LMICs rather than on the development of highly specific response preparedness planning.[59]

Froeschl et al. suggests implementing training programs and preparedness plans at all levels of the government to ensure appropriate and timely response. Additionally, development of “zonal profiles” would enable LMICs to prepare their disaster workforce to respond to likely pathogens, as familiarity with pathogens can inform preparedness planning efforts and standardized protocols.[59] Furthermore, increased cooperation among stakeholders, responders, healthcare professionals, and subject-matter experts will better inform preparedness planning efforts and ensure a coordinated response in a variety of settings.[59,105]

### *H.4 Conclusions*

Our systematic review of mostly English-language literature published since 2000 focused on a range of trainings, many of which might be categorized as “rapid response trainings” not necessarily because the

trainings themselves were rapid but because they focused on training personnel for rapid response either to infectious disease outbreaks, or to events such as complex emergencies, bioterrorism, and mass casualty incidents that could involve infectious disease outbreaks. Among our key findings are that there is a dearth of publications originating from and/or focusing on lower-middle income and low income countries. This is significant as one of the primary goals of the GHSA is to increase in-country capacity in LMIC settings to be able to respond to epidemics.[61] While it is not necessarily the case that a lack of publications on trainings means that such trainings are not taking place, limited documentation raises a concern both about the quality and standardization of such trainings and the extent to which lessons learned are being shared.

As to the trainings themselves, the evidence suggests that the most effective trainings include a combination of didactic instruction and hands-on practice and exercises, and that the training is of sufficient duration (including re-training) to allow for in-depth learning. While the metric of what is "sufficient duration" may vary, the literature supports trainings that cover multiple days, providing opportunity for learning of content knowledge, practice of skills, and evaluation of both knowledge and skills. Effective trainings also must include robust evaluation methods to measure both knowledge and skills acquisition. These evaluation methods may vary but, ideally, they should include some measure of baseline and endline knowledge and skills, which favors a pre-post evaluation approach (as opposed to post-only methods). Finally, attention needs to be given to the implementation and sustainability of rapid response training in low-resource settings. Methods that include virtual emergency departments and online modules offer promise for application in low-resource and rural settings, though proper evaluation and more research is needed to assess their effectiveness.

One of the 11 GHSA Action Packages involved a commitment to "maintaining trained, functioning, multi-sectoral rapid response teams." Such a commitment requires the development, implementation, and documentation of effective rapid response training in LMICs, utilizing well-structured curricula and integrated approaches to building knowledge and skills, and incorporating robust evaluation methods to measure effectiveness. Without such training in place, the global response to infectious disease outbreak will remain compromised and lessons learned from crisis to crisis will not be shared.

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