Public Health Emergency Operations Coordination: Qualitative Research Evidence Synthesis

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Commissioned by the National Academies of Sciences, Engineering, and Medicine,
Committee on Evidence-Based Practices for Public Health Emergency Preparedness and Response

Date: February 12, 2020

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1.0 INTRODUCTION

The National Academies of Sciences, Engineering, and Medicine (National Academies) Committee on Evidence-Based Practices for Public Health Emergency Preparedness and Response (PHEPR) commissioned a systematic review and synthesis of existing evidence to support the creation of guidelines for prioritizing public health preparedness and responses capabilities as developed by the Centers for Disease Control and Prevention (CDC).

The synthesis of evidence presented in this report addresses the capability related to public health emergency operations coordination (EOC). As defined by the CDC (2018), emergency operations coordination is "the ability to coordinate with emergency management and to direct and support an incident or event with public health or health care implications by establishing a standardized, scalable system of oversight, organization, and supervision that is consistent with jurisdictional standards and practices and the National Incident Management System (NIMS)" (p. 34).

The purpose of the evidence synthesis was to address the following questions related to public health EOC:

- *In what circumstances is activating public health emergency operations appropriate?*
- What factors (e.g., type and scale of event, type of command, complexity, past experience, mutual aid requests, policy, etc.) are useful for determining when to activate public health emergency operations?
- In what circumstances should public health activate a separate public health EOC, lead a multi-agency EOC, or play a supporting role in a multi-agency EOC based on identified or potential public health consequences?
- How does the response change following the activation of public health emergency operations?
- What benefits and harms (desirable and/or undesirable impacts) of public health emergency operations have been described or measured?
- What are the barriers and facilitators to successful public health emergency operations using ICS?

The evidence of interest for answering the questions was the findings from primary research studies that used qualitative research methods such as ethnographic observations, interviews, and focus group discussions. Given the qualitative research approach and the methodological range of primary studies available in the corpus for this evidence synthesis, the questions were treated as informing different aspects of the phenomenon of interest of public health emergency operations. That is, the evidence synthesis took public health emergency operations as its phenomenon of interest and sought to explicate this phenomenon's various aspects.

2.0 METHOD

2.1 Literature Search

A broad literature search was undertaken from which relevant qualitative research studies were selected. The literature search was conducted in the Medline (Ovid), Embase (Ovid), and Scopus databases and used the following inclusion and exclusion criteria:

- Date: 2001 - present;
- Language: English; and
- Document Type: Exclude commentaries, editorials, letters, and notes.

More details about the search process, including the search strings, are available separately in the National Academies report.

To be selected for the present evidence synthesis, a qualitative study had to use a qualitative method of data collection, such as interviews, as well as a qualitative method of data analysis, such as thematic analysis.

Based on the above, there were total 21 studies selected for the evidence synthesis. The studies (first author and year) are listed in Table 3.1.

2.2 Relevance Assessment of Individual Studies

Individual articles were judged for different levels of relevancy to the phenomena of interest (see Lewin et al., 2018 and Noyes et al, 2018, for details of the relevancy criteria). Studies were judged to have direct relevance (i.e., directly mapped onto phenomenon of interest); indirect relevance (i.e., some aspects of phenomenon of interest covered whereas other aspects are analogs/substitutes for phenomenon of interest); partial relevance (i.e., only some aspects of the phenomenon of interest covered); or unclear relevance (i.e., unclear whether underlying data were relevant) with the phenomenon of interest.

2.3 Quality Appraisal of Individual Studies

The selected studies were individually appraised using the Critical Appraisal Skills Programme (CASP; 2018) checklist, which is applicable to assessing qualitative research. Areas of appraisal by CASP include appropriateness of qualitative methodology, data collection, relationship between research and participants, ethics, rigor of data analysis, clarity of findings, and value of research. Each area is assessed using "yes," "no," or "can't tell."

We modified the checklist to include an overall rating in addition to the ratings of individual elements. Based on the CASP checklist evaluations, each study received a final overall quality rating of one of the following four categories: no or very minor concerns (no significant flaws); minor concerns (minor flaws not impacting credibility/validity of findings); moderate concerns (some flaws likely to impact credibility/validity of findings); or serious concerns (significant flaws impacting credibility/validity of findings). This overall rating was not a summation of the individual element ratings but a separate judgment.

2.4 Data Analysis and Synthesis

We used Atlas.ti (Version 8.1, Atlas.ti Scientific Software Development GmbH, Berlin, Germany), a qualitative data analysis software, for data extraction and synthesis. The primary study articles were uploaded into Atlas.ti and the extraction, coding, and synthesis processes were directly applied to these documents.

Study characteristics and key findings along with supporting information were extracted from each study. We used the general process of reading and re-reading the full article, including the abstract, rationale, method, results and analysis, and discussion sections to identify the characteristics and findings of interest.

2.4.1 Study Characteristics

Total 15 study characteristics were extracted. These included: Country and location of event; population density of event location; event; event type; event phase focus; event scale focus; event duration; event year; data collection period; data source; data providers; data providers' agencies; vulnerable populations addressed; activation addressed; and agency activated.

2.4.2 Study Findings

The key findings and supporting information from each study were extracted in the form of key phrases, sentences, and direct quotations. For studies that used multiple methods, only the qualitative portion was extracted. The purpose of extraction of findings was to identify and note evidence that mapped onto the phenomenon of interest.

Specifically, we employed the pragmatic framework synthesis method (see Barnett-Page, & Thomas, 2009; Pope, Ziebland, & Mays, 2000), which uses an iterative deductive and inductive process, to analyze and synthesize the findings. A five-step process was used: Familiarization to create a priori descriptive codes and codebook development; first-level in vivo coding using descriptive codes; second-level coding into descriptive themes (families of descriptive codes); analytic theming (interpretive grouping of descriptive themes); and charting/ mapping and interpretation. Tracy (2018), provides additional instructions on the key principles of coding qualitative data for the purposes of analysis, which was adapted for the current context.

The first step of familiarization involved an initial close reading of the project documents and the selected articles to create descriptive codes. The familiarization with the project documents unpacked the key questions, sub-key questions, context questions, evidence-to-decision issues, aims and objectives of the project, and the logic models, to identify key phrases/ words that meaningfully addressed the phenomenon of interest. The familiarization with the articles similarly identified key phrases/ words that described various aspects of the phenomenon of interest. Both sets of key phrases/ words were converted to descriptive codes, which captured the essence of the extractions and replaced the in vivo original words with ones that translated across studies, creating a common yet representative nomenclature. We developed a codebook, which compiled the codes with corresponding definitions, thereby forming a set of a priori descriptive codes.

The second step of first-level in vivo coding involved multiple close readings of the articles in their entirety, with attention to findings wherever they appeared (particularly in the abstracts, results, discussions, and conclusions). We highlighted the in vivo findings (consisting of verbatim key phrases, sentences, and paragraphs) related to the key question, sub-key questions, context questions, or evidence-to-decision issues and assigned a descriptive code. When there were no a priori codes that matched the essence of in vivo extractions, this was considered an emergent code. The emergent code was translated to a new descriptive code, and the code with a corresponding definition was incorporated in the codebook. During this process, the researchers were attentive to all meaningful extractions, whether they appeared to confirm or counter previously coded extractions. For mixed-method studies that had both qualitative and quantitative portions, only the qualitative findings were coded.

The third step of second-level coding involved a synthesis process of creating descriptive themes, where a theme was a family of descriptive codes in which codes that formed a cohesive set were grouped together. The themes represented a nuanced description, rather than just a generalized description, of the phenomenon of interest.

The fourth step involved a synthesis process of creating analytic themes. This analytical theming relied on a robust interpretation of the descriptive themes and how they intersected relationally with one another, whether, for example, separately, cumulatively, or dialectically. The descriptive themes were grouped together in a nuanced manner to create the analytic themes.

The fifth step of mapping/ charting involved explaining how the analytic themes specifically addressed the phenomenon of interest. Additionally, evidence-to-decision issues were addressed in this step by looking at how the analytic themes were grounded in descriptive themes, codes, and in vivo extractions.

2.5 Assessment of Confidence in Synthesized Findings

The fourth-step analytic themes, and in some cases the third-step descriptive themes, constituted the final set of synthesized findings. These findings were assessed for confidence using GRADE-Confidence in the Evidence from Reviews of Qualitative research (GRADE-CERQual; Lewin et al., 2015; Lewin et al., 2018).

The synthesized findings were assessed using four domains: Methodological limitations, relevance, coherence, and the adequacy of data supporting the synthesized finding. Each synthesized finding was then given an overall assessment as follows:

- High confidence - it is highly likely that the finding is a representation of the phenomena;
- Moderate confidence - it is likely that the finding is a representation of the phenomena;
- Low confidence - it is possible that the finding is a representation of the phenomena; and
- Very low confidence - it is not clear if the finding is a representation of the phenomena.

2.6 Quality Assurance of Review

Quality assurance of the review was achieved through discussion until consensus was reached. The discussion involved team members as well as the National Academies staff and methodology consultant.

2.6.1 Quality Assurance of Extraction of Data

An initial codebook for extracting study characteristics and findings was developed. After receiving feedback on a draft from team members, National Academies staff, and methodology consultant, the document was suitably revised. Training sessions for the use of the codebook were conducted with the research team.

Next, a pilot test of the codebook portion for extracting study characteristics and findings was conducted. Two team members, the lead author of the report and a graduate student research assistant, separately coded approximately 25% of the articles. An analysis of the coding showed high agreement (approx. 80%) between the two readers.

The pilot test generated suggestions for refinement from the team members. The final codebook was created after incorporating this feedback.

2.6.2 Quality Assurance of Quality Appraisal of Individual Studies

All team members discussed the different elements of the CASP ratings tool and their application to the identification and assessments of the elements within the articles. After this, two team members, the lead author of the report and a graduate student research assistant, separately used the CASP tool to appraise all the articles. The two team members discussed any disagreements. The lead author made the final determination based on the discussion.

2.6.3 Quality Assurance of Synthesis of Findings

The synthesis of findings was done by the lead author of the report. The synthesis process and the synthesized findings were discussed in weekly meetings with the second author, who closely read the synthesized findings and offered critique. A draft of the findings was also discussed with and critiqued by the National Academies staff and methodology consultant. The final synthesized findings were developed based on the discussion and critique.

The assessment of confidence in the synthesized findings was done by the lead author of the report. The second author reviewed the assessments, queried the lead author for additional information, and offered suggestions. The final assessment was decided after this discussion.

3.0 FINDINGS

3.1 Relevance Assessment and Quality Rating of Individual Studies

The relevance assessment, as summarized in Table 3.1, showed the following for the 21 qualitative research studies: 17 were of direct, 4 were of partial, 1 was of indirect, and none were of unclear relevance. Thus, 80% of the studies were directly relevant to the phenomenon of interest.

The quality rating using the CASP tool, as summarized in Table 3.1, showed the following for the 21 studies: 7 had no or very minor, 11 had minor, 2 had moderate, and 1 had serious concerns. Thus, 86% of the studies were of high and moderate and 14% were of low or very low quality.

Table 3.1. Study Citation, Relevance Assessment, and CASP Quality Rating (N = 21)

Study [First Author Only, Publication Year]	**Relevance [Direct, Indirect, Partial, Unclear]**	**CASP Rating of Quality [No or Very Minor, Minor, Moderate, Serious Concerns]**
Bigley (2001)	Direct	Minor
Buck (2006)	Partial	Moderate
Chandler (2016)	Direct	Minor
Freedman (2013)	Direct	No or very minor
Glick (2013)	Partial	No or very minor
Gryth (2010)	Direct	Minor
Hambridge (2017)	Partial	Minor
Klima (2012)	Direct	Minor
Lis (2017)	Direct	Minor
Lis (2018)	Direct	Minor
Mase (2017)	Direct	Minor
McMaster (2012)	Direct	Serious
Militello (2007)	Direct	Minor
Moynihan (2008)	Direct	Minor
Obaid (2017)	Direct	Moderate
Reeder (2011)	Direct	No or very minor
Rimstad (2015)	Direct	No or very minor
Shipps Hilts (2016)	Direct	No or very minor
Sisco (2019)	Partial	No or very minor
Thomas (2005)	Indirect	Minor
Yanson (2017)	Direct	No or very minor

Notes. Study relevance was assessed as partial if the full range of EOC operations was not examined or if the examination of EOC operations was not done during an emergency response. Study relevance was assessed as indirect if the examination of EOC operations did not have a public health component.

3.2 Study Characteristics

The majority (17) of the events studied were in the United States, 3 were in Europe, and 1 was in Central America. The events most studied were all hazards (4), infectious diseases (5), and hurricanes (4). The events were both real occurrences (13) and training exercises (7). The event phases focused on were preparation (8) and response (13). Correspondingly, the data collection was mostly done as pre-event preparation training (8) and post real event (13) with one study only collecting during a real event.

The most common data source was interviews (13) followed by participant observation (8) and document analysis (7). Study participants were from less from public health organizations (12) and more from other agencies (18). Only 8 studies addressed activation.

Table 3.2 lists additional study characteristics. The table also provides further information about all the characteristics.

Table 3.2. Study Characteristic and Characteristic Categories

Study Characteristic	Characteristic Categories
Country and Location of Event	Norway, Oslo: 1 Panama, Panama City: 1 Sweden, Stockholm: 1 United Kingdom, England (Gloucestershire): 1 United States: 17 --National: 3 --California (San Diego county; All state): 2 --Nebraska (Local county): 1 --New York (New York city; Seaboard counties): 4 --Ohio (All state; Local counties): 2 --Washington State (Puget Sound counties; Jurisdiction): 3 --Not Determinable: 2
Population Density of Event Location	Urban: 4 Suburban:1 Rural: 1 Mixed: 12 Not Determinable: 3
Event	All Hazards: 4 Airplane Crash: 1 Explosion: 2 (1 Terrorism) Fires: 1 Flooding: 1 Hurricane: 4 Infections Disease: 5 Snow Storm: 1 Tornado: 1 Train Derailment: 2 (1 Terrorism)
Event Type	Real Event: 13 Training Exercise: 7 --Functional, Full-Scale: 5 --Tabletop, Webinar, Scenario: 2 Other: 1
Event Phase Focus	Preparation for Response: 8 Actual Response: 13

Event Scale Focus	Local/County: 8 State/Multi-county: 10 National/Multi-state: 3
Event Duration	Less than Week: 9 Week or longer: 7 Not Determinable: 5
Event Year	1994-2003: 1 2001-2010: 1 2003: 1 2007: 1 2008: 1 2009: 2 2010-2013: 1 2011: 1 2012: 4 2016: 1 Not Determinable: 7
Data Collection Period	Training Exercise/Pre-Event Preparation: 8 During Real Event: 2 Post Real Event: 13
Data Source	Interviews: 13 Focus Group Discussion: 5 Participant Observation: 8 Document Analysis: 7 Survey Questionnaire: 4
Data Providers	Public Health Staff in Real Event Response: 6 Other Agencies Staff in Real Event Response: 11 Public Health Staff in Training Exercise: 3 Other Agencies Staff in Training Exercise: 7
Data Providers' Agencies	Public Health Agencies: --Local/County: 9 --State:2 --Regional Network: 3 --Tribal or Territorial: 0 Other Agencies: --Local/County: 13 --State: 4 --Regional Network: 4 --Tribal or Territorial: 0 --National: 5
Vulnerable Populations Addressed	Yes: 2 No: 19
Activation Addressed	Yes: 8 No: 13
Agency Activated	Public Health: 6 Other Agency: 9 Jurisdictional/County Multiagency: 12 Not Determinable: 1

Note. The frequencies for the study characteristic categories may not add up to 21 (the total number of studies) as some studies examined multiple categories for a characteristic.

3.3 Synthesized Findings

The phenomenon of interest for the present evidence synthesis was public health emergency operations. The findings from individual studies were analyzed and synthesized to describe this phenomenon, both as a whole and its different aspects as embodied in the questions of interest noted in the introduction to this report.

Nine synthesized findings emerged from the evidence base. The first three findings were overall and cut across different aspects of the phenomenon and thereby related to all questions of interest in some way. The next six findings were more narrowly focused on specific aspects of the phenomenon and spoke separately to different questions of interest.

All findings are summarized in Table 3.3.10. The table also presents the assessment of confidence in the evidence for the findings as judged using the GRADE-CERQual tool (see Section 2.5 for description).

The three synthesized findings that provide an overall description of public health emergency operations are presented next.

3.3.1 Mental Models and Shared Understanding of Public Health Emergency Operations

Finding 1: Knowledge of different aspects of public health emergency operations, and especially situational awareness of ongoing events, can be seen as cognitively constituted through mental models that are distributed across leaders and staff and that may be based on less-than-full information. Viewing shared understanding of public health emergency operations overall in terms of mental models can help in understanding the functioning of activation and coordination activities.

Leaders and staff responsible for preparedness for and response to an emergency event need to develop knowledge of public health emergency operations and an understanding of the event. This understanding is commonly referred to as situational awareness or operational awareness (Bigley, 2001; Glick, 2013; Lis, 2017). Building this knowledge base and especially the situational awareness of an event is critical to emergency operations.

The knowledge of different aspects of public health emergency operations, including of situational awareness of an event, can be seen as cognitively represented through mental models. These mental models are related to most aspects of public health emergency operations, including activation decisions, and resources, barriers, and facilitators to coordination. In other words, the knowledge that leaders and staff have of emergency operations can be described in terms of mental models of emergency operations that they possess in their minds.

When leaders and staff of public health and other agencies go through preparedness training for an emergency event or act as “eyes-and-ears” for monitoring an ongoing event, they are in fact creating cognitive representations of the event in the form of mental models. The full representation of all aspects of an event may be inside the mind of one leader, although more often the understanding of the different aspects of an event is distributed across multiple leaders and staff (Bigley, 2001; McMaster, 2012; Moynihan, 2008; Rimstad, 2015). The mental representations/ mental models evolve over time and it may be possible that initially they might be incorrect for some people (Bigley, 2001; Gryth, 2010). Therefore, one way to think about coordination among members of a task group is to see it as the coordination of the varying mental models that the staff and leaders have within and across agencies.

Mental models can be seen as the basis for activation decisions. Leaders and commanders rarely have all available information about an ongoing event but experienced personnel can often make rapid decisions based on their mental models of prior events (Glick, 2013; Rimstad, 2015).

Mental models can be barriers, facilitators, and resources to effective shared understanding and thereby coordination. The degree to which accurate mental models are shared across members of task groups leading to a shared understanding of an emergency event as well as of interagency functions can influence effective coordination (Bigley, 2001; McMaster, 2012; Militello, 2007; Moynihan, 2008; Sisco, 2019).

3.3.2 Rigidity and Flexibility in Public Health Emergency Operations

Finding 2: Emergency operations responses can be conceptualized and operationalized not just as rigid command and control functions but also as flexible adaptations and improvisations. Taking both perspectives on public health emergency operations can help in designing effective activation and coordination activities.

Public health emergency operations, overall, are sometimes characterized only in terms of their rigid command-control structures and the flexibility potential of the responses is downplayed. A more accurate overall conceptualization of emergency operations shows that both command and control functions as well as pre-planned adjustments and ad hoc improvisations are present (Chandler, 2016; Freedman, 2013; Hambridge, 2017; McMaster, 2012; Moynihan, 2008). As such, both perspectives are related to most aspects of public health emergency operations, including activation decisions, and resources, barriers, and facilitators to coordination.

The often changing, complex, and dynamic environment of an emergency event creates unique demands for which available command-control procedures may not apply in their entirety, requiring emergence of new organizational structures and responses (Buck, 2006; Chandler, 2016; Freedman, 2013). For example, presence of unorganized volunteers and emergent groups as well as the transformations of the structure and function of established organizations can be required for effective response (Buck, 2006). The formal structures can be reconfigured through structure elaborating, role switching, and authority migrating, among others, as a way to enhance organizational flexibility and thus reliability (Bigley, 2001; McMaster, 2012).

Similarly, professionals, especially experienced ones, do not always follow the given procedures in a strict manner but make adjustments to strategy and use creative problem solving as situations arise where the standard solutions do not have a good fit (Bigley, 2001; Freedman, 2013; McMaster, 2012; Rimstad, 2015)

3.3.3 Public Health Emergency Operations Teams as Social Groups

Finding 3: Public health emergency operations teams, especially those involving multiple agencies, can be viewed as social groups in their functioning. A history of informal social relationships through prior training leads to familiarity and trust across differences in organizational cultures that can reduce power struggles and political maneuvering, and enhance cooperation and coordination.

Public health emergency operations teams are not just task groups but can also be seen as social groups. Seeing such teams overall in social, rather than just task, terms helps understanding of most aspects of public health emergency operations, including activation decisions, and resources, barriers, and facilitators to coordination.

To see a public health emergency operations task-oriented team also as a social group means that issues of differing values, power struggles, and political machinations are no longer assumed to not exist in the functioning of the teams (Bigley, 2001). Similarly, cultural differences between staff from different organizational cultures, such as strictly hierarchical versus valuing judgment and discretion, are no longer ignored (Moynihan, 2008). Additionally, the pre-existing social power differentials and economic and political interests in the impacted communities during emergency event response and recovery periods are not hidden (Buck, 2006). Along the same lines, issues of affect and emotion, such as fear and concern about personal safety by staff members, are not suppressed. Once these intensely social processes are acknowledged, they can be productively dealt with thereby improving emergency operations functioning (Buck, 2006; Rimstad, 2015).

Seeing work teams as social groups can improve their functioning in other ways as well. Pre-event training across agencies can create informal relationships and a sense of social closeness and collegiality that can foster creativity and adaptation in response activities, trust, cohesion, and shared goals inextricably linked to the development of social relations and group formation (Buck, 2006; Freedman, 2013; McMaster, 2012; Militello, 2007).

Next, we present six findings that address specific aspects of the phenomenon of interest. These aspects correspond to the questions of interest related to activation, response changes, barriers and facilitators, and harms.

3.3.4 Activation of Public Health Emergency Operations

Finding 4: Public health emergency operations are fully activated, as support or lead, when an emergency event is large in size and complex in scope, or when the hazards it poses impact primarily or only human health as opposed to natural or built environments, as is the case, for example, with disease outbreaks. The activation may also include activation of a liaison officer and may precede the onset of an event through advance activation of interagency protocols and memorandums of understanding. Overall aspects of activation include determination of specific thresholds for activation and time to the activation decision.

Public health emergency operations are fully activated with public health as the lead or a support agency usually when the emergency event is large in size and complex in scope (Freedman, 2013; Sisco, 2019). A response to any large-scale emergency event is inherently an interagency response, with public health as an important agency in the process (Sisco, 2019).

Public health is usually activated as the lead agency for a biological emergency event such as infectious disease outbreak (Freedman, 2013; Obaid, 2017; Sisco, 2019), where the event impact is only or primarily on human health as opposed to events, such as flooding, fires, and hurricanes that directly impact natural and built environments.

An element of public health activation can be in the form of advance activation of interagency protocols and memorandums of understanding prior to an expected emergency event such as a hurricane (Lis, 2018; Yanson, 2017). Although this is not strictly activation of response operations, it can be taken as the beginning of the activation process.

Sometimes, public health activation can take the form of activation of a liaison or person-to-contact position to coordinate activities. This can be in addition to activation of other responses or it can be the only activation (Sisco, 2019).

An overall aspect of response activation is the determination of the critical point or specific threshold that elicits an activation decision. Findings from healthcare settings may offer some pointers for the public health context. An emergency event leads to a surge in demand for healthcare services, which is a continuum ranging from conventional to contingency to crisis services. The triggers and indicators that signal the transition point to implementing crisis standards of care are characterized by insufficiency of resources to meet the increased demand for health care (Lis, 2017). Similarly, a tool created by the Mayo Clinic to assess the appropriate response to infectious diseases outbreak uses the extent of burden of operations for healthcare agencies to classify an outbreak, ranging from very high to low burden, and thus determine the response (Lis, 2018). As noted above, the degree of scope of an emergency event is associated with activation of public health. Depletion of resources and placing of high burden on operations can perhaps be utilized as measures of scope of an emergency event to create a threshold for determining whether public health should be activated or not.

Another overall aspect of response activation is time to the activation decision. The five factors that may influence the time taken to activate public health include: Previous knowledge and experience; degree to which emergency

event is atypical; amount, speed, and quality of situation data available; data integration into building a picture of the situation; and perception of urgency to make decision (Glick, 2013).

3.3.5 Response Changes Following Activation of Public Health Emergency Operations

Finding 5: Response changes following activation of public health emergency operations can be seen in terms of the degree of adaptation (none, some, a great deal) of established responses. The type of response change may depend on the phase of the emergency event.

Responses changes following activation of public health emergency operations can be best described in terms of Dynes (1993; 1994) typology which can be used to classify the responses into four categories: established organized response (regular task-old structural arrangements); expanding organized response (regular task-new structural arrangements); extending organized response (nonregular tasks-old structural arrangements); and emergent organized response (nonregular tasks-new structural arrangements) (Chandler, 2016). This typology allows understanding how public health agencies navigate their responses by carrying out regular and irregular tasks while also functioning within old and new structural arrangements. The response changes can also be classified under another similar typology with three categories: standard (taught explicitly or so common that everyone would agree as to the alternatives); typical (modifications to standard operating knowledge to meet the requirements of the situation); and constructed (no standard solution available; typically involve creative problem solving (Rimstad, 2015). Another typology for response changes can come from the context of surge capacity within the health care system: conventional (spaces, staff, and supplies used are consistent with daily practices); contingency (spaces, staff, and supplies used are not consistent with daily practices but provide care that is functionally equivalent to usual patient care); and crisis (spaces, staff, and supplies have to be adapted and are not consistent with usual standards of care but provide sufficiency of care in the setting) (Lis, 2017).

What all three typologies imply is that response changes can be judged in terms of their adaptation to the emergency event situation as deviation from the planned established responses. At the minimum, the responses changes can be seen as exhibiting no, some, or lot of adaptation.

The type of adaptive response change may depend on the phase of the emergency event. The likelihood of adaptation being a lot is the highest in the earliest phases of an event (McMaster, 2012; Rimstad, 2015; Sisco, 2019).

3.3.6 Challenges to Effective Public Health Emergency Operations

Finding 6: Challenges to effective public health emergency operations are many. Some of the most salient relate to interorganizational awareness, interorganizational relationships, interorganizational cultural differences, differences in team members' knowledge and experience, communication technology, rules and regulations, volume of information, and lack of training.

The list of challenges/barriers to effective public health emergency operations is long. Some of the key barriers are noted below. While reading them it should be kept in mind that typically the opposite or absence of a barrier is a facilitator for effective operations.

Lack of inter-organizational awareness, that is, members of an operations team from an agency not having awareness of other agencies, is a major impediment to public health effective emergency operations. This lack of awareness can take the form of lack of mutual awareness of operations, lack of shared understanding of an event particularly between organizations not familiar with each other's domains of expertise and work practices, lack of understanding of role differences, and no common understanding of standard operating procedures understood by all responding organizations (Buck, 2006; Freedman, 2013; McMaster, 2012; Militello, 2007).

A similar challenge related to inter-organizational public health emergency operations is the relationships among team members from different organizations. This barrier can take the form of core members of a team who may be from one or two organizations not interacting with other team members who may be from different organizations; team members from an organization who may not have prior relationships from training sessions with members from other organizations may work independently; new members added at a later point to team may not form relationships; mistrust between agencies and disagreement over who is in charge; a wide variety of response organizations; and different interpretations of an emergency event (Freedman, 2013; Lis, 2018; McMaster, 2012; Militello, 2007; Moynihan, 2008; Thomas, 2005).

Another challenge related to inter-organizational public health emergency operations is cultural differences. These differences can be between the organizational values of individual team members or differences between cultures of the organizations (Bigley, 2001; Moynihan, 2008).

Communication technology also presents challenges to effective public health emergency operations. These challenges can include incompatible communication systems, especially between civil and military; new technologies for emergency event that are not familiar and different from those used for routine operations; system/ equipment noise in communication channels; not enough shared electronic displays; lack of or forgotten knowledge on use of communication systems; outdated email and phone lists; problems with data-entry systems; ticket/request software for interagency assistance; and radio traffic overload and lack of radio discipline (Gryth, 2010; Klima, 2012; Mase, 2017; McMaster, 2012; Militello, 2007; Reeder, 2011; Yanson, 2017).

Rules and regulations that are needed during routine public health operations can pose challenges for emergency operations. These can include rules leading to bottlenecks during surge at public health laboratories; HIPPA rules prohibiting access to non-public health staff or secured shared data repositories on individual computers; unclear rules about overtime compensation and working at non-routine locations; and lack of clarity of rules about information sharing, including with the media and public (Freedman, 2013; Shipps Hilts, 2016; Sisco, 2019; Yanson, 2017)

Differences in team members' knowledge and experience also present a challenge to effective public health emergency operations. These can manifest as, differences in willingness to enter into affected areas, in training in command-control environments, in level of facility with tools and systems, in knowledge of roles and functions, in knowledge of medical procedures and equipment, and in emergency operations plans (Freedman, 2013; Klima, 2012; Militello, 2007; Rimstad, 2015).

The increased volume of information to be processed and integrated can also be challenging for efficient public health emergency operations. The increase in volume can come from surge in phone calls, teleconferences, and emails; from new evolving issues that generate new information; conflicting information and attempts at its resolution; new guidances and related information; multiple public health roles requiring different streams of information gathering and dissemination; a long duration of emergency event and response; and information flow in the entire network (Chandler, 2016, Freedman, 2013, Mase, 2017, Reeder, 2011, Gryth, 2010, Rimstad, 2015, Sisco, 2019).

Training can also act as a challenge to effective public health emergency operations. Lack of or limited training can be a problem (Moynihan, 2008; Shipps Hilts, 2016; Yanson, 2017). Type of training, typically lack of functional exercises, can also pose a problem for effective response (Klima, 2012, Thomas, 2005).

3.3.7 Resources that can Facilitate Effective Public Health Emergency Operations

Finding 7: Resources that can facilitate the effectiveness of public health emergency operations can be many. Some of the salient resources include training, databases, supplies, mechanisms for communicating with the

public and media, and having a liaison/point-of-contact position. The need for various resources often changes over the course of an event.

Resources for public health emergency operations can serve as facilitators for effective responses. Resources can have a wide range, of which some salient ones are noted below.

Preparedness training can be a critical resource. Training, especially functional exercises, can highlight the gaps between plans and responses and provide means to update the plans and for public health, and challenge and test the stated epidemiologic and laboratory capacity (Freedman, 2013; Lis, 2018). Preparedness increases emergency event knowledge and experience that can help with responding to an actual event, enhancing the familiarity of staff with each from disparate agencies, and improving the awareness of functions of different agencies (Glick, 2013; Gryth, 2010; Hambridge, 2017; Klima, 2012; Lis, 2017; Lis, 2018; McMaster, 2012 Militello, 2007; Obaid, 2017; Reeder, 2011; Thomas, 2005).

Another resource can be availability of databases prior to an event. The databases can be of public health staff in a region so that they can be alerted and deployed as needed (Freedman, 2013), and of geolocation, geospatial, and health surveillance data that map out the needs of a community (Sisco, 2019).

Supplies such as portable generators along with adequate fuel supplies, specialized medical items (e.g., insulin, oxygen tanks, N95 masks, protective suits) and everyday items (e.g., infection control cleaning supplies) for or shelters or homes can become critical resources (Sisco, 2019).

Another resource is a mechanism for communicating with the public and media. Often public health is asked for information regarding rumors, warning, and guidance as well as dealing with conflicting information (Mase, 2017, Sisco, 2019) and so having a pre-planned informational materials and dissemination procedures can be a resource. In addition, public call lines and a one-stop interagency joint information center can be an important resource during emergency operations. When possible, a designated liaison or person-to-contact in an agency can be an important resource for managing interagency coordination activities (McMaster, 2012).

It should be kept in mind that the needs for different types of resources and their amounts changes over the course of an emergency event (Sisco, 2019). For example, the resource needs in the earlier phases when there is a demand surge may be different from the later phases of an event.

3.3.8 Facilitation of Response to Vulnerable Populations

Finding 8: The response of public health emergency operations to the needs of vulnerable populations can be facilitated by interagency planning that, among other things, addresses establishing a task force, creating needed databases, providing care in shelters, ensuring access to medications, dealing with power outages, and meeting transportation needs

An aspect of effective public health emergency operations is the response to vulnerable populations. In this context, pre-event planning for effective public health emergency responses may not always explicitly include addressing the needs of groups such as the elderly. Establishment of an interagency task force, which includes community organizations, prior to an event whose objective is to specifically plan for vulnerable populations can greatly facilitate such responses (Sisco, 2019).

The interagency task force, among other things, can ensure creation of databases such as those showing locations of high concentrations of retirees, care in shelters as well as staff availability for specialized services, availability of medical equipment and medications including such as methadone in absence of medical records, alternative sources of power during outages and re-fueling for such sources, and regular and specialized transportation (Chandler, 2016, Sisco, 2019).

3.3.9 Harms of Activation of Public Health Emergency Operations

Finding 9: Activation of public health emergency operations may lead to several undesirable effects, the salient of which are related to staffing deployment, staff stress and burnout, and adaptation-generated interorganizational distrust and chain-of-command disruption.

Once public health emergency operations are activated, not all effects of this activation may be intended and desired. The unintended and undesired effects can be anticipated and planned for, and in that sense may be considered as challenges to achieving effective responses. Some of the more salient harms of activation of public health emergency operations are noted below.

Activation can negatively affect staffing deployment. This can happen in several ways, including when the training of new surge staff at a facility requires experienced staff to be taken away from their duties (Freedman, 2013), staff struggle to continue providing essential routine services to the community (Reeder, 2011), demands of the emergency event lead to uneven workload distribution for staff (Militello, 2007), too little or too many staff get assigned to shelters and other facilities (Sisco, 2019), and there is a need for large-scale turnover of staff to account for staff burnout and their home organization needs (Moynihan, 2008). Activation can exacerbate staff burnout and stress related to staffing deployment. It can also happen with inexperienced personnel who are more worried about their personal safety (Rimstad, 2015).

Activation can lead to improvised responses that are adaptive to the demands of the emergency event. Such adaptations can result in misunderstandings and distrust with other agencies which can jeopardize the incident response (McMaster, 2012) and the adaptive response may be considered illegitimate and thus distrusted if it is perceived as not directly fitting the organizational goals (Bigley, 2001). Adaptive modifications to standard procedures can lead to loss of situation awareness for commanders which can affect the chain-of-command decision-making (McMaster, 2012).

3.3.10 Summary of Synthesized Finding and Confidence in the Finding

The nine synthesized findings as discussed above are summarized in the table below. The table also presents the GRADE-CERQual assessment of confidence in the evidence supporting each finding.

Table 3.3.10 Summary of Synthesized Finding and Confidence in the Finding

Objective: Describe the phenomenon of public health emergency operations, both overall and its various specific aspects			
Perspective: Staff of public health and other emergency operations response agencies			
Summary of Finding	**Studies Contributing to the Finding (First Author Only)**	**Overall CERQual Assessment of Confidence in the Evidence for the Finding**	**Explanation of Assessment**
A. Overall Findings Relevant to All Aspects of Emergency Operations			
1. Knowledge of different aspects of public health emergency operations,	Bigley (2001); Glick (2013);	Moderate	The 9 studies have no, very minor, or minor concerns

and especially situational awareness of ongoing events, can be seen as cognitively constituted through mental models that are distributed across leaders and staff and that may be based on less-than-full information. Viewing shared understanding of public health emergency operations overall in terms of mental models can help in understanding the functioning of activation and coordination activities.	Gryth (2010); Lis (2017); McMaster (2012); Militello (2007); Moynihan (2008); Rimstad (2015); Sisco (2019)		for methods, coherence, and relevance, but have moderate concerns for adequacy.
2. Emergency operations responses can be conceptualized and operationalized not just as rigid command and control functions but also as flexible adaptations and improvisations. Taking both perspectives on public health emergency operations can help in designing effective activation and coordination activities.	Bigley (2001); Buck (2006); Chandler (2016); Freedman (2013); Hambridge (2017); McMaster (2012); Moynihan (2008)	High	The 7 studies have no, very minor, or minor concerns for methods, coherence, adequacy, and relevance.
3. Public health emergency operations teams, especially those involving multiple agencies, can be viewed as social groups in their functioning. A history of informal social relationships through prior training leads to familiarity and trust across differences in organizational cultures that can reduce power struggles and political maneuvering, and enhance cooperation and coordination.	Bigley (2001); Buck (2006); Freedman (2013); McMaster (2012); Militello (2007); Moynihan (2008); Rimstad (2015)	Moderate	The 7 studies have no, very minor, or minor concerns for methods, coherence, and relevance, but have moderate concerns for adequacy.
B. Activation of Public Health Emergency Operations			
4. Public health emergency operations are fully activated, as support or lead, when an emergency event is large in size and complex in scope, or when the hazards it poses impact primarily or only human health as opposed to natural or built environments, as is the case, for example, with disease outbreaks. The activation may also include activation of a liaison officer and may precede the onset of an event through advance activation of interagency protocols and	Freedman (2013); Glick (2013); Lis (2017); Lis (2018); Obaid (2017); Sisco (2019); Yanson (2017)	Moderate	The 7 studies have minor concerns for methods and relevance, but moderate concerns for coherence and adequacy.

memorandums of understanding. Overall aspects of activation include determination of specific thresholds for activation and time to the activation decision.			
C. Response Changes After Activation of Public Health Emergency Operations			
5. Response changes following activation of public health emergency operations can be seen in terms of the degree of adaptation (none, some, a great deal) of established responses. The type of response change may depend on the phase of the emergency event.	Chandler (2016); Lis (2017); McMaster (2012); Rimstad (2015); Sisco (2019)	High	The 5 studies have no, very minor, or minor concerns for methods, coherence, adequacy, and relevance.
D. Barriers and Facilitators to Public Health Emergency Operations			
6. Challenges to effective public health emergency operations are many. Some of the most salient relate to interorganizational awareness, interorganizational relationships, interorganizational cultural differences, differences in team members' knowledge and experience, communication technology, rules and regulations, volume of information, and lack of training.	Bigley (2001); Buck (2006); Freedman (2013); Gryth (2010); Klima (2012); Lis (2018); Mase (2017); McMaster (2012); Militello (2007); Moynihan (2008); Obaid (2017); Reeder (2011); Rimstad (2015); Shipps Hilts (2016); Sisco (2019); Thomas (2005); Yanson (2017)	High	The 17 studies have no, very minor, or minor concerns for methods, coherence, adequacy, and relevance.
7. Resources that can facilitate the effectiveness of public health emergency operations can be many. Some of the salient resources include training, databases, supplies, mechanisms for communicating with the public and media, and having a liaison/point-of-contact position. The need for various resources often changes over the course of an event.	Freedman (2013); Glick (2013); Gryth (2010); Hambridge (2017); Klima (2012); Lis (2017); Lis (2018); Mase (2017); McMaster (2012); Militello (2007); Obaid (2017); Reeder (2011); Sisco	High	The 14 studies have no, very minor, or minor concerns for methods, coherence, and relevance, but moderate concerns about adequacy.

	(2019); Thomas (2005)		
8. The response of public health emergency operations to the needs of vulnerable populations can be facilitated by interagency planning that, among other things, addresses establishing a task force, creating needed databases, providing care in shelters, ensuring access to medications, dealing with power outages, and meeting transportation needs.	Chandler (2016); Sisco (2019)	Low	The 2 studies have no or very minor concerns for methods and coherence, but moderate to serious concerns for adequacy and relevance.
E. Harms of Public Health Emergency Operations Activation			
9. Activation of public health emergency operations may lead to several undesirable effects, the salient of which are related to staffing deployment, staff stress and burnout, and adaptation-generated interorganizational distrust and chain-of-command disruption.	Bigley (2001); Freedman (2013); McMaster (2012); Militello (2007); Moynihan (2008); Reeder (2011); Rimstad (2015); Sisco (2019)	High	The 8 studies have no, very minor, or minor concerns for methods, coherence, adequacy, and relevance.

4.0 DISCUSSION

The purpose of the evidence synthesis was to describe and understand the phenomenon of public health emergency operations, both overall as well as focused on specific aspects including activation decisions and response changes after activation, challenges and resources associated with effective coordination, and harms of activation. The analysis and synthesis of evidence from 21 qualitative research studies yielded nine findings. Three of the findings described the phenomenon overall whereas the other six described the specific aspects. Of the nine findings, four were assessed as having high, three having moderate, and two having low confidence. Thus overall, the majority (seven out of nine) of findings were seen as being based on evidence of strong quality.

4.1 Evidence to Decision Framework

4.1.1 Balance of Benefits and Harms

For a public health emergency, the benefits and harms of commencing emergency operations have to be weighed on the metric of the health of the population. The studies in the evidence base assume the benefits of preventing morbidity and mortality in an emergency event without explicitly stating so, and we can agree that these benefits are a consequence of the emergency operations. The harms of activation on human health that are mentioned are of two sorts: Disruption of routine services that may still be needed in an emergency event (Freedman, 2013; Reeder, 2011) which has the potential to negatively impact public health and negative effects on staff such as stress and burnout (Militello, 2007; Moynihan, 2008; Rimstad, 2015). Balancing the above benefits and harms on the metric of public health, the benefits clearly predominate the harms.

The issue can also be framed in terms of an alternative scenario: If public health emergency operations were not started, would there be more benefits or harms to the health of the population? None of the studies examine this scenario, but one can surmise that in the absence of public health emergency operations the morbidity and mortality rates would be much higher. Additionally, based on the available evidence and using the metric of the health of the population, the only benefits would be continuation of routine health care and reduction of staff stress and burnout. Thus, under this alternative scenario also, the benefits outweigh the risks using the metric of public health.

A metric of system outcomes can also be used to gauge the benefits and harms of activating public health emergency operations. In other words, we can examine whether the outcomes of activation at the public health system level, rather than at the population health level, are mostly benefits or harms. In this regard, we can think of short term benefits and harms that occur during the course of an emergency event and long term benefits and harms that accrue over the course of a series of such events.

Harms of activation on the public health system such as staff stress and burnout, turnover of professionals, uneven staff workload distribution, and adaptation generated inter-organizational distrust and chain-of-command disruption are likely to be present only during the span of an event and not persist post-event for any appreciable length of time. However, there may be situations where harms like staff stress, organizational functioning due to employee turnover, and inter-organizational distrust may get embedded in the system and carry-over from event to event.

A reasonable inference from the evidence available in the studies is that the system level benefits may be more long term than short term. Some studies (Bigley, 2001; Buck, 2006; Militello, 2007) suggested that staff having experience from responding to prior emergency events made quicker and better decisions (presumably relative to staff without such experience) implying that the benefit becomes visible only over time in responses to future events. Similarly, some studies (Buck, 2006; Freedman, 2013) suggested that development of social relations and associated trust across organizations from response to a previous event showed up in the current event in the form of smoother inter-organizational coordination. Additionally, the accretion of institutional knowledge of what

works and what does not is an accumulative process; in the absence of activation of a response, this learning is not possible. Thus, it may be imperative to keep in mind the time-scale of benefits and harms when examining their balance at the system level.

4.1.2 Acceptability and Preferences

Effective public health emergency operations require commitment from a variety of stakeholders, ranging from local/ county to national level and from public health to police, fire, and other agencies. An even more wider range of stakeholders may be involved for some emergency events, such as K-12 school systems and the armed forces.

The set of studies in the evidence base did not directly, or even indirectly, address the issue of acceptability and preferences. However, none of the studies had even a mention of any reluctance on part of any agency to join real event emergency response operations or a preparedness training exercise. Extrapolating from this, we can conclude that all stakeholders find their roles in participating in emergency operations acceptable.

Perhaps, the only hesitation in joining emergency operations would be on part of inexperienced frontline staff who may be strongly concerned about their safety. Although this preference is at the level of individuals, one may see it as a result of lack of sufficient training of such staff at an agency level.

4.1.3 Equity

Vulnerable or at-risk populations, such as the elderly or infirm, are especially in need of continued or additional health care during emergency events. The harms from absence of public health emergency operations are higher for them compared to the general population.

Only two studies (Chandler, 2016; Sisco, 2019)in the evidence base addressed this issue. The studies, did however, provide suggestions for how the response of public health emergency operations for such populations can be facilitated to be more effective as discussed in Finding 8 above. Of these suggestions, perhaps the main avenue to ensure equity in public health emergency operations is pre-event preparation where the needs of such populations are high on the planning agenda.

4.1.4 Resource and Economic Considerations

Resources that can facilitate more effective public health emergency operations can take varied forms. As discussed in Finding 7 above, these include provision of preparedness training, ideally functional or full-scale; construction of comprehensive and accurate databases; stocking of supplies; development of an organizational mechanism for communicating with the public and media; and creation of a liaison/ point-of-contact position in agencies. It should also be noted that the need for different resources often changes over the time course of an emergency event.

The economic considerations regarding these resources were not addressed in the studies in the evidence base. However, one can surmise that to build these resources into the emergency response infrastructure in general and the organizational structure of response agencies more specifically will require some financial commitments.

4.1.5 Feasibility and PHEPR System Considerations

The findings from this evidence synthesis are feasible to implement in the field. The findings can offer guidance to agencies for articulating their broad strategic vision as well as for planning and conducting emergency operations. In the last two decades, an all-hazards approach has built capacity in emergency response agencies, including public health, at all local/county, state, and national levels. The incorporation of these findings will

represent mostly a strengthening and focusing of existing capacities rather than creation of any new capacity. For example, all agencies conduct preparedness training exercises. The finding regarding resources suggests that agencies should conduct more frequent functional and full-scale exercises relative to other types, which requires a shift of focus rather than creation of a new capacity.

4.2 Limitations

A limitation of the evidence synthesis was the limited number of studies in the evidence base directly related to public health agencies as well as emergency operations activation. Although all studies were relevant to the broader phenomenon of interest, they all together did not provide enough of a "thick" corpus to closely describe the specific aspect of public health emergency operations activation.

4.3 Conclusion

The nine findings from the synthesis of evidence from qualitative research represent a description and understanding of the phenomenon of public health emergency operations. Together, the findings help see the phenomenon with more depth at an overall level as well as at the level of its specific aspects. The findings generally have strong confidence and so can serve as a guide for developing recommendations for emergency operations in the field and lend themselves to future research.

5.0 REFERENCES

References marked with an asterisk (*) are included in the review evidence base.

Barnett-Page, E., & Thomas, J. (2009). Methods for the synthesis of qualitative research: a critical review. *BMC Medical Research Methodology, 9*:59. doi: 10.1186/1471-2288-9-59

*Bigley, G. A., & Roberts, K. H. (2001). The incident command system: High-reliability organizing for complex and volatile task environments. *Academy of Management Journal, 44,* 1281-1299.

*Buck, D. A., Trainor, J. E., & Aguirre, B. E. (2006). A critical evaluation of the incident command system and NIMS. *Journal of Homeland Security and Emergency Management, 3*:3, Article 1.

Centers for Disease Control and Prevention (CDC). (2018). *Public health emergency preparedness and response capabilities: National standards for state, local, tribal, and territorial public health.* Atlanta, GA: U.S. Department of Health and Human Services.

*Chandler, T., Abramson, D. M., Panigrahi, B., Schlegelmilch, J., & Frye, N. (2016). Crisis decision-making during Hurricane Sandy: An analysis of established and emergent disaster response behaviors in the new york metro area. *Disaster Medicine & Public Health Preparedness, 10,* 436-442.

Critical Appraisal Skills Programme (CASP). (2018). *CASP qualitative checklist.* Available at: http://www.casp-uk.net/casp-tools-checklists.

Dynes R. R. (1993). Disaster reduction: the importance of adequate assumptions about social organization. *Sociological Spectrum, 13,* 175-192.

Dynes, R. R. (1994). Community emergency planning: False assumptions and inappropriate analogies. *International Journal of Mass Emergencies and Disasters, 12,* 141–58.

*Freedman, A. M., Mindlin, M., Morley, C., Griffin, M., Wooten, W., & Miner, K. (2013). Addressing the gap between public health emergency planning and incident response lessons learned from the 2009 H1N1 outbreak in San Diego county. *Disaster Health Disaster Health, 1,* 13-20.

*Glick, J. A., & Barbara, J. A. (2013). Moving from situational awareness to decisions during disaster response: Transition to decision making. *Journal of Emergency Management, 11,* 423-432.

*Gryth, D., Radestad, M., Nilsson, H., Nerf, O., Svensson, L., Castren, M., & Ruter, A.. (2010). Evaluation of medical command and control using performance indicators in a full-scale, major aircraft accident exercise. *Prehospital & Disaster Medicine, 25,* 118-123.

*Hambridge, N. B., Howitt, A. M., & Giles, D. W. (2017). Coordination in crises: Implementation of the national incident management system by surface transportation agencies. *Homeland Security Affairs, 13,* Article 3, 1-30.

*Klima, D. A., Seiler, S. H., Peterson, J. B., Christmas, A. B., Green, J. M., Fleming, G., Thomason, M. H., & Sing, R. F. (2012). Full-scale regional exercises: Closing the gaps in disaster preparedness. *The Journal of Trauma and Acute Care Surgery, 73,* 592-597

Lewin, S., Booth, A., Glenton, C., Munthe-Kaas, H., Rashidian, A., Wainwright, M., Bohren, M. A, Tunçalp, O., Colvin, C. J., Garside, R., Carlsen, B., Langlois, E. V., & Noyes, J. (2018). Applying GRADE-CERQual to qualitative evidence synthesis findings: introduction to the series. *Implementation Science, 13* (Supplement 1): 2, 1-10. doi: 10.1186/s13012-017-0688-3

Lewin, S., Glenton, C., Munthe-Kaas, H., Carlsen, B., Colvin, C. J., Gulmezoglu, M., Booth, A., Garside, R., & Rashidian, A. (2015). Using qualitative evidence in decision making for health and social interventions: An approach to assess confidence in findings from qualitative evidence syntheses (GRADE-CERQual). *PLOS Medicine.* doi:10.1371/journal.pmed.1001895.

*Lis, R., & Resnick, A. T. (2018). Coordinated communications and decision making to support a regional severe infectious disease response. *Health Security, 16,* 158-164.

*Lis, R., Sakata, V., & Lien, O. (2017). How to choose? Using the Delphi method to develop consensus triggers and indicators for disaster response. *Disaster Medicine & Public Health Preparedness, 11,* 467-472.

*Mase, W. A., Bickford, B., Thomas, C. L., Jones, S. D., & Bisesi, M. (2017). After-action review of the 2009-10 H1N1 influenza outbreak response: Ohio's public health system's performance. *Journal of Emergency Management, 15,* 325-334.

*McMaster, R., & Baber, C. (2012). Multi-agency operations: Cooperation during flooding. *Applied Ergonomics, 43,* 38-47.
*Militello, L. G., Patterson, E. S., Bowman, L., & Wears, R. (2007). Information flow during crisis management: Challenges to coordination in the emergency operations center. *Cognition, Technology and Work, 9,* 25-31.
*Moynihan, D. P. (2008). Combining structural forms in the search for policy tools: Incident command systems in u.S. Crisis management. *GOVE Governance, 21,* 205-229.
Noyes, J., Booth, A., Lewin, S., Carlsen, B., Glenton, C., Colvin, C. J., Garside, R., Garside, R., Bohren, M., Rashidian, A., Wainwright, M., Tuncalp, O., Chandler, J., Flottorp, S., Pantoja, T., Tucker, J. D., & Munthe-Kaas, H. (2018). Applying GRADE-CERQual approach to qualitative evidence synthesis findings-paper 6: How to assess relevance of the data. *Implementation Science, 13* (Supplement 1): 4, 51-61. doi: 10.1186/s13012-017-0693-6.
*Obaid, J. M., Bailey, G., Wheeler, H., Meyers, L., Medcalf, S. J., Hansen, K. F., Sanger, K. K., & Lowe, J. J.. (2017). Utilization of functional exercises to build regional emergency preparedness among rural health organizations in the us. *Prehospital & Disaster Medicine, 32,* 224-230.
Pope, C., Ziebland, S., & Mays, N. (2000). Analysing qualitative data. *BMJ: British Medical Journal, 320,* 114-116.
*Reeder, B., & Turner, A. M. (2011). Scenario-based design: A method for connecting information system design with public health operations and emergency management. *Journal of Biomedical Informatics, 44,* 978-988.
*Rimstad, R., & Sollid, S. J. M. (2015). A retrospective observational study of medical incident command and decision-making in the 2011 Oslo bombing. *International Journal of Emergency Medicine, 8,* 1-10.
*Shipp Hilts, A., Mack, S., Eidson, M., Nguyen, T., & Birkhead, G. S. (2016). New York State public health system response to Hurricane Sandy: Lessons from the field. *Disaster Medicine & Public Health Preparedness, 10,* 443-453.
*Sisco, S., Jones, E. M. A., Giebelhaus, E. K., Hadi, T., Gonzalez, I., & Lee Kahn, F. (2019). The role and function of the liaison officer: Lessons learned and applied after Superstorm Sandy. *Health Security, 17,* 109-116.
*Thomas, T. L., Hsu, E. B., Kim, H. K., Colli, S., Arana, G., & Green, G. B. (2005). The incident command system in disasters: Evaluation methods for a hospital-based exercise. *Prehospital & Disaster Medicine, 20,* 14-23.
Tracy, S. J. (2018). A phronetic iterative approach to data analysis in qualitative research. *Journal of Qualitative Research, 19,* 61-76.
*Yanson, A., Shipp Hilts, A., Mack, S., Eidson, M., Nguyen, T., & Birkhead, G. (2017). Superstorm sandy: Emergency management staff perceptions of impact and recommendations for future preparedness, New York State. *Journal of Emergency Management, 15,* 209-218.

6.0 APPENDIX

Table 6.1. Illustrative Excerpt of Findings Synthesis Process Showing Development of Descriptive and Analytical Theme

Descriptive Codes: a priori and Emergent	**Verbatim Text from Article Linked to Descriptive Code**	**Descriptive Themes: Families of Descriptive Codes**	**Analytic Theme: Interpretive Grouping of Descriptive Themes**
(A) Post-decision to activate-factors: informational needs for situational awareness [a priori]	. Situational awareness was defined similarly to Klein's concept, as the decision maker's conscious or subconscious perception of critical data elements, cues, and associative patterns in the present situation that relate to past experience and knowledge together enabling the FCO to develop a mental picture and so understanding the situation (Glick, 2013). . Coordination to go smoothly, it is important that all participants in the EOC have a shared understanding of the situation, current priori ties, and actions being taken (Militello, 2007). . Shared situation awareness (Militello, 2007). . Shared understanding of the situation (Militello, 2007). . The triggers and indicators identified are vital to providing the basis for situational awareness information gathering and decision-making concerning health care during an emergency in our region (Lis, 2017).	. (A) + (C) + (D): Situational awareness and other knowledge may be seen as mental representations in the form of mental models. . (E): Mental representations are likely to be incomplete across individuals based on experience, training, and other such factors. (E) + (F): Mental representation of an event is distributed across individuals (B): Coordination across individuals may be seen in terms of shared mental representations	Finding 1: Knowledge of different aspects of public health emergency operations, and especially of situational awareness of ongoing events, can be seen as constituted through mental models that are distributed across leaders and staff and that may be based on less-than-full information. Seeing public health emergency operations overall in terms of mental models can help with understanding of the functioning of activation and coordination activities.
(B) Post-decision to activate factors: facilitators to coordination: shared mental models. [a priori]	. Distributed teams and the coordination difficulties they face, focusing on issues such as team cognition, shared mental models, and shared situation awareness (Militello, 2007). . Coordination to go smoothly, it is important that all participants in the EOC have a shared understanding of the situation, current priori ties, and actions being taken (Militello, 2007).		

	. Largely overlooked contingencies critical to the success of this tool, such as the interaction of critical crisis factors (the experience of responders, the length of the crisis, and the diversity of the network) and management factors (standard operating procedures [SOPs], trust, and shared mental models) (Moynihan, 2008). . Shared mental models assume that responders have a common conception of the nature of the problem and their respective roles in it. We find equivalents to the concept of shared mental models elsewhere in the study of crises (Moynihan, 2008). . The high levels of uncertainty and multi-domain nature of major emergencies requires effective communication and sharing of information between agencies; though awareness of even a 'simple'' incident can vary widely and achieving shared understanding across different organisations is labour intensive. (McMaster, 2012)		
(C) Situational awareness as mental representation. [Emergent]	. The resulting "situational awareness" (i.e., disaster data integrated by the FCO into a mental picture of the situation) (Glick, 2013). . Situational awareness was defined similarly to Klein's concept, as the decision maker's conscious or subconscious perception of critical data elements, cues, and associative patterns in the present situation that relate to past experience and knowledge together enabling the FCO to develop a mental picture and so understanding the situation (Glick, 2013). . May gain accurate situational awareness more quickly by being able to know what data to		

	request, what sources to query, and how to more rapidly integrate the data into their mental framework depicting the current disaster situation (Glick, 2013).		
(D) Mental picture/ Mental framework of event. [Emergent]	. Data Integration Factor: the decision maker's ability to integrate situational data elements into a mental framework/ picture (Glick, 2013). . Situational awareness was defined similarly to Klein's concept, as the decision maker's conscious or subconscious perception of critical data elements, cues, and associative patterns in the present situation that relate to past experience and knowledge together enabling the FCO to develop a mental picture and so understanding the situation (Glick, 2013).		
(E) Mental representation factors [Emergent]	. Integrates these data elements into a mental picture that may vary based on their past knowledge and experience with the particular characteristics of the disaster itself and with the FCO's experience driven skill to rapidly integrate complex data into situational awareness (Glick, 2013). . The highly experienced FCO has more disaster knowledge and so may be more proficient at what data to request or look for and then integrate it into a mental picture of the disaster (Glick, 2013). . Shared mental models interacted with crisis characteristics in a number of relevant ways. Paucity of experience meant that the actors had a poor starting base for conceptualizing or making sense of the situation. Time allowed responders to develop a shared understanding of the crisis in the		

	months that followed (Moynihan, 2008)		
(F) Distributed awareness/ distributed mental representations. [Emergent]	. Fragmented situation awareness. Some participants were overloaded, while others were underutilized. As the workload for this core group increased, they had less time to share information and offload tasks. At the same time, others in the room became more removed from the situation as they did not have access to the frequent updates from first responders (Militello, 2007). . Whereas the ambulance commander was quite tied up in radio communication and non-critical or more detailed decisions, the medical commander could take on a more withdrawn and monitoring position. This enabled a bird's eye view of the situation and made it easier to assess resource balance and suggest downsizing at an earlier stage. This difference in approach and therefore situational awareness may be one of the advantages of this dual command model (Rimstad, 2015). . As a result, evolving, discrepant, and disconnected representations can become more and more widely dispersed across the system in a short period of time (Bigley, 2001). . Initial incorrect representation can propagate through the system (Gryth, 2010).		