Developing Public Health Emergency Response Leaders in Incident Management: A Scoping Review of Educational Interventions

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Abstract

During emergency responses, public health leaders frequently serve in incident management roles that differ from their routine job functions. Leaders' familiarity with incident management principles and functions can influence response outcomes. Therefore, training and exercises in incident management are often required for public health leaders. To describe existing methods of incident management training and exercises in the literature, we queried 6 English language databases and found 786 relevant articles. Five themes emerged: (1) experiential learning as an established approach to foster engaging and interactive learning environments and optimize training design; (2) technology-aided decision support tools are increasingly common for crisis decision-making; (3) integration of leadership training in the education continuum is needed for developing public health response leaders; (4) equal emphasis on competency and character is needed for developing capable and adaptable leaders; and (5) consistent evaluation methodologies and metrics are needed to assess the effectiveness of educational interventions.

These findings offer important strategic and practical considerations for improving the design and delivery of educational interventions to develop public health emergency response leaders. This review and ongoing real-world events could facilitate further exploration of current practices, emerging trends, and challenges for continuous improvements in developing public health emergency response leaders.

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Introduction

Background and Rationale

Real-world public health emergencies and exercises have shown that public health leaders frequently fulfill critical incident management roles that differ from their routine job functions, a departure from what they know and do routinely. Coupled with limited time and resources, variable experience managing emergencies and inconsistent fluencies with incident management and coordination roles among leaders may adversely impact the overall effectiveness of public health emergency responses.

While training and exercise programs as educational interventions are commonly used methods for fostering and transmitting the appropriate emergency management knowledge, skills, abilities, and attitudes (KSAA) to the public health responder workforce, best practices in these areas remain undetermined. To address this challenge, we conducted a scoping review of existing literature to describe prevalent methods and opportunities to improve educational interventions applicable to developing public health emergency response leaders.

This scoping review's objectives aimed to (1) identify and summarize relevant peer-reviewed and gray literature that describes existing approaches, systems, methods, techniques, and/or modalities directly related to developing public health emergency response leaders; (2) identify and summarize key themes in existing literature of non-public health disciplines (ie, education/adult learning, military science, leadership studies, and crisis leadership/management) that can be applied to inform the development of public health emergency response leaders; and (3) describe emerging priorities and opportunities to improve the effectiveness of educational interventions for developing public health emergency response leaders. Specific assumptions regarding the focus and target audience of this review, as well as clarification of distinctions among commonly used terms, are included in the Methods section.

Methods

Assumptions and Definitions

Public health emergency response leaders, rather than personnel engaged in emergency response activities (eg, emergency medical technicians, first responders, health care professionals), are the intended focus and target audience of this review. This review is not intended to create, develop, or define leadership competencies or the content that comprise leadership competencies. In addition, we made the following distinctions in commonly used terms to clarify the parameters of this review.

1. Leader vs Leadership
   - *Leader*: individual(s) responsible for directing others and/or making decisions.
   - *Leadership*: specific competencies, skills, attributes, qualities, and actions pertaining to making decisions or directing, managing, or influencing others in the interest of achieving tactical or strategic goals.
2. Training vs Exercises
   - *Training*: imparting knowledge and skills to a target audience using 1 or more modalities (eg, didactic, online, just-in-time) for grasping and retaining imparted knowledge and skills.
   - *Exercises*: 1 or more modalities (eg, tabletop, functional, full-scale exercises) that provide participants with the opportunity to translate into practice the knowledge, skills, and abilities imparted/received during training.
3. *Attitude*: the acceptance and perception of effectiveness of training and exercise modalities. Attitude is also reflected by demonstrated receptiveness to participate in training and exercise activities and may be assessed (in part) by how well participants retain imparted knowledge, skills, and abilities, and translate these into practice.

Literature Source, Search Strategy, and Eligibility

Working with an informationist, we developed search strategies using consistent search terms and queried 6 English language bibliographic databases: Academic Search Complete, Education Resources Information Center (ERIC), Embase, Ovid MEDLINE, PubMed, and Web of Science. We also identified additional articles by manually searching the Defense Technical Information Center (DTIC).

Our search for relevant articles encompassed the following fields: public health; disaster medicine; education/adult learning; military science; leadership studies; and crisis leadership/management. The articles identified for this review were published between January 1990 and October 2017. Tailored search strategies for each database are provided in the Online Supplement.

Inclusion and Exclusion Criteria

We established specific inclusion and exclusion criteria with corresponding codes for this review (Table 1). Each article included in full-text review covered at least 1 topic related to existing practices in developing public health emergency response leaders through training (designated by inclusion codes T1-T4) and exercises (designated by inclusion codes E1-E4). As this may be viewed as an emerging discipline, we did not apply exceedingly rigid exclusion criteria to ensure that any evidence that could positively influence current practices is captured.

Table 1. Article inclusion and exclusion criteria with corresponding code

INCLUSION CRITERIA AND CODE
Training
1. **(T1)** Approaches, systems, methods, techniques, and/or modalities that apply to training public health emergency response leaders.
2. **(T2)** Best or promising practices from non-public health disciplines (ie, education/adult learning, military science, leadership studies, and crisis leadership/management) that may inform the training of individuals to serve as public health emergency response leaders.
3. **(T3)** Improvements and challenges for developing or delivering training geared toward leadership personnel competency development.
4. **(T4)** Novel methods, tools, and/or mechanisms for developing or delivering training programs.
Exercises
1. **(E1)** Facilitation of response leaders' and/or responders' preparedness through exercises.
2. **(E2)** Approaches, systems, methods, techniques, and/or modalities that pertain to the effectiveness of exercises in facilitating (1) retention of knowledge and (2) translation of imparted knowledge, skills, abilities, and attitudes into practice.
3. **(E3)** Identification of gaps in knowledge, skills, abilities, and attitudes among individuals preparing to serve as emergency response leaders through exercises.
4. **(E4)** Development of leadership characteristics through exercises. Includes metrics used to assess knowledge, skills, abilities, and attitudes demonstrated through exercise participation.
EXCLUSION CRITERIA AND CODE
1. **(R1)** Not in English.
2. **(R2)** Conference proceedings, meeting abstracts, or no full article for review.*
Note:
*In instances where conference proceedings or meeting abstracts serve as examples or are supportive of key themes, such literatures were cataloged in References.

Article Selection Process

The following process in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) guidelines was used to select articles for review (Figure 1).[1] Citations for all articles identified in this review were documented and organized using EndNote® (Philadelphia, PA, USA).

1. **Identification** – checked redundancy to maintain uniqueness of each article identified in the literature search
2. **Screening** – screened the title and reviewed the abstract of unique citations based on the inclusion and exclusion criteria to determine eligibility for full-text review. Each citation was catalogued by the article inclusion or exclusion criteria code(s) (see Table 1) described previously
3. **Eligibility review** – reviewed full-text articles to determine final inclusion or exclusion in the scoping review

Content Extraction

To identify key themes, 2 co-authors (YL and NNP) independently reviewed and conducted structured content extraction from each article captured for a full-text review, including a brief synopsis and keywords. Keywords were manually documented and included training and/or exercise approaches, systems, methods, techniques or modalities, learning theories, evaluation methods and outcomes (eg, pre-/post-educational intervention surveys on self-reported gains), leadership characteristics or strategies, tools, guidance,
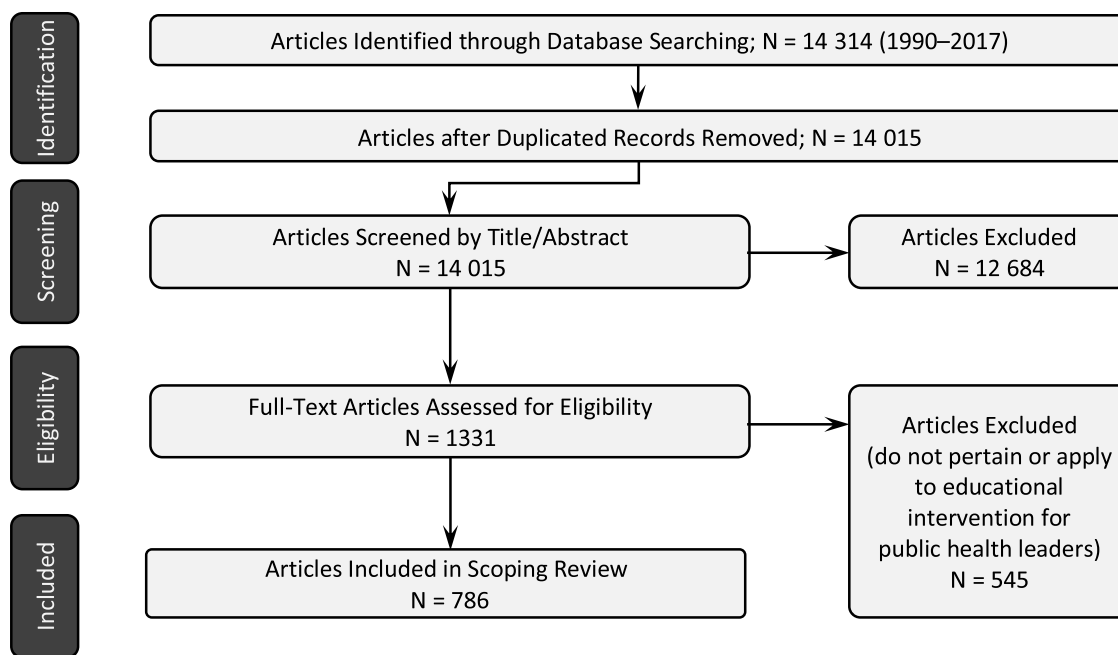
Figure 1. Article selection process.

Table 2. Articles included in the scoping review

DATABASE	UNIQUE CITATIONS	FULL TEXT REVIEW	FINAL INCLUSION
Academic Search Complete	329	141	54
DTIC	20	20	19
Embase	2730	277	66
ERIC	3672	111	24
Ovid MEDLINE	5344	484	388
PubMed	216	25	12
Web of Science	1704	273	223
TOTAL	**14 015**	**1331**	**786**

and needs in the context of – or potentially applicable to – developing leaders. The co-authors also examined the content extracted to identify and discuss emergent themes and achieve consensus surrounding representative articles for resultant themes.

Study Selection

Using the methodology described, we identified 14 015 citations (excluding duplicates) in the title/abstract screening stage. Subsequently, title/abstract screening enabled our review to narrow the list of articles to 1331 for a full-text review. Finally, 786 articles, predominantly descriptive and qualitative studies, met eligibility criteria following a full-text review (see Figure 1; Table 2).

Results

General Study Characteristics

We identified articles as meeting 1 or more of the inclusion criteria related to the major categories of training or exercise. Many articles fulfilled multiple eligibility criteria and frequently addressed both training and exercises.

Of the 786 articles included in the scoping review, descriptive and qualitative studies (n = 740, 94.1%) predominated. By contrast, quantitative studies (n = 46) represented 5.9% of the articles.

Across all databases, a significantly larger number of articles addressed training as opposed to exercises. Specifically, 675 articles pertaining to training met eligibility criteria (n = 675/786, 85.9%), whereas 234 articles addressing exercise methods met eligibility criteria (n = 234/786, 29.8%). In addition, 192 articles covered multiple training criteria (n = 192/786, 24.4%), 87 articles discussed multiple exercise criteria (n = 87/786, 11.1%), and 64 articles addressed both training and exercises (n = 64/786, 8.1%).

Delineating articles further by inclusion criteria and corresponding codes referring to specific topics in training (T1-T4) and exercises (E1-E4) (see Table 1), 285 articles (n = 285/786, 36.3%) described approaches, systems, methods, techniques, and/or modalities that may apply to training response leaders (T1). Two hundred twenty articles (n = 220/786, 28.0%) described best or promising practices from non-public health disciplines that may inform the training of individuals to serve as public health emergency response leaders (T2). One hundred forty-one articles (n = 141/786, 17.9%) focused on improvements and challenges for developing or delivering training geared toward the development of leadership personnel competency (T3). Finally, 195 articles (n = 195/786, 24.8%) highlighted novel methods, tools, and/or mechanisms for developing or delivering training programs (T4) (Table 3).

Among all articles included in this review, 87 (n = 87/786, 11.1%) reported on the facilitation of response leaders' and/or responders' preparedness through exercises (E1). Ninety-eight articles (n = 98/786, 12.5%) addressed approaches, systems, methods, techniques, and/or modalities that pertain to the effectiveness of exercises (E2). Another 86 articles (n = 86/786, 10.9%) pertained to identification of gaps in KSAA among individuals preparing to serve as emergency response leaders through exercises (E3). Finally, 48 articles (n = 48/786, 6.1%) focused on the development of leadership characteristics through exercises (E4) (see Table 3).

Table 3. Article statistics associated with training and exercise inclusion criteria

TRAINING	T1	T2	T3	T4	Multiple T	TOTAL
	285 (36.3%)	220 (28.0%)	141 (17.9%)	195 (24.8%)	192 (24.4%)	675 (85.9%)*
EXERCISE	E1	E2	E3	E4	Multiple E	TOTAL
	87 (11.1%)	98 (12.5%)	86 (10.9%)	48 (6.1%)	87 (11.1%)	234 (29.8%)*

Notes:
*All percentages are calculated using the total number of articles (N = 786) as the denominator; articles may address training, exercise, or both and can pertain to 1 or more subcategories within training or exercise, thus total percentages exceed 100.

Table 4. Frequency of keywords associated with each theme

KEYWORDS FOR EACH THEME *(NUMBER OF ARTICLES INCLUDED)*				
Experiential Learning	Technology Adaptation	Educational Continuum	Holistic Leadership	Evaluation Methodologies
Decision-making Skills *(170)*	Decision Support *(116)*	Training Design *(101)*	Leadership Strategies *(42)*	Evaluation *(89)*
Simulation *(159)*	Modeling *(72)*	Frameworks *(76)*	Guidance *(42)*	Effectiveness *(59)*
Training Design *(124)*	Virtual Reality *(10)*	Competencies *(71)*	Behavior/Behavioral *(34)*	Pre-/Post-intervention *(22)*
Gaming *(20)*	Augmented Reality *(3)*	KSAA *(55)*	Critical Thinking/Judgment *(22)*	Self-reported Gains *(18)*
Teamwork *(11)*	Online Format *(32)*	Curriculum Design and Development *(38)*	Adaptability/Flexibility *(17)*	Cost-effectiveness *(13)*
Interactive *(11)*	Distance Learning Format *(14)*	Multi-/Interdisciplinary Collaboration *(65)*	Non-technical Skills *(13)*	
Blended Learning *(7)*	Just-In-Time *(8)*	Academia *(44)*	Cognitive Skills *(13)*	
Problem-Based Learning *(7)*		Partnerships *(8)*	Emotional Intelligence/ Psychological Factors *(12)*	
			Teamwork *(11)*	
			Attitude *(7)*	

Thematic Findings

We assigned each article that met inclusion criteria 1 or more keywords that encapsulated the main themes identified in the article. These selected keywords formed subthemes; related subthemes were combined. From these, the following 5 themes emerged:

Theme 1: Experiential Learning – Incorporating Realism into Training and Exercises

Existing literature describes experiential learning as an established approach for designing and delivering training and exercise activities, specifically in supporting interactive learning environments. The objective of experiential learning is to provide learners with a realistic context from which to gain knowledge and develop skills. An important form of experiential learning is problem-based learning (PBL). In contrast to didactic learning, which emphasizes direct presentation of facts and concepts, PBL is a teaching method that conveys concepts and principles in the context of complex real-world challenges. Ideally, PBL encourages critical thinking, logical reasoning, decision-making, and teamwork. PBL tools such as scenario-based training, case studies, and serious/applied games facilitate the acceptance, retention, and application of KSAA. In addition, the growing utilization of modeling and simulation tools as mechanisms to augment the design, delivery, and dissemination of educational interventions and enhance realism in experiential learning supports this goal. The literature also discussed blended learning – the combination of traditional training methods and modalities (eg, information-based didactic delivery and learning) and experiential learning.

The theme of experiential learning is interwoven with numerous studies that highlight interactivity, case studies, hands-on decision-making, and teamwork as principal methods of training. Articles comprising this key theme focused on how to develop *decision-making skills* (n = 170)[2–171] under either realistic or *simulated* (n = 159)[6–8,17–20,22–24,30,37,38,40–42,52,53,56,59–61,70,72,73,76–79,83–88,91,97,104, 118,133,138,147,149,153,156,157,159,163,169,170,172–281] conditions (eg, exercises, virtual reality [VR] simulations). In accordance with experiential learning, many studies explored, developed, or tested unique *training design* (n = 124)[18,38,43,45,47,56,80,90,94,111,132,137,151,155,185,204,213,217, 221,236,239,246,249,254,270,271,282–379] or *gaming* (n = 20)[5,51,90,159,187,197,206, 222,234,238,249,259,274,280,289,341,380–383] while incorporating *teamwork* (n = 11)[51,143,182,268,272,308,384–388] *interactive* (n = 11)[111,115,143, 197,199,215,239,312,338,389,390] *blended learning* (n = 7)[6,391–396] and PBL (n = 7)[155,328,362,397–400] formats (Table 4).

Representative of this theme, Cesta et al. (2011) outline the necessity of fostering creative decision-making by developing engaging and realistic scenarios in support of experiential learning.[32] The resulting system developed supports trainers in incorporating exercises into 4- to 5-hour training sessions with exercises for classes of decision makers to practice in joint decision-making under stress. Yang-Im et al. (2009) point out the advantages of the experiential nature of large-scale exercises, including building trust among individuals and their respective organizations.[277] In addition, Setliff et al. (2003) describe several independent workforce initiatives (ie, the Sustainable Management Development Program, the Management Academy for Public Health, and the Leadership and Management Institute) at the US Centers for Disease Control and Prevention (CDC) aimed primarily at strengthening management and leadership capacity through interactive adult learning, with emphasis on interaction, decision-making, reflection, and application.[143] Furthermore, Stern (2014) speaks to the desire for well-designed training and exercises tailored to the needs of strategic leaders in order to develop and maintain critical problem-solving and communication skill sets.[401] Last, Wilson et al. (2014) describe the historical evolution of emergency training and elaborated on the advantages of a blended learning format of a 3-day course in the United Kingdom; the course used an immersive learning environment

(ie, "Hydra" Simulated Operations) to provide incident command training for civil emergencies.[375]

Theme 2: Technological Adaptation – Describing the Evolution from Human-Driven Leadership to Technology-Assisted Leadership

Technological adaptation has become increasingly common among decision makers. In particular, there has been a distinct evolution from exclusively human-driven leadership and decision-making to increasing the incorporation of technology-based aids and tools. In contrast to the previous theme in which modeling and simulation tools support and enhance the experiential learning environment, this theme describes technological solutions in broader terms as capabilities that support decision-making among emergency response leaders and the design, delivery, and dissemination of educational interventions.

Importantly, while existing literature demonstrated increasing utilization and growing acceptance of technological tools, this review notes the lack of definitive evidence on the accessibility, ease of use, and cost-effectiveness that can be generalized to recommend specific technological solutions for training, exercises, and decision-making during emergency response. In other words, evidence described in existing literature is primarily subjective based on user experiences, and the positive impacts of technological tools are still emerging. This observation underscores the need – also noted subsequently in Theme 5 – to develop methodologies and metrics that can be applied consistently across diverse learning environments to evaluate the effectiveness of educational interventions, including the impact of technological tools.

Descriptive studies, particularly from the engineering and computer science literature, highlighted technology in development and the utility of technological decision-support tools. Of note, both technology-aided *decision support* (n = 116)[2,7–12,17,26,29, 34,37,39,42,55,57,59,60,62,66,69,84,85,95,97,104,105,107,110,113,122,124,125,128,129,135,139–141,144,158,160,165,166,170,191,194,195,199,207,218,228,235,238,247,253,281,379,398,402–458] and *modeling* (n = 72)[17,22,23,25–27,46,48,53,54,57,62,70,72,73,76,86,88,91,116, 118,120,126,133,140,145,147,156,163,169,196,207–209,214,218–220,222,228,242,247,259,261, 288,406,408,411,414,415,418,428,431,453,458–475] represent a large proportion of technological advancements. Although many articles discuss simulation with reference to exercises, simulation was less commonly associated with technology-aided training. Furthermore, the definition of simulation in literature is not precise; it is often used interchangeably with – and in differing contexts ranging from – computer-based simulation to multiagency exercises. For this reason, simulation is not exclusively tied to technology. Nonetheless, a subset of articles shows clear linkages to technology, including those describing *virtual reality* (*VR*; n = 10)[229,236,246,260,278,287,307,315,319,475] and *augmented reality* (n = 3)[214,383,476] to support training design, delivery, and dissemination that make use of *online* (n = 32),[4,15,54,85,132,181,199, 222,234,333,372,374,390,424,433,477–493] *distance learning* (n = 14),[74,80,269, 394,466,481,484,486,490,493–497] and *just-in-time* (n = 8)[99,269,324,453, 477,478,498,499] methods (see Table 4).

The following representative articles further illustrate the subthemes of technological adaptation. Hsu et al. (2013) present a review of advents in technology-based approaches for disaster response training using VR environments, including the rationale and advantages of VR-based training.[315] Little et al. (2015) describe preliminary research to determine how emergency managers and other officials use decision support systems for natural disaster planning, response, and recovery.[445] This study aims to identify specific desirable system attributes and suggest areas for improvement. In addition, Santella et al. (2009) describe the utility of a modeling tool to aid decision-making for critical infrastructure protection.[140] This study presents capabilities of the Critical Infrastructure Protection Decision Support System (CIPDSS) model from the US Department of Homeland Security and describes the developmental challenges of such a model. Finally, Tena-Chollet et al. (2016) discuss the development of technology-based learning approaches and teaching strategies and describe a novel learning system that uses a semi-virtual training environment for strategic crisis management and decision-making.[159]

Existing literature also revealed a noteworthy trend in technology-aided decision support. Over time, an increasing number of articles highlighted the utilization of modeling, simulation, and other technological tools to support decision-making. Specifically, from 1993 to 2000, 10 articles pertaining to this topic appeared in the literature; from 2001 to 2010, 108 articles were published; and from 2011 to 2017, 145 were published on this topic (Figure 2).[3,4,8–10,12,13,15–19,22,23,25,26,30,34,36,37,40,41,43,52,53,56,57,59–64,66,69, 71–73,76–79,82–84,87,88,91,97,110,113,115,117,118,120,122,124,125,127–129,133,135,138–140,145–147,149,153,156–161,163,166,170,180–182,185–187,189–201,203,204,206,207,209–212,214,215,218,219,221–229,231–233,235,237–251,253,254,257–264,267–269,272–276,278, 279,281,287,305,307,315,319,344,364,369,379,381,383,391,399,403,404,406,408–415,418, 419,423,425,428–436,438,439,442–445,447–453,455–461,464,466,469,470,472,475,477,479, 483,484,488,491,494,496,500–532]

Theme 3: Educational Continuum – Incorporating Leadership Training in Public Health Academic and Professional Development Curricula

The educational continuum encompasses learning beginning with degree-granting programs and professional schools and progressing through postgraduate and workforce development (ie, on-the-job) training programs. Presently, public health leadership training primarily focuses on postgraduate or job-related training and varies widely in content and delivery. Integrating leadership training throughout the educational continuum will provide opportunities for developing future leaders systematically. As such, there is growing recognition that leadership training merits equal emphasis as traditionally accepted training priorities (eg, technical skills). The literature underscores the importance of the following:

- Curriculum development and training design that promote relevant learning and knowledge acceptance
- Multidisciplinary training that fosters an understanding of the interdependencies of decision-making across disciplines
- Training that emphasizes the standardization of core competencies in workforce development through existing frameworks or guidance
- Evolving educational priorities that address concerns and issues in the present academic and professional development environment

Educational elements for structuring leadership training as part of a systematic pipeline included *training design* (n = 101),[18,38,43,45, 80,90,94,132,137,155,185,204,217,236,239,270,271,283,284,286–292,295–302,304–312,314–316, 318–321,323,327,331–335,337,338,340,341,343–350,352–354,356–359,361–363,365–374,376, 377,533–542] *frameworks* (n = 76)[5,16,17,29,38,52,63,65,74,77,92,98,110,113,119, 153,159,168,171,177,179,197,200,220,292,296,299,334,357,363,387,388,404,415,436,443,466,521, 528,538,543–578] incorporating overarching principles or paradigms, *competencies* (n = 71)[79,94,201,251,252,272,274,283,289,304,311,312,314,335,340,348, 353,356,366,370,372,373,389,479,482,483,486,489,521,530,538,554,560,567,570,574,576,578–611] *KSAA* (n = 55),[93,132,206,211,233,239,248,254,275,276,285,291,296,302,331,335,338,361,
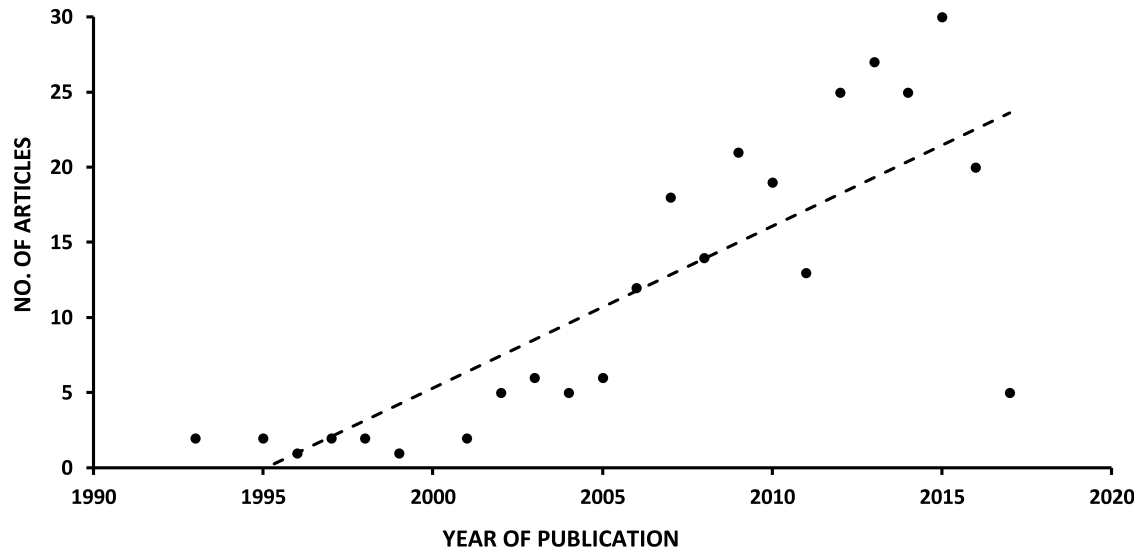
Figure 2. Chronological trend of articles pertaining to technology-aided decision-making or decision support through modeling, simulation, or other tools.

381,385–387,477,478,481,483,549,565,592,596,599,612–635 and *curriculum design and development* (n = 38).[6,74,93,217,252,270,286,308,312,370,386,387,389,391,521,548,549,558,573,587,588,598,635–650] In this context, multiple studies also addressed *multidisciplinary or interdisciplinary collaboration* (n = 65),[82,96,100,117,152,167,181,211,239,242,248,258,272,277,279,328,335,353,357,362,459,480–482,485,507,508,513,514,521,546,551,579,588,597,613,622,628,635,636,650–674] *academia* (n = 44),[4,89,100,139,143,206,217,242,300,302,309,331,332,390,428,480,481,484,485,490,521,538,545,565,581,582,588,597,623,644,649,662,665–669,675–681] and other *partnerships* (n = 8)[206,485,581,628,667,671,682,683] (see Table 4).

Existing literature supported the importance of integrating leadership training into the educational continuum. Specifically, Deitchman (2013) proposes a number of attributes for crisis leadership in public health, including competence in public health science; flexibility and decisiveness; ability to maintain situational awareness and provide situational assessment; ability to coordinate diverse participants across multiple disciplines; communication skills; and the ability to inspire trust.[684] The author notes that, among these attributes, only competence in public health science is currently a goal of public health education. In addition, Gebbie et al. (2013) describe implications of emergency preparedness and response core competencies for managing public health emergencies; and Walsh et al. (2012) discuss core competencies in disaster medicine and public health emergencies that may be adapted to inform the development of formal leadership training in the field.[624,685] Finally, Richmond et al. (2014) highlight the work of then CDC-funded Preparedness and Emergency Response Learning Centers (PERLCs) to enhance workforce readiness and competencies through schools of public health accredited by the Council on Education for Public Health.[567] While not specifically focused on leadership development, PERLC learning programs through an integrated national learning network emphasized the importance of linking academia with practice in public health education.

Theme 4: Defining Leadership Holistically – Developing Leaders through Competency and Character

Leadership competencies traditionally define the knowledge, skills, and abilities that an individual needs in order to lead successfully. In the context of developing future leaders, competencies provide the basis of and inform the key needs for leadership training.

Articles from this review revealed an emerging perspective that, in addition to technical competencies, the *character* or *soft skills* of an individual are critical leadership qualities. In the context of this study, leadership character serves as the *attitude* component of the KSAA construct and addresses the non-technical, cognitive, behavioral, and/or interpersonal skills of an individual. In other words, *how does a leader react, interact, or adapt in an environment through logical reasoning, critical thinking, and decision-making?* Several articles suggested that psychometric questionnaires might have value in predicting leadership styles among candidates who may serve in public health emergency response leadership roles.[49,50,97,382,399,608,686–688]

Studies under this key theme addressed *leadership strategies* (n = 42),[28,43,80,89,301,302,374,393,495,544,571,577,580,616,631,653,654,673–675,679,684,689–708] *guidance* (n = 42),[71,75,92,93,99,121,192,195,340,347,352,445,492,494,543,545,551,563,580,624,639,642,659,667,709–726] and *behavior/behavioral* (n = 34)[38,43,47,49,60,95,116,121,162,197,202,211,233,260,275,276,285,296,301,310,331,384,388,437,532,625–627,629,631,670,689,727,728] aspects of leadership as well as *critical thinking/judgment* (n = 22).[30,45,60,74,80,95,97,101,148,163,299,314,404,440,530,636,686,729–733] A subset of articles also elaborated on the *adaptability/flexibility* (n = 17),[20,21,49,79,150,208,301,385,386,646,650,660,730,734–737] *non-technical skills* (n = 13),[43,50,80,101,190,233,295,374,380,598,688,711,736] *cognitive skills* (n = 13),[10,20,47,49,79,168,216,301,437,501,609,688,738] *emotional intelligence/psychological factors* (n = 12),[30,116,162,206,437,452,455,592,616,690,707,739] *teamwork* (n = 11),[51,143,182,268,272,308,384–388] and *attitude* (n = 7)[285,385,488,617,618,625,635] aspects of leadership (see Table 4).

Representative of this key theme, Carone et al. (2013) identify critical factors to support effective crisis management by joining experiences in the field and knowledge of organizational models for crisis management and executive empowerment with coaching and behavioral analysis.[296] The study examines the relationships among human behavior, emotions, and fears, and how these correlated with decision-making. Hadley et al. (2011) use a novel Crisis Leader Efficacy in Assessing and Deciding (C-LEAD) Scale to measure leadership efficacy in order to assess information and crisis decision-making.[71] In addition, King et al. (2016) seek to elucidate important characteristics of disaster response personnel, including leaders.[590] The authors suggest that these characteristics are not limited to the knowledge and skills typically included in

disaster training and that further research is needed on how best to incorporate these attributes into competency models, processes, and tools for developing an effective disaster response workforce. Finally, Schmalzried et al. (2007) highlight that both experience and continuity of leadership (eg, preservation of institutional knowledge and other non-technical leadership attributes) are critical for managing public health crises.[740] This study also notes that, even though 43.7% of top executives reported planning to leave their current position within 6 years, succession planning is not a high priority among the majority of local health departments.

Theme 5: Evaluation and Measures of Effectiveness in Training and Exercises – Reflecting on Current Practices and Opportunities for Progress

Generally, existing standards for evaluation of training and exercises demonstrate ample room for growth as few articles pertaining to evaluation and assessing the effectiveness of training and exercises offer specific frameworks or tools. Even fewer evaluation tools are consistent or generalizable. Currently, the majority of evaluation instruments and measures of effectiveness consist of pre- and post-intervention surveys or interviews that document self-reported gains. The limited amount of measurable data presents a challenge to assess or compare the relative effectiveness or quality of educational interventions objectively and meaningfully.

As noted, the preponderance of literature included mostly descriptive and qualitative studies as well as narrative and informational articles with relatively few quantitative or data-driven studies. The literature broadly discussed topics of *evaluation* (n = 89)[6,18,27,77,132,156,205,208,230,239,244,250,254,287,298,305,325,354,371,385, 389,455,475,479,488,489,500,514,539,547,558,565,569,579,584,588,599,601,612,613,622,623,625, 628,630,633,635,637,638,652,667,710,732,741–776] and *effectiveness* (n = 59),[42,79, 132,137,150,151,156,185,186,189,190,193,211,224,230,231,237,250,273,275,277,284,290, 295,333,352,365,385,389,392,455,459,489,531,539,565,581,599,603,613,620,623,633,637, 649,658,701,715,732,749,761,772,777–783] with respect to educational interventions. Despite this, very few studies included quantitative assessments. Most studies addressed evaluation and effectiveness with respect to *pre- and post-intervention* (n = 22)[181,287, 305,479,488,500,558,565,599,601,612,613,622,623,628,630,633,635,652,757,768,784] and *self-reported gains* (n = 18).[58,239,298,365,386,480,481,488,500,523,531,614,623,652,679,680, 768,785] Few studies addressed the topic of *cost-effectiveness* (n = 13) [18,179,190,237,259,271,274,390,480,493,652,786,787] (see Table 4).

A number of representative articles supported these observations. In an exploratory study on disaster exercise evaluation, Beerens et al. (2016) indicate a general lack of academic interest for standardized evaluation; the study pointed out that, while exercises take place routinely and are often used for research purposes, their evaluations are seldom the focus of attention.[710] As an extension, Gebbie et al. (2006) emphasize that consensus-based and public health-specific planning and assessment criteria are necessary to facilitate measurable improvements.[752]

While scant, literature pertaining to evaluation and measures of effectiveness in training and exercises includes a small selection of notable articles that suggest steps for improvement. For example, Biddinger et al. (2010) describe an evaluation of 38 public health emergency preparedness exercises employing realistic scenarios and reliable and accurate outcome measures.[778] This study notes a demonstrated utility of these exercises in clarifying public health workers' roles and responsibilities, facilitating knowledge transfer among these individuals and organizations, and identifying specific public health systems-level challenges. In addition, Hites et al. (2010) identify what constitutes quality in public health

emergency preparedness training and proposed guidance to practitioners in selecting training packages.[661] This study describes the development and selection of guidelines for suitable high-quality courses.

In addition, Miller et al. (2007) describe a unique study that attempted to link specific learning methods of a public health leadership development program with participant outcomes.[331] This study finds that learning projects were strongly associated with developing collaborations, whereas assessment tools and coaching were most often associated with increased self-awareness. Potter et al. (2010) examine the evidence base for preparedness training effectiveness and consider whether past experience could help guide future efforts to educate and train public health workers in responding to emergencies and disasters.[347] This study concludes that reviews of progress in preparedness training for the public health workforce should occur regularly and that governmental investment in preparedness training should continue with future evaluations based on measurable performance improvement. However, Savoia et al. (2013) find limited analysis on what makes an exercise an effective tool to assess preparedness.[772] This project aims to achieve consensus on (1) attributes that make an exercise an effective tool to assess preparedness and (2) elements that make an after action report an effective tool to guide preparedness improvement efforts. In a separate article, Savoia et al. (2014) determine that evaluation of simulated emergencies has been historically inconsistent, and little research exists to describe how data acquired from simulated emergencies actually support conclusions about the quality of the public health emergency response system.[569] This article proposes a conceptual framework to measure system performance during emergency preparedness exercises.

Discussion

This discussion frames the 5 themes identified as subjects that hold long-term strategic significance (ie, an educational continuum that extends to a foundational educational framework and a holistic perspective on leaders) and as areas that merit consideration for practical implementation through formative training and exercise programs.

Theme 1: Experiential Learning – Incorporating Realism into Training and Exercises

Lessons learned from real-world events and exercises have frequently served as the premise for establishing training priorities. While traditional instructional design entails passive learning, training design has evolved to incorporate active learning formats that not only provide students with opportunities to apply individual competencies for translating KSAA into actions, but also reflect on the outcomes of their actions to identify training needs and priorities.

Experiential learning serves as a prominent example of active learning for public health emergency response training. It allows students – or leaders in the context of this review – not only to apply leadership competencies to make incident management decisions or react/adapt to fluid emergency conditions, but also to evaluate the effectiveness of their decisions in minimizing adverse outcomes of an incident within context (eg, austere environments). In other words, the design and application of experiential learning for developing incident management leaders can

be particularly impactful given the low-probability but high-consequence nature of public health emergencies and disasters.[603]

In the context of experiential learning to facilitate immersive and context-specific learning environments, educational games and simulation enhance training and exercise design and conduct as well as the assessment of technical competencies and personnel readiness in disaster medicine.[19,249–251,289] For example, the Uniform Services University of the Health Sciences developed a military medicine training curriculum that consists of low-, mid-, and high-fidelity simulations as experiential learning tools to emulate combat field conditions.[217] To standardize disaster medical assistance team training, the Australian Medical Assistance Team training incorporated extensive immersion training and exercise activities to assess personnel readiness.[648] In addition, modeling and simulation tools augmented VR training for Ebola virus disease management in health care settings, immersive simulations for pandemic influenza preparedness training, and incident management training for decision makers.[131,159,259,349]

In application, the effectiveness of experiential learning relies upon the design (focusing on the learning environment) and delivery (focusing on the learner) of the educational intervention (ie, training and exercises). Specifically, employing PBL as a learning theory in training design provides a structured framework that facilitates data-driven and context-specific (eg, case-based scenario) analytical thinking to achieve learning objectives. With continuing advancements in and growing adaptation of technological innovations for training delivery, modeling and simulation (eg, disease propagation models, VR) add realism, context, and the perspective of austere environments to enhance the learner experience.[155,217,362] In conjunction, application of structured learning theories and technological tools extends experiential learning as a meaningful practice for reinforcing KSAA among training and exercise participants. For example, various disciplines have used PBL to provide emergency manager training for decision-making under stressful conditions, ranging from managing severe weather events to responding to bioterrorist attacks.[155,362]

While there is tremendous value in experiential learning, this discussion does not discount the merit of passive learning through traditional instructional design (eg, classroom-based learning). While it does not entail an active participatory role among students, passive learning has established value in communicating new and vast quantities of information to large audiences. In the context of developing public health emergency response leaders, this discussion also recognizes the combined benefits of experiential learning (active learning) and traditional instructional design (passive learning) as an extension of blended learning to aid individuals in translating leadership competencies gained in a classroom setting to practical actions through context-specific or simulated environments. For example, in modernizing the military's pedagogical methods for specialized unit training, the US Army adopts blended learning to integrate traditional instructional design and technological solutions to provide context-specific training.[395]

Implications for the Public Health Community

While there can be tremendous value in experiential learning for public health departments and agencies across multiple levels of government, the practicality of developing such educational programs is a function of its demand across the public health community. Collaboration among federal, state, and local public sector partners can reduce the resource burdens associated with independently developing and implementing experiential learning

products and materials. Beyond collaborative efforts within the public sector, interdisciplinary and external partnerships with academia may be considered to develop joint experiential learning programs (eg, shadowing programs to observe emergency operations center [EOC] activities).

The overarching implications of experiential learning on the public health community culminate with 2 key considerations. First, the scalability of existing experiential learning programs will dictate various public health departments' or agencies' ability to adopt, scale, and tailor these concepts, approaches, or processes for organizational or jurisdictional purposes. Second, as resource commitments rise with increasing complexity, recognizing the context of, need for, and resources accessible to develop, implement, and sustain experiential learning programs will be critical to their success.

Theme 2: Technological Adaptation – Describing the Evolution of Human-Driven Leadership to Technology-Assisted Leadership

Fluid crisis conditions require flexible and informed decision-making among emergency response leaders. The advent of and perpetual advancements in technological innovations have transformed crisis decision-making in recent years. While the emergency management community has increasingly embraced technological tools (see Figure 2), the capabilities of such tools have also expanded. For example, computer- or web-based tools that originated with information capture, presentation, and dissemination for maintaining situational awareness (eg, WebEOC, geographic information systems [GIS]) have evolved into complex decision support systems that encompass modeling and simulation capabilities to help decision makers plan for, respond to, and recover from disasters. Existing literature described decision support systems as a broad spectrum of technological innovation and tools, ranging from spreadsheet-based tools to commercially available software platforms. In the context of emergency response and crisis management, the recent transformation of crisis decision-making through the expansion and advancements in technology-aided decision support tools encompasses data integration platforms as well as sophisticated modeling and simulation capabilities to inform incident management decisions. For example, a seismic damage estimation case study in Canada integrates GIS and a specialized seismic risk assessment tool to provide the basis for identifying vulnerable areas and supporting risk management decisions.[285] A diverse range of smartphone applications from public and private sector entities provides emergency notification, public information, and data visualization capabilities to support disaster and emergency response.[409] In addition, a policy informatics system using a simulation-based model integrates information from multiple data sources to support decision-making at the strategic and policy levels.[410]

The growing adaptation of technology-based decision support tools also includes simulation-based resource modeling for public health preparedness and response, logistics support in humanitarian assistance, GIS-based spatial decision support, situational awareness for incident managers, and data mining and aggregation through social media platforms.[18,127,147,158,227,235,264,418,434,507,522,600]

Reflecting on the growing trend in technological adaptation that may be attributed to the emergence of technological innovations and increasing output in literature over time, the evolution of human-driven to technology-assisted leadership has considerable implications on (1) research and development of technological

tools for crisis management, (2) training on the proper and practical application of technological tools in crisis management, and (3) technology-aided design and delivery of educational interventions (ie, training and exercises), in general.

Decision support systems can inform decision-making in crisis management. As decision makers react and adapt to changing crisis conditions, decision support systems can provide these leaders with modeling or real-time data to inform incident management decisions. In addition, given the technical capability to simulate incident management decisions, decision support systems can allow decision makers to evaluate the outcome of those decisions before implementing them. In this respect, the role of decision makers or leaders is critical in the research and development (eg, assess needs, identify capability requirements, develop/improve user-interface), testing, revision, validation, acceptance, and deployment of new or existing decision support systems.[223,699]

The growing prevalence of decision support systems, including through modeling and simulation support, is a prominent example of the technology-aided leadership approach. In parallel, technology-aided training design and delivery play an important role for developing public health emergency response leaders. Evident in training and exercises across multiple disciplines, technology-aided training design and delivery have a proven record in distance learning, self-paced learning, and interactive learning through web-based or mobile platforms, as well as in audio or video formats, particularly in reaching larger audiences. Technology-aided training programs are not only appropriate for customary workforce development programs, but also valuable for just-in-time-training during emergency responses. Notably, this review showed that the incorporation of technology in training and exercise activities in the context of developing public health leaders is promising but comprised only a relatively small portion of articles focused on the impact of technology. As such, the evolution of human-driven leadership to technology-assisted leadership centers on the increasing trend and ubiquity of technological tools to support decision-making. In other words, while evidence of the positive impact of technology is emerging, the preponderance of literature does not provide definitive and generalizable evidence.

Recognizing the value of technology-based tools and technology-aided training programs, the authors also acknowledge the potential limitations of technological innovations. Decision makers or leaders should not rely solely on their modeling and simulation capabilities to inform incident management decisions. Rather, decision makers or leaders should concede the unpredictability of real-world incidents and react or adapt incident management decisions to fluid emergency conditions.

In the context of this study for developing public health response leaders in incident management through educational interventions, achieving the true potential of technological innovations and adaptation requires the integration of pedagogy and technology.

Implications for the Public Health Community

Ease of use, accessibility, and economies-of-scale of technology in decision support and training may hold promising advantages; but, to date, these potential benefits have not been well-studied or described. As previously noted, existing literature does not provide definitive and generalizable evidence on the positive impact of technological solutions but rather suggests an increasing trend in their use and adaptation. Comparable to appreciating the value and challenges of

embracing experiential learning, the limiting factors for technological adaptation in the public health community are limited resources and technical capabilities.

Overall, although technological innovations and adaptations may have considerable value for training leaders and supporting informed incident management decisions, realizing their true potential requires a conscious effort to evaluate their utility in operational environments, which, as alluded to earlier, depends on their end users' experience and feedback for continuous improvement. In addition, as current evidence on the positive impact of technology is emerging and subjective based on user experience and adaptation, further objective research and evaluation on both the growing consumption and the effectiveness of technological solutions are necessary to provide definitive recommendations on technological implementation.

Theme 3: Educational Continuum – Incorporating Leadership Training in Public Health Academic and Professional Development Curricula

The educational continuum represents the continuous process of learning, which starts with degree-granting programs and professional schools and proceeds through continuing, on-the-job training. Currently, most leadership training leans toward postgraduate or job-related training.[116,309,490,662,678] Examples of job-related leadership training include the Public Health Leadership Institute, a program designed to expand and enhance the leadership skills of senior public health officials,[678] and a distance learning series of current preparedness topics delivered via a synchronous web-conferencing system by the Northwest Center for Public Health Practice at the University of Washington. In contrast, fewer examples of leadership training take place earlier in the educational continuum during formal schooling.[338,681]

The process by which future leaders gain competencies must be developed and reinforced throughout the educational continuum in a systematic manner. Currently, training is often developed in response to urgent needs rather than derived from established competencies.[269,324] Integration of leadership training throughout the educational continuum would lead to increased standardization, ensuring that future leaders acquire leadership skills systematically. Targeted leadership training should also be incorporated at all levels. Completing training at leadership institutes (eg, National Public Health Leadership Institute) promotes collaborative leadership and building knowledge-sharing and problem-solving networks.[669]

The literature also highlights the value of multidisciplinary training.[6,485,622,664,666,670] As public health emergency response requires extensive cooperation and coordination, often involving multiple disciplines and diverging perspectives, multidisciplinary training can help identify coordination challenges and potential solutions that a single discipline or area of focus may miss or narrowly address. As such, understanding the interdependencies of multidisciplinary decision-making is critical to the success of public health emergency response leaders.[670]

Collaborative partnerships among governmental agencies, academia, and industry continue to emerge. These affiliations are a driving force in developing future training to meet evolving leadership needs (eg, develop a better understanding of the role of technology in leadership decision support and decision-making). For example, CDC-sponsored PERLCs focused on the development, delivery, and evaluation of targeted learning programs for enhancing workforce readiness.

Those who serve in leadership positions bring considerably different levels of prior training and experience to the task. Newly designated leaders in the public health emergency response context may lack critical KSAA to perform effectively. Similarly, these individuals may lack the relevant KSAA to manage numerous individuals and large organizations effectively during a response.

While leadership training is an essential element of public health workforce development, systematic efforts to interweave leadership training specifically geared for public health emergency response vis-a-vis traditional training or educational curricula have not widely occurred. Public health leaders put to the test during crises have shown that subject matter expertise alone does not necessarily correlate with effective leadership. Accordingly, public health practitioners who may fulfill leadership roles or positions in public health emergency response should engage in leadership education and training throughout their entire educational continuum, starting with public health academic degree programs.

Establishing a blueprint (eg, beginning with foundational disaster preparedness and management concepts and culminating in advanced methods to manage complex and multidisciplinary responses) for developing future leaders in public health emergency response increases uniformity of training practices and consistent translation of KSAA into decision-making practices. Such an educational framework can aim at (1) building and refining comprehensive curricula suited for leaders from the earliest stages of career development, (2) incorporating the curricula into formal academic programs, and (3) integrating the curricula with specific job-related training for public health emergency response leaders.

Implications for the Public Health Community

Leadership training among workforce development programs varies widely across the public health community. To address this challenge, the public health community generally recognizes the need for incorporating leadership training at all phases of the education continuum, especially public health leadership geared toward disasters and emergency response. Initiatives such as PERLCs located within accredited schools of public health serve as examples of how leadership training supported by government and academic partnerships can suitably leverage opportunities for learning. These centers incorporated leadership training into educational curricula as they prepared the next generation of leaders to face current and emerging public health threats. Public health departments and agencies across state and local governments often express significant interest in leadership training and stand to benefit considerably from such initiatives. However, competing priorities and resource constraints in developing or implementing new or revised workforce development programs present important barriers. Therefore, engaging academic partners to leverage existing leadership training for integration throughout workforce development programs may be 1 approach to overcome such barriers.

Theme 4: Defining Leadership Holistically – Developing Leaders through Competency and Character

Technical competencies among responders are an implicit requirement of public health emergency response. At the same time, the fluidity and/or austerity of emergency conditions often demand leaders to work outside of their comfort zone, thus requiring adaptability and flexibility to make incident management decisions that correspond to the present operational environment.[386]

Traditionally, technical competencies achieved primarily through specialized education and levels of experiences have encompassed leadership. Recognizing this established approach, the authors also believed that existing literature presented an emerging perspective on leadership traits that places equal emphasis on the *character* or *soft skills* of an individual.[47,49,50,359,738]

Increasingly prevalent in military strategies and emerging leadership studies, existing literature suggests that character encompasses personality (eg, resiliency under stress), cognitive abilities (eg, analytical thinking, problem solving, decision-making), and interpersonal skills (eg, communication, receptiveness of diverging views).[47,382,399,608,646,736] In the broad context of crisis management and emergency response, these traits comprise the emotional intelligence of leaders and enable them to apply technical competencies and adapt to external environments.[116,570]

Recognition of competency and character as the defining traits of leaders stands in contrast to the traditional emphasis on technical competencies for leaders. Application of established educational models or approaches is valuable for developing the competency and character of public health emergency response leaders in incident management.

As discussed in Theme 1, experiential learning, particularly with the aid of modeling and simulation tools, may also allow students to develop character collaboratively by applying personal qualities and exercising cognitive and interpersonal skills, as well as identifying potential individual deficiencies among these traits.

In addition, to serve as public health emergency response leaders in incident management, position descriptions specify the required technical or domain-specific competencies (eg, epidemiology, infectious disease). However, there is limited evidence to support standardized instruments specific to measuring leadership character traits in public health emergency response.

This discussion extends to the challenge in selecting leadership candidates, specifically based on the need for specific character traits. In the context of military leadership studies, existing literature discusses the potential utility of structured psychometric assessments (eg, Myers-Briggs Type Indicator® [MBTI®]).[382,603,687,688] Although there is value in such tools for *recognizing* personality types, this review infers that the suitability (eg, costs, potential bias for or against certain personality types) of using such assessments as *indicators* of leadership character traits, *predictors* of performance, and *selection criteria* for leaders warrants further examination. For public health emergency response, a framework for character traits among incident management leaders may be considered. Specifically, this leadership character framework may describe the relevant traits as a career maturity process through which individuals can develop these traits from a combination of domain-specific education tailored to and experiences from serving as incident management leaders.

Implications for the Public Health Community

The competency and character of incident management leaders are critical to the success of public health emergency response, especially at the local level where all responses originate. In addition to recognizing the importance of character as a leadership trait, public health departments and agencies across multiple levels of government may collaboratively identify and reach consensus on the elements that constitute leadership character specific to public health emergency response.

Such collaboration can establish a baseline reference by describing possible dimensions or exhibitive behaviors that are

appropriate for identifying or gauging leadership character; this baseline may be expanded through continuing partnerships across multiple levels of government and with other public health community partners and stakeholders with incident management roles. To aid in the identification of individuals to serve in leadership positions, consensus on the appropriate instruments, tools, or processes for assessing or gauging character is also vital to developing a leadership character framework.

Theme 5: Evaluation and Measures of Effectiveness in Training and Exercises – Reflecting on Current Practices and Opportunities for Progress

A critical finding from this scoping review is the relative weaknesses in evaluation and measures of effectiveness of training and exercises. Although many articles broadly touched upon the topics of evaluation and effectiveness, relatively few incorporated actual evaluations; even fewer still incorporated formal measures of effectiveness.[500] Except for a few notable articles, there was limited discussion of adaptable frameworks, specific instruments, or processes that may be applicable to consistently evaluate and measure effectiveness of training public health emergency response leaders. In particular, a glaring absence was the lack of discussion on cost-effectiveness, as only a handful of studies referenced distance technology, computer simulation, and gaming technology as potentially cost-effective training options.[237,274,480]

In addition, the majority of literature from this review included mostly descriptive and qualitative studies, narratives, and informational articles; and the predominant form of evaluation included self-reported gains and pre- and post-intervention surveys.[256,298,592,612,613,622,630,750,768] There were relatively few quantitative or data-driven studies.[37,479] Moreover, very few articles reported directly on real-world responses as many of the informational articles on this topic, by nature, did not involve study design but were included by the reviewers as a reflection of the emerging nature of this key theme. While not to detract from the clear value of this body of work, it does demonstrate the tremendous degree of difficulty in performing, documenting, and disseminating the results of meaningful evaluation, especially those taken from real-world events, in a manner that can objectively inform future training and exercises.

The heterogeneity of training and exercise designs further limits the ability to generalize conclusions regarding effectiveness. In other words, when training or exercises activities are not developed systematically or structured from well-established competencies with clearly defined learning objectives and success criteria, efforts at evaluation prove difficult. Without formal evaluation processes, assessing the effectiveness of training and exercises is challenging at best and limited in scope. While qualitative evaluation may inform the prospective design of training or exercises, these assessments are highly subjective in nature, especially in the absence of metrics. For example, discrepancies in the implementation of the current exercise evaluation process (ie, Homeland Security Exercise and Evaluation Program) call for consistent and systematic evaluation metrics to assess leadership performance in this context.

The sparse number of studies involving quantitative analysis of real-world response highlights the complexities of performing meaningful evaluation or developing measures of effectiveness. To address this challenge, automated information collection and pre-positioned methods for data capture coupled with dedicated resources for post-event analysis may yield critical insights for future responses and training. In addition, comparative studies of cost-benefit analyses for various types of training and exercises may also be an important area for further exploration.

Implications for the Public Health Community

The lack of consistent evaluation and measures of effectiveness in training and exercise has significant impacts on the broader public health community. For example, descriptive articles identified in this scoping review have suggested that technology-aided exercises may be more cost-effective than full-scale exercises. While this may be true on a jurisdictional or organizational basis for practical exercise planning, execution, and evaluation, there is no evidence derived from true cost-benefit analyses to demonstrate the effectiveness of technology-aided exercises in comparison to full-scale exercises. The lack of quantifiable metrics to demonstrate the effectiveness of training and exercises, in general, leads to uncertainty as to the appropriate training programs to implement for developing public health emergency response leaders. Additionally, the absence of consistently-used metrics and limited evidence pertaining to training and exercise effectiveness largely precludes conclusive recommendations on best practice methods for implementation.

Strengths and Limitations

This scoping review describes the landscape of educational interventions that applies to developing public health emergency response leaders in incident management. Strengths of this review include analyses of relevant articles not only in public health practice, but also in additional disciplines (see Methods) to glean applicable content that may benefit the development of public health emergency response leaders through educational interventions. To recognize trends in relevant professional development opportunities, this review considered a broad range in publication dates between January 1990 and October 2017.

Reflecting on the broad time parameter and diverse disciplines that comprised this review, 1 limitation relates to existing literature encompassing the broad and liberal use of the term *best practice* to describe educational practices that may be successful, effective, preferred, or promising. As such, the precise meaning and objective measures to classify educational *best practice* warrant further exploration. In addition, relevant articles published since the original time-parameter used in this review were not considered. Finally, articles included in this review were focused primarily (85%) on the United States, so insights gathered from this review may not apply fully in international contexts, particularly in nations where public health preparedness and response systems and capabilities are not structured comparably as those in the United States.

Conclusion

Readiness among leaders, especially those who may be required to fulfill incident management roles that differ significantly from their routine job functions, is critical to the success of public health emergency response missions. This review aimed to understand the landscape for developing public health emergency response leaders in incident management. Specifically, we intended to elucidate existing and desired practices as well as opportunities to improve training and exercises as vital educational interventions. Key themes synthesized through this review highlighted preferred educational models and approaches, a growing trend in technology-assisted leadership as well as the need to develop a

foundational education framework, to define leadership holistically with equal emphasis on competency and character, and to develop consistent and systematically apply assessment methodologies and metrics to measure training and exercise effectiveness.

Since developing and sharing incident management KSAA specific to public health emergency response leaders is an emerging discipline, it is important to note that not all existing practices have necessarily been published or widely disseminated. Therefore, further exploration of prevalent professional development opportunities should be considered to augment the findings of this review, specifically to identify other innovative or novel approaches in training and exercises, emerging trends or patterns across the public health community, and challenges faced by public health emergency response leaders and practitioners.

Building upon identified key themes, leadership experiences from recent real-world events or incidents may also be considered for future research, particularly those that have occurred or have been published since the time parameter of this review. In particular, the ongoing coronavirus disease (COVID-19) pandemic, an unprecedented and significant public health emergency with severe and adverse global health and economic impacts, may provide valuable insights on critical needs for successful public health emergency response, as well as requirements for capable leaders to manage public health emergency response effectively and efficiently. As the novel COVID-19 pandemic continues to evolve, the public health community's fluid, prolonged, and multidisciplinary response may highlight and inform the prioritization of critical competencies (eg, crisis risk communication, disaster mental health), character needs (eg, stress management, decision-making), and practical educational approaches (eg, pedagogical design and delivery methods) that may enrich the development of capable and adaptable leaders for managing future public health emergencies.

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