

Review and Evidence Mapping of Scholarly Publications Within the CDC's 15 Public Health Emergency Preparedness and Response Capabilities

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Harvard T.H. Chan School of Public Health

Marcia A. Testa, M.P.H., M.Phil., Ph.D.^{1,2,3,7}, Elena Savoia, M.D., M.P.H.^{1,2,3}, Rachel Nicole Piltch-Loeb, Ph.D.,³, Paul Biddinger, M.D. FACEP^{3,4,5}, Maxwell Su, Sc.D.¹, Johanna F. Hayes, Sc.M.^{6,7} Sergio Saldivar Salazar, M.D., Sc.M.⁶, Sailee Bhambere, B.D.S., M.P.H.,² Ryosuke Fukuda, M.D., M.P.H.², Allison Hill, Ph.D.², M.P.H., Henry Onyeaka, M.B.B.S., M.P.H.², Api Chewcharat, M.D., M.P.H.²,

1. Department of Biostatistics, Harvard T.H. Chan School of Public Health, Boston, MA
2. M.P.H. Program in Quantitative Methods, Harvard T.H. Chan School of Public Health, Boston, MA
3. Emergency Preparedness Research, Evaluation and Practice Program, Division of Policy Translation and Leadership Development, Harvard T.H. Chan School of Public Health, Boston MA
4. Harvard Medical School, Boston, MA
5. Department of Emergency Medicine, Division of Emergency Preparedness, Massachusetts General Hospital Boston, Boston, MA; Department of Emergency Medicine Harvard Medical School, Boston, MA.
6. Phase V Technologies, Inc., Wellesley Hills, MA
7. Massachusetts Association of Health Boards, Wellesley Hills, MA

The National Academies of Sciences, Engineering and Medicine

Lisa Brown, M.P.H., Autumn Downey, Ph.D.

Health Services Research & Development Service, Department of Veterans Affairs

Karli Kondo, Ph.D.

Harvard T.H. Chan School of Public Health Communicating Author:

Marcia A. Testa, M.P.H., Ph.D.

617-432-2818, testa@hsph.harvard.edu

Department of Biostatistics
Harvard Chan School of Public Health
677 Huntington Ave
Boston, MA 02115

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EXECUTIVE SUMMARY

Background

Synthesizing the knowledge base for public health emergency preparedness and response (PHEPR) capabilities and functions is a critical step for prioritizing, planning, and developing future education and research programs. While several studies have reviewed public health emergency preparedness and response (PHEPR) research studies, to date, none have compiled, stratified, or benchmarked the published research literature using the PHEPR capabilities and practices.

Objectives

To conduct a systematic review of the literature, categorizing the retrieved articles into capabilities and practices, abstracting structured and unstructured data, characterizing the empirical qualities of the studies, and using descriptive statistics and graphical evidence mapping methods to explore the scope, depth and extent of the published literature supporting the practices of PHEPR.

Research Design

We conducted a multi staged, iterative, systematic scoping review and evidence mapping of research studies published between September 2001 and April 2019 retrieved from MEDLINE, EMBASE, PUBMED, SCOPUS and other data sources. The articles evaluated the actions of public health (local, state or national level) in the United States and worldwide that involved the practices, functions, task and resources described in the 15 capabilities as documented in the reported published entitled “Public Health Emergency Preparedness and Response Capabilities, National Standards for State, Local, Tribal, and Territorial Public Health” published by the Centers for Disease Control and Prevention (CDC).

Methods

The raw data abstraction database consisted of the article’s citation data (title, authors, keywords, journal, year of publication, abstract), capability suggestions, primary capability assignment, primary practice assignment, and unstructured, free-text qualitative descriptive data (e.g., location of the study, aim of the study, type of data collection and evaluation, type of data, location of the study and why the reviewer chose the primary capability category). It also

consisted of 22 structured variables characterizing study characteristics, including the type of study, outcomes, time frame, data collection methods, agency, sample size, impact variable, and geographical setting. These variables were used in a taxonomy analysis to create a reduced transformed variables database for performing descriptive statistics, evidence maps and cluster analyses.

Results

A total of 5,526 articles were retrieved from 13 separate electronic and expert-guided searches. Of these, 1,872 were classified into one of the 15 PHEPR capabilities with the final reconciliation yielding [1,692 articles](#), of which 1,106 articles qualified as evidence-based studies for the evidence mapping analyses. This database of 1,692 articles included non-evidentiary articles on opinion, position and descriptive studies in addition to systematic, chart and documents reviews. The evidence mapping database of 1,106 articles excluded these two study design categories. The most frequent capability classification was *Capability 1 – Community Preparedness* (21.9%) and the least frequent, *Capability 12 – Public Health Laboratory Testing* (1.4%). The most common study design category was *non-impact quantitative studies* representing 33.5% of all articles and 51.3% of evidentiary studies. Modeling studies were the next most common type of study(14.6%), followed by qualitative studies (13.4%) and after-action reports (12.1%). Of the 567 non-impact quantitative studies, 338 (59.6%) used surveys or questionnaires for data collection, while the remaining used some other form of secondary data collection. Only 95 (8.5%) of the 1,106 studies qualified as quantitative impact studies. Just under half of all studies (46.7%) involved a real disaster. The most common study outcome was the individual health outcome (30.4%). Across the capabilities there were differences among the agencies and organizations to whom the research was addressed. The most common agency was at the Country or National level (24.5%) with 63.2% of studies conducted in the U.S. The multidimensional, evidence maps revealed different study profiles across both capabilities and practices with regard to study design, outcomes, geographic setting, agency and disaster type as explained further in the Conclusions and Discussion section.

Limitations

The task of finding and classifying the body of research underlying all of the 15 PHEPR capabilities was challenging due to the broad scope, complexity, and nature of the research

topics, and due to time limitations, it was not possible to conduct all searches sequentially. Therefore, it is likely that studies were missed. Another limitation was that while capabilities might be largely independent of each other, many studies had secondary or tertiary capabilities that were not represented in the evidence maps most likely underestimating the research for these secondary and tertiary capabilities. Each capability had unique practices, 69 practices across all capabilities. These practices also required selecting one primary practice for each study which also might result in underestimating the number of articles across highly associated practices. Finally, there are limitations as to what can be gleaned from the two-way frequency tables and the multidimensional evidence maps. The magnitude of the “gaps” perceived visually in the maps should be interpreted based upon weighting in terms of not only the observed white space on the map and the density of similar symbol clusters, but the particular hazard (e.g., disease outbreak, hurricane) of interest and vulnerability (e.g., resources and reliance) for a specific jurisdiction.

Future Analyses

Some of the limitations cited above could be addressed by conducting more refined clustering analyses and paired with a hazard vulnerability and jurisdictional risk weighting. Natural language processing of the text of the abstracts also could be used to abstract more detail on disaster type and jurisdictional and geographic areas affected for this purpose.

Conclusions and Discussion

Although the prioritization could be better defined with more refined clustering methods and hazard vulnerability weighting by disaster type and jurisdiction, simple visual inspection of the evidence maps indicated that evidentiary support for certain capabilities and practices were weaker than others. In particular, the following practices were identified as being weaker than others accounting for the potential probability and severity of the disaster or emergency most likely to be mitigated by improving the capability in the practice area. The top three practices needing further evidentiary support were: Capability 11 – Non-Pharmaceutical Interventions Practice 3 - Community Social Distancing; Capability 1 – Community Preparedness – Practice 6 – Mental and Behavioral Health and Practice 4- Vulnerable Populations. Other areas that appeared to be weak were Capability 2 – Practice 3 – Long Term Health Outcomes; Capability 3 Practice 4 – Crisis Leadership; Capability 7- Mass Care – Practice; Capability 10 – Practice 2

Healthcare System Coordination; Capability 13 – Public Health Surveillance and Epidemiology Investigation and Practice 4 Animal Surveillance and Vector Control and Capability 14 – Responder Health and Safety – All Practices. It should be noted that in lieu of additional clustering and hazard vulnerability and jurisdictional risk weighting, selection of these research priority practices from the evidence maps required incorporating background knowledge and expertise not evident in the map. It is important for the different stakeholders to review the maps to incorporate their own individual knowledge and expertise.

In summary, the evidence maps from this scoping review are presented primarily as a graphical reference guide for practitioners, researchers, policy planners and funding agencies. They should be used as a tool for answering targeted questions pertaining to the existing scope of the evidence for specific practices and to the extent possible determine which areas of research are the weakest and strongest. Prioritizing those practices most deserving of further research and funding is dependent not only upon the size of the evidence gaps observed, but also the type of disaster or emergency, resources, workforce personnel and other components of the public health system available to the federal, state and local public health agencies.

BACKGROUND

Cataloging and grading the research evidence for public health emergency preparedness and response (PHEPR) capabilities and functions is a critical step for prioritizing, planning, and developing future education and research programs. In 2011, recognizing the need for PHEPR practice standards across public health agencies in the United States, the Centers for Disease Control and Prevention (CDC) established the 15 PHEPR capabilities. Since that time the CDC revised those capabilities in reaction to lessons learned from real-world disaster and emergency responses, advances in public health preparedness science, new regulations and guidance's, advances in technology, findings from internal reviews and assessments, expert feedback from the practice community, and input from allied federal agencies and professional associations. The most recent update to these standards was published in January 2019 ¹, and hereafter will be referred to as the "PHEPR Capability Standards". These standards form the basis for current education and training for state, local, tribal, and territorial public health agencies. They are used by the 50 states, four cities, and 8 U.S. territories receiving funding through the CDC's Public Health Emergency Preparedness (PHEP) cooperative agreements ².

While several studies have reviewed the PHEPR research knowledge base, to date, none have compiled, stratified, or benchmarked the published research literature using the PHEPR capabilities and practices. In 2014, Leinhos et al. reported that the CDC-sponsored network of academic Preparedness and Emergency Response Research Centers (PERRCs) ^{3,4,5} funded between 2008 and 2013 conducted 34 research projects, resulting in more than 130 peer-reviewed publications and 80 tools. ⁶ The Centers also trained more than 30 new investigators and engaged more than 500 research partners. In a 2015 scoping review and stakeholder study, Khan et al. noted that primary PHEPR research was weak. ⁷ In their analysis of 58 qualifying research studies, they found knowledge gaps in attitudes and beliefs, collaboration and system integration, communication, quality improvement and performance standards, and resilience. In 2017, Savoia et al. evaluated the scope of public health preparedness systems research in the U.S. from 2009 to 2015 as benchmarked against a 2008 Institute of Medicine report that identified four research priority areas including, training, emergency communications, maintaining sustainable response systems and performance metrics. ⁸ Their analysis of 156 articles revealed that PHEPR systems research had evolved from general inquiry evaluating

specific interventions using more empirical design with support from CDC funding. In a 2018 follow-up analysis, Savoia et al. reported that the CDC-sponsored Preparedness and Emergency Response Research Centers (PERRCs) played a substantial role in the majority of the research conducted in this field⁹. In 2019, the CDC conducted a study to specifically catalog and evaluate the evidence database within the areas of system evaluation criteria and metrics. They found 29 articles that developed or assessed organizational characteristics, emergency response performance, and workforce capacity or capability.¹⁰

The National Academies of Science and Engineering (NASEM) Committee on Evidence-Based Practices for Public Health Emergency Preparedness and Response (PHEPR) has been tasked with conducting a comprehensive review and grading of the evidence for PHEPR practices based on evidence-based literature generated since September 11, 2001. NASEM commissioned this systematic review and evidence mapping to inform its deliberations regarding the extent and nature of the research undertaken about practices that fall within the 15 PHEPR capabilities. A PHEPR practice is broadly defined as a type of process, structure, or intervention whose implementation is intended to mitigate the adverse effects resulting from a public health emergency on the population as a whole or within subgroups of the populations. Our primary objective for this study was to conduct a scoping review and evidence mapping of the academic literature to aid in the Committee's deliberations.

METHODS

Systematic Search Approach

To classify the global construct of capability into practices, it was necessary to clearly define the underlying domains, functions tasks and resources pertaining to each capability. From the PHEPR Capability Standards report we see that the standards are organized into six domains and two tiers ([Table 1](#)). Tier 1 standards form the foundation for public health emergency preparedness and response. Tier 2 capability standards are more cross-cutting, and their development relies upon having Tier 1 capability standards established in collaboration with external partners and stakeholders. Each capability is also defined in terms of its specific *functions, tasks, and resources*. **Functions** are critical segments of the capability that must be carried out to achieve the capability definition. [Table 2](#) lists the functions for each of the

capabilities. *Tasks* are the action steps aligned to one or more capability functions. Capability tasks must be accomplished to complete a capability function. Structural public health system capacities comprise the *resources* required at the infrastructure, informational, organizational, physical, human, and financial levels to address a public health need or emergency.

Our systematic review approach has the characteristics of scoping, quick evidence assessment and mapping reviews¹¹ in that it is primarily intended to categorize, describe and identify gaps. These types of reviews lend themselves to a generalized approach to finding and characterizing the studies in the field with minimal attempts to evaluate them for quality. The approach was selected in order to systematically^{12,13} map and synthesize PHEPR practice trends and characteristics that are applicable to the 15 PHERP capabilities. Due to the broad and complex nature of these multidimensional capability constructs, the sensitivity and specificity of identifying the capabilities and practices using electronic search engines was found to be extremely low. As such, the electronic searches served primarily to assemble a broad collection of general PHEPR publications that could be classified by manually reviewing the abstracts and full text in a sequential, multi-stage, targeted capability approach that classified the publication as either belonging primarily to one target capability or not. If the article was determined not to belong to the target capability, the reviewer suggested a better fitting alternative capability and recycled the citation back through the review process. It was also initially anticipated that the grey literature would be part of the search process. However, due to the requirement that the sources be primarily research-based, the grey literature including abstracts, proceedings monographs and other unpublished reports in nearly all cases did not meet the inclusion criteria needed to be deemed evidence-based research. As such, we only included articles published in academic journals as described in the inclusion and exclusion criteria below.

Inclusion and Exclusion Criteria

The following inclusion and exclusion were applied as part of the selection of articles. There was no requirement that the article contain evidence-based information since that was a determination to be made of the basis of the structured and unstructured study or report characteristics.

Inclusion Criteria:

1. The article includes the actions of Public Health (local, state or national level) in the United States and worldwide that involves the practices, functions, task and resources described in the 15 Capabilities described in the document entitled “Public Health Emergency Preparedness and Response Capabilities, National Standards for State, Local, Tribal, and Territorial Public Health”, from the Center for Preparedness and Response, Centers for Disease Control and Prevention, October 2018, Updated January, 2019.
2. The article includes public health actions in some aspect of public health and emergency preparedness, response, or recovery.
3. The article includes an evaluation of public health actions during an emergency event (whether based on qualitative or quantitative data) or the article proposes standards or guidance that have been derived from a process.
4. The article is published in a scholarly journal.

Exclusion Criteria:

1. Articles that were published before September 1, 2001.
2. The article does not include an abstract, either structured or unstructured.
3. Evidence referring to settings of complex humanitarian emergencies or conflict clearly outside the scope of public health.
4. All other areas not specifically related to the public health preparedness capabilities. For example, while basic science, genetics, climate change, and clinical medicine research topics may impact health outcomes, they are not specifically germane to influencing or improving the 15 PHERP capabilities.

Search Strategy and Process Flow

Our search strategy was designed to maximize between-capability thematic differences while minimizing within-capability differences. Since there was not one well-defined, homogeneous search topic, the search strategy was undertaken as a multi-stage, iterative process involving manual, rather than electronic categorization using search terms. We created a brief outline for each capability that included a set of key text phrases, terms and relevant passages from the PHEPR Capabilities Standards report. Together with the NASEM project team, practice definitions were created for each capability that mirrored to a large degree the capability functions and tasks. The full text of the PHEPR Capability Standards report was used to clarify

definitions. In total, 69 practices were created. The key terms and phrases for the practices are given in [Appendix 1](#).

Manual classification of the capabilities, practices and unstructured and structured data abstraction was carried out by the team of Harvard Chan researchers. The results of electronic searches from MEDLINE, EMBASE, PUBMED and SCOPUS were exported into EndNote X9. A search code was defined for the different searches as applicable so that the search process could be documented. The title, abstracts and keywords were reviewed initially, and any publication or article was removed if there was no direct relevance to the PHEPR topic, or if it did not meet other inclusion or exclusion criteria. The full text was obtained if available online using the Harvard Countway Library Online System and if not the articles were retrieved and scanned by the Harvard Countway librarians. The electronic searches conducted by the NASEM librarians for each of the 15 capabilities were used for the targeted manual classification reviews. After classification and determination was made the full text of the article was used to extract structured and unstructured data on study characteristics. Additional targeted reviews were added through expert-assisted guided searches as required until a minimum number of between 25 and 75 articles (depending upon the scope of the capability) were retrieved.

Briefly, an initial PubMed basket search was conducted on the phrase “public health preparedness”. Based upon the distribution of the articles distributed across the 15 capabilities, targeted searches and guided expert searches were conducted on each of the individual capabilities starting with the basket search capabilities that had the lowest numbers of retrieved articles. The final search conducted was a basket search of the PERRC publications. A more detailed explanation can be found in [Appendix 2](#). The flowchart characterizing the search process is depicted in Supplemental [Figure S1-Panel 1](#), [Panel 2](#) and [Panel 3](#) and the corresponding numerical tallies of the articles retrieved, selected and categorized by capability are given in Supplemental [Table S1](#). Of the 1,872 articles that were classified into one of the 15 Capabilities (or Alternative Capabilities, n = 10, later recoded as one of the 15 Capabilities), 150 were removed because a final review determined that they were either conference proceedings, scientific abstracts, duplicates across capabilities or possessed some other disqualifying characteristic, or the 8 variables above could not all be classified with the information given. The final database contained 1,692 articles.

Abstraction, Database Coding and Transformed Variables for Evidence Mapping

The raw data abstraction database consisted of the article's citation data (title, authors, keywords, journal, year of publication, abstract), capability suggestions, primary capability assignment, primary practice assignment, and free-text qualitative descriptive data (e.g., location of the study, aim of the study, type of data collection and evaluation, type of data, location of the study and why the reviewer chose the primary capability category). It also consisted of the 22 structured variables listed in [Appendix 3.1](#). The evidence mapping required that the data be transformed to yield categories suitable for producing evidence maps, graphics and other visualizations. As such, using a computerized taxonomy algorithm, the 22 structured variables in Appendix 3.1 "*Structured Variables for Data Abstraction*" were used to create eight collapsed variables with more limited response options, including: primary capability, primary practice, study design, sample size, setting disaster type, agency and outcomes as described in more detail in [Appendix 3.2](#). The brief definitions for the *study design categories* can be found in [Table 3](#). The brief definitions for the *outcome categories* can be found in [Table 4](#). Similar to the study design variable, in order to produce these reduced outcome categories, a taxonomy algorithm was employed. This initial categorization was then reviewed and reconciled by the NASEM and Harvard Chan reviewers.

After a final reconciliation of the eight variables referenced above was conducted independently by the NAS reviewers, descriptive frequency tables and visualization graphics were produced as described in more detail below. Some of variable responses were consolidated further to optimize the presentation of the visualizations. In order to focus the evidence mapping analysis on evidence-based studies, the evidence mapping database excluded articles from the two study design categories listed above, "Opinion, Concept, Position Papers" and "Literature/Documents Review" as described in [Table 3](#) resulting in an evidence mapping database subset consisting of 1,106 articles.

Statistical Methods

Search codes, citations, keywords and abstract text, unstructured and structured data was abstracted by manual review and entered into an Excel database. The data were imported into SPSS Version 25 and descriptive statistics, graphics and frequency tables were generated. The

transformed variables described above were exported into Excel for the creation of the evidence mapping visualizations and clustering analyses.

The structure of the evidence maps was in the general form of a two-dimensional grid populated with symbols each representing an individual study and had a distinct appearance depending upon the specific characteristics of the study which appear in the legend. For example, in the Capability x Outcome maps (e.g., see [Figure 9](#) in the Results Section) as noted in the legends, the circle and triangles represent individual and organizational sampling units respectively. The purple-shaded symbols indicate that the study was comparative, and the blue-shaded symbol that the study was non-comparative. If the symbol was a solid shade, the study involved a real disaster, if vertically hashed, the study involved a simulated disaster, and if diagonally hashed, the study did not involve a disaster. The sample sizes were represented by the relative size of the symbol which also depended upon the sampling unit. For these Capability x Outcome maps graphs, in general, the larger, solid purple symbols (either circles or triangles) are more rigorous since they involve real disasters, are comparative impact studies, and have larger sample size. Hence, the appearance of a clusters of symbols tells one about not only the prevalence of the studies within a cell, but also other characteristics as well. The Practice by Study Design maps had a third dimension that produced a map for each capability.

Since the capabilities covered different scopes, the density of the areas covered within a cell is proportional to the total sample size for that capability, and as such, one should be cautious when comparing densities between capabilities. Also, the practices (rows) are different for each capability and the total densities for a particular capability should not be used for between-capability comparison purposes. Statistical analyses using two-step clustering was undertaken to reveal natural groupings that would otherwise not be apparent. Additional preliminary analysis employed natural language processing of the abstract text to create more refined topic codes, such as the type of disaster or emergency (e.g. “infectious disease outbreaks”). These codes were used to further evaluate the capability and practice research areas to determine the type of hazard and the potential vulnerability of the population affected.

RESULTS

Overall Capability Distribution and Publication Time Trends

[Table 5](#) and [Figures 1a](#) and [Figure 1b](#) show the absolute and relative distributions of publications across the [15 Capabilities for the full publication database \(N = 1,692\)](#) and the evidence mapping database (1,106). Among the 1,692 articles in the full database, the most frequent capability classification was *Capability 1 – Community Preparedness* (21.9%) and the least frequent, *Capability 12 – Public Health Laboratory Testing* (1.4%). The relative proportions for each of the capabilities reflected not only the research interest in the capability area, but how broadly and how complex the capability was defined. Community Preparedness covers a wide range of topics, while the foundational research for laboratory testing lies outside of the public health preparedness topic area. In the evidence mapping database, (N = 1,106) *Capability 1 – Community Preparedness* was also the most common (20%) while *Capability 5 - Fatality Management* and *Capability 12- Public Health Laboratory Testing* were the least common (both 1.4%).

For planning purposes, it is interesting to examine the research production time trends. [Figure 2](#) displays the number of publications in the full database by year showing a precipitous drop in the U.S. rate of publication production in 2015. This was also the year that funding for the academic centers for public health preparedness ended. By 2018 the number of publications returned to just above 2014 publication rates; however, in 2018 the United States accounted for only 55.6% of all studies, nearly 15% lower than in 2013 (69.5%). Conversely, as a proportion of all studies, non-U.S. studies increased from 24.6% to 40.4% during that same period. For the evidence database, the time trends were similar.

Overall Study Design Distributions

As shown in [Table 6](#) and [Figure 3](#), 34.6% of all articles were classified as non-evidentiary (*Study Design Category 1 - Opinion, Concept, Position Papers or Category 3 - Literature/Documents Review*), while 65.4% of publications included some form of systematic data collection and analysis that could provide evidence regarding the PHEPR Capabilities. For better graphical visualization of the mapping charts, the four original “quantitative” study design categories were collapsed into two categories, one for the impact studies (comparative and non-

comparative) and one for the non-impact studies (survey and non-survey). The most common study design category was *non-impact quantitative studies* representing 33.5% of all articles and 51.3% of evidentiary studies. Of the 567 non-impact quantitative studies shown in [Table 6.1](#), 338 (59.6%) used surveys or questionnaires for data collection, while the remaining used some other form of secondary data collection. Most *quantitative non-impact studies* were sampled cross-sectionally (395/567, 70%) as compared to longitudinally (39/567, 6.9%). The remaining studies were coded as other timeframes (e.g., event description). There was a total of 95 (8.5%) *quantitative impact studies*. The 22 *quantitative non-comparative impact studies* also were predominantly cross-sectional (17/22, 77.2%). In contrast, of the 73 *quantitative comparative impact studies* only 12/73 (16.4%) were coded as using cross-sectionally collected data while 45/73 (61.6%) used longitudinally collected data. Among evidentiary studies, *modeling studies* (14.6%) were the next most common type of study after *quantitative non-impact studies*, followed by qualitative studies (13.4%) and after-action reports (12.1%).

Type of Disaster, Outcome, Study Design, Agency Focus and Geographic Setting by Capability

Type of Disaster by Capability

The 1,106 evidence-based publications had a relatively heterogeneous distribution across capabilities with regard to their focus on the types of disasters, outcomes and agencies studied or targeted. The [Figure 4](#) horizontal bar chart displaying the absolute number of publications stratified by capability shows that there are very different disaster capability profiles. As shown in [Table 7](#) and [Figure 4](#), for all publications, just under half of all studies (46.7%) involved a real disaster. While *Capability 1 – Community Preparedness* had the most evidence-based studies as previously reported, only 21.3% of all studies in this category involved a real disaster. *Capability 15 – Volunteer Management* was the only capability that had a fewer percentage of studies of real disasters (14.9%). This would be anticipated because of the planning focus of the functions related to these two capabilities. In contrast, *Capability 2 – Community Recovery* studies by the nature of its associated functions and resources were almost entirely focused on the consequences of real events (98.8%), as were *Capabilities 4 -Emergency Public Information and Warning* (69.7%), *13 - Public Health Surveillance and Epidemiological Investigation* (69.6%) and *5-Fatality Management* (66.7%), but to a slightly lessor degree. Other capability

areas that focused primarily on modeling and disaster simulations were *Capabilities 9 - Medical Materiel Management and Distribution* (38.9%) and *11 – Non-Pharmaceutical Interventions* (38.4%).

As detailed in [Appendix 3](#) and [Data Element 15](#) “If either “Real” or “Simulated” was selected, what type of disaster or emergency best describes it?”, 17 different types of emergencies were coded for a more detailed analysis. In the mapping evidence database, of 516 real disasters or health emergencies shown in [Table 7](#), “infectious disease outbreaks” were the most common (209/516, 40.5%), followed by hurricanes (18.4%), earthquakes (9.5%), chemical emergencies (2.5%), floods (2.3%), other terrorism associated event (1.9%), Tsunami (1.4%), extreme heat (1.4%), tornado (1.4%), radiation (1.2%), winter weather (1.0%), bioterrorism attacks (1.0%), bombing (1.0%), and with the remaining events (Explosions, land and mudslides, mass shootings and wildfires) less than 1%. The “other events” category allowed the reviewer to enter free text for an event type which accounted for 9.7% of total responses. An additional 5.4% were not coded, most often because the reviewer thought that the articles addressed different or specific types of real disasters. However, of the 50 free-text events entered, nearly all could be coded into one of the original 17 categories with less specificity than recorded by the reviewer in the free-text field.

Type of Study Outcomes and Study Design by Capability

[Table 8.1](#) and [Figure 5](#) show that the most common outcome studied was the individual health outcome (30.4)%. The horizontal bar charts stratified by capability indicated that there were also different outcome-type profiles across the capabilities. Except for the *cost outcome*, which represented only 1.3% of all studies, the other three outcome types across all the evidence studies were relatively equally balanced, including *process* (25%), *system* (22.4%) and *individual non-health outcomes* (20.9%). The bolded cells in [Table 8.1](#) represent the maximum percentage across outcome types within the capability. The capability groups formed under the maximum percentage values largely reflect the *functions* of the capability. For example, capabilities that have the *individual health outcome* as their most common outcome (maximum cell value within capability) included *Capability 2-Community Recovery* (64.3%), *Capability 13 - Public Health Surveillance and Epidemiologic Investigation* (58.8%), *Capability 11 - Non-Pharmaceutical Interventions* (55.4%), *Capability 14 - Responder Safety and Health* (54.9%), *Capability 5 -*

Fatality Management (46.7%), and *Capability 7 Mass Care* (33.0%). These capabilities form a conceptual cluster in that they are fundamentally different than the capabilities that have the *process outcome* as their maximum cell value, namely, *Capability 4 - Emergency Public Information and Warning*, *Capability 6 - Information Sharing*, *Capability 8 - Medical Counter Measure Dispensing*, *Capability 10 - Medical Surge*, and *Capability 12 - Public Health Laboratory and Testing*. The *individual health outcome* capabilities focus on interventions that impact human health and recovery, while the *process outcome* capabilities focus on information, warning, dispensing and testing – all representing processes of the PHEPR system. *Individual non-health* outcomes aligned most strongly with *Capability 1 - Community Preparedness* and *Capability 15 - Volunteer Management* capabilities which again reflect the planning, training and education functions, rather than response and recovery functions. *Capability 3 - Emergency Operations Coordination* and *Capability 9 - Medical Materiel Management and Distribution* capabilities most often assessed *system-level outcomes*.

The ability to measure and evaluate different types of outcomes is largely related to the type of study design. For example, since it is very difficult to experimentally test whether a particular social distancing intervention works during an infectious disease outbreak unless the epidemic is ongoing, modelling studies are often used. [Table 8.2](#) and [Figure 6](#) show the distribution of the study design categories by capability. A total of 50 (44.6%) of the 112 studies classified as *Capability 11- Non-Pharmaceutical Interventions* used *modelling* which was the maximum study design percentage across the capabilities. For those outcomes that required a direct assessment from an individual, quantitative survey studies were the most common design as demonstrated by the fact that 50 (61.7%) out of the 81 studies under *Capability 2 – Community Recovery* used a quantitative survey design. The only other capability that used the quantitative survey design more than *Capability 2* was *Capability 15 – Volunteer Management*, which reflects the types of evaluations that are often used to assess the perceptions, motivations and attitudes among volunteers. The highest proportion of quantitative comparative impact studies relative to the other designs were those related to *Capability 1 - Community Preparedness* (12.2%). This is probably due to the greater feasibility of conducting experimental designs on issues of planning and training during periods of non-emergency. (). As also shown in [Table 8.2](#), overall the percentage of studies using a *quantitative comparative impact design* --

the design that is considered to have the most internal validity for comparative assessment -- was only 6.6%.

Type of Agency and Geographic Setting by Capability

The agencies and organizations for whom the evidence would be most appropriate was originally coded into the categories listed in [Appendix 3, Data Element 20](#). For evidence mapping, these response categories were reduced to three categories: 1) State, Local, Territorial and Tribal public health governmental agencies (SLTT); 2) Healthcare Institutions, and 3) All Other Organizations, Agencies and Governments as noted in [Table 9](#). Similar to the cross-tabulations of capabilities by disaster type and outcome, across the capabilities there were differences among the agencies and organizations for whom the research was addressed. As shown in [Figure 7](#), the profiles of the number of research publications across the capabilities varied between the different agency types. From [Table 9](#), it can be seen that the most common agency involved or addressed was the “Other Category” (42.9%). If this category is broken down into the six sub-categories, 271/475 (57.1%) were classified as “National or Country” governmental agencies. The majority of these (52%) were studies based outside of the United States. This is most likely due to the fact that unlike the United States, many countries have more nationally directed healthcare and public health systems.

As shown in [Table 10](#), of the 1,106 evidence-based research studies, 699 (63.2%) were based in the United States, 366 (33.1%) were based in other countries or regions outside of the U.S. and 41 (3.7%) were considered worldwide or global. The geographic setting (United States versus Non-US or Global) across the 15 capabilities is displayed in [Figure 8](#). While most of the capabilities reflected the overall pattern of 63.2% U.S. studies, there were three capabilities where the United States dominated more than 15 percentage points higher than the average of 63.2% based in the United States. These capabilities included *Capability 8 - Medical Countermeasure Dispensing* (87.3%), *Capability 15 - Volunteer Management* (77.4%) and *Capability 03 - Emergency Operations Coordination* (76.6%). There were two capabilities where the United States did not dominate, *Capability 11 - Non-Pharmaceutical Interventions* (46.4%) and *Capability 5 – Fatality Management* (50.0%).

Multidimensional Evidence Maps

Examining Potential Gaps in the Strength of Evidence for PHEPR Quantitative Impact Studies

As indicated previously in [Table 6](#), 95 studies were categorized as quantitative impact studies. Of these, 22 were non-comparative and 73 were comparative, 23 were non-US or global and 72 were based in the United States. In order to visually evaluate these impact studies, multidimensional evidence maps were constructed graphically depicting each study by a symbol with distinctive outcome, sampling unit, sample size and disaster type characteristics using a two-dimensional grid (Capability by Outcome) as described in the Statistical Methods Section. [Figure 9](#) shows the results for the 72 studies conducted in the United States, while those conducted outside of the United States are shown in [Figure 10](#).

As mentioned in the Methods section, one has to be cautious when comparing cell-densities across the capabilities, here represented by rows, because of the differences in the scope, target area and practices resulting in substantially different sample sizes among capabilities. The key to valid interpretation is to look across the columns within each capability to visualize the *relative distributions* of the *outcome categories*. As shown in [Figure 9](#), there are *no solid symbols* in the *individual non-health outcomes* column for *Capability 1 – Community Preparedness*. Looking at the legend, one sees that solid symbols represent *real disasters*, meaning that there are no real disaster studies in this particular *outcomes cell*. We can also see that all the circles representing studies on individuals, and triangles represent studies that are organizations. The size of the symbol shows the distribution of larger versus smaller studies – here showing a good balance among the different sizes. The total cell density is 15 studies within the *outcome category, individual non-health outcomes*, more than any other PHEPR Capability x Outcome cell. As mentioned previously, since community preparedness studies are typically not undertaken during a real disaster, there would most likely be non-individual health outcomes. Furthermore, the individual non-health outcomes are most likely related to education and training. In contrast, [Figure 9](#) shows that *Capability 11 – Non-Pharmaceutical Interventions* has all *solid circles* under the outcome “individual health” and the fact that they are solid indicates a “real disaster” study design. The differences between these two capabilities would be expected since preparedness studies would focus more on non-health individual

outcomes occurring prior to disasters, while non-pharmaceutical intervention research, such as social distancing, would most likely be evaluated during an outbreak. In this map, there are clearly gaps in areas that one might expect to see quantitative impact studies, such as community recovery, public information and warning, mass care, public health laboratory testing and volunteer management. For these capabilities there are just a few or no studies populating the cell. [Figure 10](#) shows the multi-dimensional characteristics for non-U.S. studies. These 23 studies were clustered primarily in two areas of the evidence map – one cluster was in non-pharmaceutical interventions, and the other cluster in community preparedness. For both capabilities individual health and individual non-health outcomes were used. There are too few studies to discern any other revealing patterns.

Multidimensional Evidence Maps for Examining Potential Gaps in the Strength of Evidence for PHEPR Practice Areas within the 15 Capabilities by Study Design, Outcome, Organization and Setting

Evidence maps were created displaying the study design, outcome, organization and setting stratified by practice area within capability using the 1,106 articles in the evidence database. Each capability map contains a two-way grid with *practices* as rows and *study design* as columns. Each symbol within the cells of the matrix represents one publication, with circles indicating U.S. studies and triangles indicating non-U.S. studies. The five different types of *outcomes* were depicted by different colored symbols, while the presence and direction of the hash marks were indicative of the *type of agency*. The primary capability by practice cell frequencies and percentages within each capability are given in [Table 11](#) and the evidence maps are shown in Figures 11.1 – 11.15 and described in more detail below. These maps are a good way to visually inspect patterns prior to undertaking a multivariable cluster analysis or weighting by hazard vulnerability scores. This graphical approach combined with descriptive frequencies and proportions allows one to examine the characteristics of each study and to observe directly how these individual cases distribute across capabilities and practices.

Capability 1 - Community Preparedness accounted for the largest number of evidence-based publications (221/1,106; 20%) and most tended to cluster within the more rigorous quantitative and qualitative study designs cells ([Figure 11.1](#)). The most common practice areas were vulnerable populations and education and training. *Practice - 6 - Mental and Behavioral*

Health was the least frequent area of study accounting for only 17 (4.6%) of publications. The practices *1- Risk Assessment*, *2 - Community Partnership Building*, *4- Vulnerable Populations*, *5-Household/Individual Preparedness*, *7- Training and Education* and *8-Pre-Incident Planning* were most heavily supported by quantitative non-impact studies. The distribution across outcomes showed a relatively higher number of individual non-health outcomes (n = 76) and system level outcomes (n = 65) as compared to the other outcome categories. This distribution most likely reflects the focus on knowledge, behavior, and personal and workforce preparedness outcomes as well as systems outcomes, such as those involved in evaluating building resilience and executing plans. The largest unpopulated areas were in practices *6 - Mental and Behavioral Health* and *Practice 3 - Information Sharing and Social Networks*. Both of these unpopulated areas could signify important gaps in current research and knowledge.

As shown in [Figure 11.2](#), **Capability 2 - Community Recovery** had a strong focus on quantitative, cross-sectional surveys reflected by the heavy cluster of studies within the *quantitative non-impact study design* and individual health outcomes (purple color) in the following practice areas: *1 - Post-Disaster Needs Assessment*; *2 - Monitoring and Surveillance and 3 - Long-Term Health Outcomes*. In contrast, the open areas among those same practices in the *quantitative impact study design* column are revealing. Only *3 - Long-Term Health Outcomes* had just two studies, with the other two having none. One might expect that studies evaluating treatment and programs mitigating the long-term effects of disasters would be of major interest. In addition, the two practices, *4 - Public Health System Operations* and *5 - Evaluating Recovery Efforts* had just a few studies, while and *6 - Post Event Risk Communication* had only one quantitative impact study.

Capability 3 - Emergency Operations and Coordination and **Capability 4 - Emergency Public Information and Warning** ([Figure 11.3](#) and [Figure 11.4](#)) shared similar patterns of relatively balanced distributions across the study design types in those practices that were well populated, as well as fairly even distributions with regard to outcomes, organization and setting. The one exception is the unpopulated area within the *Capability 3 - Practice 4 – Crisis Leadership* cell which had no studies across all study design columns. It should be mentioned here that only the primary or most dominant practice was coded and displayed here. Leadership training programs could have been part of other capabilities such as *01-Community*

Preparedness, 03-Emergency Operations Coordination or 10-Medical Surge. The outcomes studies which showed a preponderance of green (individual non-health, red (process) and orange (system) outcomes seemed appropriate for these capabilities. The higher proportion of non-solid symbols indicated that healthcare and national and federal agencies were more likely to be the target audience for these research studies.

Capability 5 – Fatality Management has clearly defined and limited functions and as such, only two practices resulting in the capability with the fewest number of articles, ([Figure 11.5](#)). The studies within this capability had a focus on individual health outcomes (purple color) and mostly quantitative non-impact study designs (second column). There were more non-U.S. studies which is most likely due to the fact that many large casualty disasters requiring fatality management have occurred outside of the United States.

Capability 6 – Information Sharing ([Figure 11.6](#)) stands out as compared to other capabilities because it had proportionally more articles with a quantitative impact design with more system (orange), process (red) and individual non-health (green) outcomes. Considering the practices of this capability, *1-Stakeholder Identification and Relationship Building*, *2 - Information Sharing and Data Elements* and *3 – Situational Awareness*, one would anticipate that these types of outcomes would be the most appropriate to study.

Capability 7- Mass Care ([Figure 11.7](#)) shows more open areas in the two practices of *3 - Shelter Considerations* and *4 - Vulnerable Populations*. These are two areas where one might have expected to see more studies. However, again only the primary practice was analyzed and many of the practices overlapped. For example, the first two practices, *1-Mass Care Assessment* and *2 - Mass Care Population Health* could have studies involving shelter consideration for vulnerable populations. The fact that the practices were by definition represented under one construct make them by definition non-mutually exclusive. Further investigation using clustering algorithms and natural language processing to search for more specific phrases within the text of the abstracts could be useful for evaluating the relationships among the more highly associated practices.

Capability 8 - Medical Countermeasure Dispensing ([Figure 11.8](#)) displays the same type of patterns among setting, organization and outcome as other capabilities; however, with regard to study designs there is a strong focus on *modeling* relative to the proportion of modeling

designs observed in other capability categories. The two Capability 8 practices, 3 - *Communication and Coordination* and 4 - *Monitoring Reports and Adverse Events* appear to be under representative. Unlike the case described above involving the correlated practices, these two practices, 3 and 4, seem to be more independent with *Capability 8 Practices, 1 – Medical Counter Measure Needs Assessments* and 2 - *Dispensing System and Coordination*. As such, the gap in the underpopulated Capability 8- Practice 3 and 4 cells are more likely to point to a true research knowledge deficit.

For a somewhat related capability, **Capability 9 - Medical Materiel Management and Distribution** ([Figure 11.9](#)) patterns are distinctive because of the separation between U.S. and non-U.S. studies, with the U.S. studies concentrated toward the more empirical end of the study design spectrum. The larger number of *modeling* studies in the areas of *individual health outcomes* (purple symbols) seem appropriate given that the evaluation of shipments and distributions are often studied through supply chain modeling programs.

Capability 10 – Medical Surge ([Figure 11.10](#)) publications are highly concentrated in three cells representing *quantitative non-impact* study design and the two practices, 1 - *Workforce and System Preparations* and 3 - *Management During Events* with proportionally more non-U.S. studies and healthcare-based, after-action studies. *Practice 2 – Healthcare System Coordination* had few studies relative to the practices 1 and 2. It is of interest to note the high density of non- U.S. studies within practice 3 - *Management During Events* in the after-action study design .

Capability 11 – Non-Pharmaceutical Interventions ([Figure 11.11](#)) had a number of interesting clusters. Ninety percent of After-Action Report publications were conducted outside the U.S. All the publications with after-action study designs under *Practice 5-Monitoring Non-Pharmaceutical Interventions* were not only non-U.S., but were all targeted toward agencies that were not either state and local government or healthcare (diagonally hatched triangles). All but one reported on individual health outcomes (purple). The practice 3 -*Community Social Distancing* articles dominated other practices, representing 40% of all studies for this capability. In particular there were proportionally more modeling studies in this practice and the dominant color over the entire grid was purple indicating the interest in studying individual health

outcomes, particularly with modeling studies. Notably, there were few studies on the Practice 4 - Legal Considerations of Social Distancing.

Capability 12 – Laboratory Testing ([Figure 11.12](#)) had relatively few studies making it difficult to assess any patterns. However, as with the distribution of study design types over all studies, most of the Capability 12 studies fell within the most common study design category “Quantitative Non-Impact”. There were no studies found for sample management, and only one for laboratory activities. This might be due to the fact, that investigation in these areas typically are published in disciplines that might not self-identify as public health or public health preparedness. As would be expected for this capability, the process outcome was the most frequent type of outcome.

Capability 13 - Public Health Surveillance & Epidemiology Investigation ([Figure 11.13](#)) studies showed the highest number of studies within *Practice 1 - Surveillance and Detection*. *Individual health outcomes* (purple symbols) with the three other practice except for Practice 4 – Animal Surveillance and Vector Control --showing similar densities. As with most other capabilities, quantitative non-impact study designs were the most common. Of note, animal surveillance and vector control practices included only two studies, one in the U.S. and one outside the U.S. Given the high number of infectious diseases transmitted through animals and insects and the strong focus on disease surveillance and reporting as a core function of public health, this practice seems underrepresented with regard to evidentiary studies.

Capability -14 Responder Health and Safety ([Figure 11.14](#)) included a large proportion of *individual health outcomes* (purple symbols) with the highest number again within the *quantitative non-impact* study design category for *Practice 1-Occupational Health* and *2 - Behavioral Health*. Practice 3 -Planning showed more individual non-health studies. The four studies on *Practice 4 - Personal Protective Equipment* were all conducted outside of the United States.

Capability 15 – Volunteer Management ([Figure 11.15](#)) was dominated by *individual non-health outcomes*, in the *quantitative non-impact* study design category, with proportionally more studies conducted in the United States. There were no studies in *Practice – 4 Demobilizing*; however, it is possible that this specific practice also might be captured in *Practice 2- Coordination and Organizing*.

STUDY LIMITATIONS

There are several limitations in any scoping or evidence mapping review. In our study, we were particularly challenged by the nature and number of the capabilities that did not lend themselves to using electronic searches for purposes of classification. The extremely low sensitivity obtained by the targeted electronic searches required substituting intensive manual classification conducted in a multistage process. This low detection rate was most likely due to the combination of the broad nature of the capability definitions and the low prevalence of research publications in the specific area of public health preparedness. Furthermore, ideally each targeted capability search would have been completed prior to the next targeted capability search, and all recycled articles entered in the recycle review bin and pre-classified for the next search. However, due to time limitations, it was not possible to conduct all searches sequentially, and by the end of the study we estimated that additional articles might have been added to the evidence database (see Appendix 2) with more time.

Another limitation was that while capabilities might be largely independent from each other, many studies had secondary or tertiary capabilities that were not represented in our evidence maps. This could have led to underestimating the research for these secondary and tertiary capabilities. Moreover, each capability had unique practices, 69 in total across all capabilities. It was also required that only the primary practice be selected for each article. By definition, the practice categories were related to each other through their parent capability, and as such were not truly mutually exclusive. Again, the selection of only one practice per research article could underestimate the amount of research evidence for that practice.

Finally, there are limitations regarding what can be gleaned from the two-way frequency tables and the multidimensional evidence maps. The magnitude of the “gaps” perceived visually in the maps should be interpreted based upon weighting in terms of not only the observed white space on the map and the density of similar symbol clusters, but the particular hazard (e.g., disease outbreak, hurricane) of interest and vulnerability (e.g., resources and reliance) for a specific jurisdiction. These two factors would adjust the size of the physical gap as seen on the map by enlarging the gap for disasters and emergencies that have a higher hazard impact and a higher vulnerability rating. Currently, using the maps to set priorities assumes that all the different types of hazards, vulnerabilities and jurisdictions are comparable. In addition,

the scope and breadth of the capability construct is related to the sample size, namely, the broader the construct, the larger the number of studies. For this reason, one needs to be cautious about comparing raw frequency densities between capabilities. The two-way frequency tables with the corresponding percentages reported can be used to standardize comparisons, but multivariable combinations are more difficult. We propose some solutions to these analysis limitations in the section below.

Future Analyses: Clustering Analysis, Natural Language Processing and Hazard Vulnerability and Jurisdictional Risk Assessment for Using and Prioritizing the Evidence

This literature search and abstraction of the data provide a powerful database that can be used for several future analyses, including: 1) evaluating the importance of the study characteristics by capability and practice; 2) setting priorities for local jurisdictions using the data in conjunction with a hazard vulnerability and jurisdictional risk assessment model, and 3) quickly searching and retrieving information based upon categories created using simple natural language processing on the text of the abstract for determining potential gaps in specific research applications for PHEPR capabilities and practices. Moreover, while the evidence maps are very good for examining the individual characteristics of the studies across the 15 capabilities and 69 practices, this creates very large “crowds” across a large matrix making it difficult to determine how many distinct study type profiles there might be within the capabilities and practices. The capability matrices included 69 practices across five study designs resulting in 345 cells. To aid with the examination of these data we propose using clustering techniques that accommodate both categorical and continuous variables. As an example, we performed a two-step cluster analysis using all studies that had a sample size recorded. The question we wanted to answer was “Among those evidence studies which had a recorded sample size ($n = 793$), were there clusters of studies that had similar characteristics?” In addition, if clusters could be found, what were the most important study characteristics associated with those clusters? How good was the cluster separation, and what were the predictor variable profiles across clusters? [Figure S2](#) shows that the clustering algorithm discovered *three clusters* of published articles using the two-step cluster procedure based upon the study characteristics displayed in the evidence maps, except that the agency variable was not collapsed.

The clusters were relatively equal in size with the largest to smallest cluster ratio = 1.35 which is considered optimal. Ideally, this cluster ratio should be less than 3.0. The cluster quality was only fair; however, considering that the variables used in the evidence mapping were reduced both in number and in the responses from the full set of structured variables, this was expected. The importance of the predictors in defining the clusters is reported in [Figure S3](#). As shown, the most influential variable is the *study setting* – whether it was based in the United States or outside of the United States or global. Reflecting back to the evidence maps, one could see many triangles (non-US studies) grouping together in the practice by study design cells of the capability matrix maps. The next most important predictor of the clusters was the *disaster type* which was also observed in the evidence maps. The capability variable was not part of the cluster formation, but is shown as an evaluation variable. There were no “swamping” predictors - variables that totally dominated the cluster groupings. The 69 practices were not included as predictors because they were nested within capability and as such, formed natural groupings.

The relative importance across the predictor variables formed a good step function indicating that the variables contributed to the clusters – just some more than others. [Figure S4](#) shows the distribution of the study characteristics within each of the three clusters. It also shows the capabilities as an evaluation variable indicating that the capabilities vary by the study design group clusters. This graphic is shown for illustrative purposes only, since each graph expands to a full-size graph that shows the detailed responses. [Figure S5.1](#), [Figure S5.2](#) and [Figure S5.3](#), compare the summary values for each study characteristic within the cluster profiles. Using the capabilities as an evaluation variable one can see which capabilities are strongly or weakly related to their clusters. Each publication is given a cluster membership score that can be used for even further analysis.

The final method that was explored with these data was the use of simple natural language processing algorithms of the unstructured text in the abstracts. Phrases were created and then searched within each publication abstract where binomial variables (flags) recorded the presence or absence of each phrase. The phrases were then joined using simple Boolean logic as one would do in any electronic search. Using this method, one can evaluate the number of papers that support capabilities within a particular disaster or emergency area or jurisdiction. As an example, [Figure S6](#) shows the distribution of study designs (expanded classification) for all

publications involving infectious disease outbreaks using the full database set. [Figure S7](#) takes those publications dealing with infectious disease outbreaks and shows the relative ranking in terms of numbers of publications by practice area. As one might expect, the practices that scored the highest were *Capability 11 – Non-Pharmaceutical Interventions*, *Practice 2 – Patient Contact - Isolation and Quarantine* and *Practice 3 – Community Social Distancing*. [Figure S8](#) shows how one can combine even more flags revealing studies within a specific area such as infectious diseases that could be used to evaluate further gaps in PHEPR research.

CONCLUSIONS AND DISCUSSION

This study focused on selecting and categorizing the evidence from the published literature for the 15 Capabilities by conducting a systematic review of the literature, categorizing the retrieved articles into capabilities and practices, abstracting structured and unstructured data, characterizing the study design and methods, and using descriptive frequency statistics and graphical techniques to explore the scope, depth and extent of the published literature supporting the practices of public health preparedness and response. We confirmed the findings of others that evidence-based research in this field is relatively low as compared to other areas of public health. We also confirmed that electronic searches targeted to the themes of the individual capabilities have a very low yield rate, without even considering any other inclusion or exclusion criteria.

A total of 508 (30%) of the 1,692 articles in the final capability-classification database were determined to belong to the study design category that did not involve systematically collecting data or analyzing information in a structured way. These studies were not designed for exploring new hypothesis, evaluating practices and processes, or drawing inferences about public health systems and health outcomes. The articles largely expressed opinions, concepts, and positions from authors based upon their collective experiences. For these publications, it was not possible to abstract study design characteristics as required for the evidence mapping. However, since all articles were categorized by capability and practice and included a substantial amount of textual data in the keywords and abstracts, in addition to data on disaster type, setting, and agency, a qualitative analysis of these articles could be undertaken in the future. An additional 78 articles involved literature, systematic and document reviews that critically appraised and synthesized existing evidence of legal, environmental and medical documents, but

did not involve primary research. While these articles also were excluded from the evidence mapping and analysis, public health preparedness practice could benefit by synthesizing this information as well.

The main product of this study is the ability to use the evidence maps and analysis results to examine which capabilities and practices might be considered high priority for future research funding because they are lacking in evidence-based information and knowledge. However, while unpopulated areas across capabilities and practices can be observed in the evidence maps, the missing components for determining the negative impact of an existing gap in evidence and the potential positive impact of closing that gap are the prevalence and severity of the disaster or emergency and the vulnerability of the population at risk. Drawing from our own work on hazard vulnerability analysis¹⁴, one could assign a risk score for the different types of hazards for a specific setting, accounting for the level of resources available. This jurisdictional hazard vulnerability score could be used to adjust the size of the open areas shown in the maps in order to conduct a more formal gap analysis. This type of gap analysis refines the prioritization of the practice areas where future research studies may be needed. Having compiled the 1,106 articles into the evidence database, it is also worthwhile to consider how to use this information for different applications, including not only the development of new research programs, but for the delivery of education and training, and for formulating new public health plans and policies.

The most useful way to use the tables and maps presented here is to select those capabilities and practices that show few research studies with characteristics that would be deemed most scientifically rigorous and appropriate to inform a particular practice. Among the 1,106 PHEPR evidence studies, there were very few quantitative impact studies, only 8.5 percent overall. While further research as mentioned above could refine the method for selecting the specific capability and practice, there are several areas that we feel revealed themselves as priorities. The top three practices that stand out as having the highest priority for more evidentiary research are:

Capability 11 – Non-Pharmaceutical Interventions Practice 3 - Community Social

Distancing: Given that pharmaceutical interventions are nearly always evaluated by quantitative impact studies and most of those are quantitative comparative impact studies, the fact that only two U.S. Capability 11 studies were found points to a study design-specific research priority. It

was noted that most of the studies in this practice were modeling studies. Knowing which types of community social distancing programs work better than others during real infectious disease outbreaks is imperative for controlling diseases such as mumps, measles chickenpox, Ebola, H1N1, SARS and most recently Corona Virus 2019 ¹⁵.

Capability 1 – Community Preparedness – Practice 6 – Mental and Behavioral Health:

While mental and behavioral health is typically considered the domain of health care, public health nurses and social workers are increasingly responsible for the victims of disasters and public health emergencies. This research area could be coupled with Capability 1 – Practice 4 below.

Capability 1 – Practice 4- Vulnerable Populations: Quantitative impact studies were rare with only one U.S. quantitative comparison study . With an increasing number of elderly, homeless, and undocumented immigrants in rural areas, towns and cities studies the impact of infectious diseases and natural disasters specifically in these vulnerable populations should also a high priority.

The other seven practices qualifying in the as one of the top ten practice practice priorities for expanded research include:

Capability 2 – Practice 3 – Long Term Health Outcomes: Studies evaluating treatment and programs mitigating the long-term effects of disasters would be of major interest. Studies are currently very rare in these areas.

Capability 3 Practice 4 – Crisis Leadership: Although this practice might be covered in other capabilities and practices, evidence-based leadership training is important for ensuring successful operations.

Capability 7- Mass Care – Practice 3 - Shelter Considerations and Capability 7 – Mass Care – Practice 4: Vulnerable Populations: Both practices had only a few studies and these practice areas could also be combined with Capabilities 1 – Practices 6 and 4 mentioned above.

Capability 10 – Practice 2 Healthcare System Coordination: This practice had only two quantitative impact and two modeling studies, and the linkage between public health and health systems is a major priority of the PHEP cooperative agreements.

Capability 13 – Public Health Surveillance and Epidemiology Investigation - Practice 4 - Animal Surveillance and Vector Control. This practice had only one U.S. process-based, quantitative non-impact study and one non-U.S. process-based modelling study. Given the future potential for both animal- and vector-borne disease, this would seem to be an important practice areas for future research.

Capability 14 – Responder Health and Safety – All Practices. All practices within this capability were shown to be lacking in quantitative impact studies which would seem to be a natural paring for this type of study design.

The evidence maps from this scoping and evidence mapping review are presented primarily as a descriptive numerical and graphical reference guide for practitioners, researchers, policy planners and funding agencies. They should be used as a tool for answering targeted questions pertaining to the existing scope of the evidence for specific practices and to some extent to determine which areas of research are the weakest and strongest. Our priority list given above was based upon not only viewing the maps, but our knowledge as both researchers and practitioners of public health preparedness for nearly 20 years. Again, we caution that the density of the studies within practice by study design cell clusters must be viewed appropriately within the context of the capability, structure, functions, and resources. It is difficult to quantify this necessary conceptualization. Since the tables presented here provide for at most three-way classifications, the ability to simultaneously observe the multiple study characteristics using this evidence mapping approach is extremely useful for identifying topic areas that have little evidence. Prioritizing which areas with little information are most deserving of further research and funding is dependent not only upon the size of the evidence gaps observed, but also the type of disaster or emergency, resources, workforce personnel and other components of the public health system available to the federal, state and local public health agencies. These factors should be taken into account when translating the results of this systematic scoping and evidence mapping review to aid in policy planning and program prioritization.

Contributors

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The Harvard T.H. Chan School of Public Health including Project Director (author MAT) and Project Co-Directors (authors ES and PDB) formulated the methods and directed the literature searches, data management, analysis and report writing. The initial stages of the project were undertaken in conjunction with the Master of Public Health (M.P.H.) in Quantitative Methods practicum course as part of the content development for the PHEPR social media learning collaborative as described above. The research staff also included Research Associates and Fellows (authors MS, RNP-L, JFH and SS-S) in addition to postgraduate, doctoral level students who worked on this project as part of their M.P.H. degree requirements (authors SB, RF, AH, HO, AC).

Tables

Table 1. PHEPR Capability structure identifying domains, capabilities and tiers.

Domain	Capability
Community Resilience	Community Preparedness (Tier 1) Community Recovery (Tier 2)
Incident Management	Emergency Operations Coordination (Tier 1)
Information Management	Emergency Public Information and Warning (Tier 1) Information Sharing (Tier 1)
Countermeasures and Mitigation	Medical Countermeasure Dispensing and Administration (Tier 1) Medical Materiel Management and Distribution (Tier 1) Nonpharmaceutical Interventions (Tier 2) Responder Safety and Health (Tier 1)
Surge Management	Fatality Management (Tier 2) Mass Care (Tier 2) Medical Surge (Tier 2) Volunteer Management (Tier 2)
Biosurveillance	Public Health Laboratory Testing (Tier 1) Public Health Surveillance and Epidemiological Investigation (Tier 1)

Table 2. Capabilities and Functions

Capability	Functions
1: Community Preparedness	1: Determine risks to the health of the jurisdiction 2: Strengthen community partnerships to support public health preparedness 3: Coordinate with partners and share information through community social networks 4: Coordinate training and provide guidance to support community involvement with preparedness efforts
2: Community Recovery	1: Identify and monitor community recovery needs 2: Support recovery operations for public health and related systems for the community 3: Implement corrective actions to mitigate damage from future incidents
3. Emergency Operations Coordination	1: Conduct preliminary assessment to determine the need for activation of public health emergency operations 2: Activate public health emergency operations 3: Develop and maintain an incident response strategy 4: Manage and sustain the public health response 5: Demobilize and evaluate public health emergency operations
4: Emergency Public Information and Warning	1: Activate the emergency public information system 2: Determine the need for a Joint Information System 3: Establish and participate in information system operations 4: Establish avenues for public interaction and information exchange 5: Issue public information, alerts, warnings, and notifications
5: Fatality Management	1: Determine the public health agency role in fatality management 2: Identify and facilitate access to public health resources to support fatality management operations 3: Assist in the collection and dissemination of antemortem data

	<p>4: Support the provision of survivor mental/behavioral health services</p> <p>5: Support fatality processing and storage operations</p>
6: Information Sharing	<p>1: Identify stakeholders that should be incorporated into information flow and define information sharing needs</p> <p>2: Identify and develop guidance, standards, and systems for information exchange</p> <p>3: Exchange information to determine a common operating picture</p>
7: Mass Care	<p>1: Determine public health role in mass care operations</p> <p>2: Determine mass care health needs of the impacted population</p> <p>3: Coordinate public health, health care, and mental/behavioral health services</p> <p>4: Monitor mass care population health</p>
8: Medical Countermeasure Dispensing and Administration	<p>1: Determine medical countermeasure dispensing/administration strategies</p> <p>2: Receive medical countermeasures to be dispensed/administered</p> <p>3: Activate medical countermeasure dispensing/administration operations</p> <p>4: Dispense/administer medical countermeasures to targeted population(s)</p> <p>5: Report adverse events</p>
9: Medical Materiel Management and Distribution	<p>1: Direct and activate medical materiel management and distribution</p> <p>2: Acquire medical materiel from national stockpiles or other supply sources</p> <p>3: Distribute medical materiel</p> <p>4: Monitor medical materiel inventories and medical materiel distribution operations</p> <p>5: Recover medical materiel and demobilize distribution operations</p>
10: Medical Surge	<p>1: Assess the nature and scope of the incident</p> <p>2: Support activation of medical surge</p> <p>3: Support jurisdictional medical surge operations</p> <p>4: Support demobilization of medical surge operations</p>

<p>11: Nonpharmaceutical Interventions</p>	<p>1: Engage partners and identify factors that impact nonpharmaceutical interventions 2: Determine nonpharmaceutical interventions 3: Implement nonpharmaceutical interventions 4: Monitor nonpharmaceutical interventions</p>
<p>12. Public Health Laboratory Testing</p>	<p>1: Conduct laboratory testing and report results 2: Enhance laboratory communications and coordination 3: Support training and outreach</p>
<p>13. Public Health Surveillance and Epidemiologic Investigations</p>	<p>1: Conduct or support public health surveillance 2: Conduct public health and epidemiological investigations 3: Recommend, monitor, and analyze mitigation actions 4: Improve public health surveillance and epidemiological investigation systems</p>
<p>14: Responder Safety and Health</p>	<p>1: Identify responder safety and health risks 2: Identify and support risk-specific responder safety and health training 3: Monitor responder safety and health during and after incident response</p>
<p>15: Volunteer Management</p>	<p>1: Recruit, coordinate, and train volunteers 2: Notify, organize, assemble, and deploy volunteers 3: Conduct or support volunteer safety and health monitoring and surveillance 4: Demobilize volunteers 52</p>

Table 3. Definitions for the Outcome Categories Used for Evidence Mapping, Tabular and Visualization Analysis

<p>1. Opinion, Concept, Position Papers</p>	<p>An answer of “No” to the question “<i>Did the study collect or use data in a systematic and scientific manner?</i>” is required. For these publications, there is no form of systematic information or data collection, rather the publication gives an opinion, a commentary, guideline or it only describes a process, experience, event or meeting without collecting data in a systematic way and without associated descriptive statistics or graphs. For the purposes of this categorization, the minutes of a meeting or notes from an experience would not count “Yes” to the above question, unless there were minutes that were recorded systematically so that the text from the minutes could be analyzed using formal qualitative analysis and conclusions drawn as supportive evidence. The reviewer was then asked to select the type of publication as either Position Paper, Opinion-Comments or Description to confirm this selection. This type of publication does not rise to the level of any of the study designs listed below. (<i>Excluded from the Evidence Database</i>)</p>
<p>2. After-Action Report/Review</p>	<p>Either In addition to a publication describing an After-Action Report/Review formal write-up, this category also includes papers that more informally include a series of events and responses, with potentially the numbers of events occurring during a disaster or emergency or individuals participating in a program, clinic or receiving care. Generally, no data is that systematically summarizes or assesses the impact of an intervention, process or other actions taken. This category could include professional expertise and commentary about what worked and/or didn't work, either from people involved or the researchers/authors. This category also includes descriptions of events (and responses to events). Program evaluations refer (more) to Do not rise to the level of qualitative research.</p>

3. Literature/Documents Review	Included all types of literature searches (including systematic searches) and document reviews as part of the evaluative assessment of documents. Identifies, selects, critically appraises, and synthesizes documents including the published literature, legal records, medical charts in order to answer a clearly formulated question. <i>(Excluded from the Evidence Database)</i>
4. Modeling	A study that uses an analytical methodology that accounts for events over time and across populations, that is based on data drawn from primary or secondary sources and in the context of health care-evaluation. The aim of the study is typically to predict or estimate outcomes prior to occurrence or to understand, define, quantify, visualize, or simulate outcomes by referencing commonly accepted knowledge and data. There are different types of models for different aims, including conceptual models to better understand, operational models to operationalize, mathematical models to quantify, and graphical models to visualize the subject area.
5. Qualitative	Articles that do not provide quantitative results and are not either surveys or modeling studies. Formal qualitative research with methodological rigor is required. These studies typically use focus groups, brainstorming, nominal group techniques, analysis of interviews and open-ended survey and formal qualitative analytical methods of analysis.
6. Quantitative Surveys	Studies that collect quantitative data using sources such as interviews, surveys, questionnaires, focus groups – collecting information from residents, victims, patients.
7. Quantitative Not Surveys	Studies that collect quantitative data using sources such as clinical assessments, medical records, medical devices, laboratory reports – not direct reports from residents, victims or patients.
8. Quantitative Non-Comparative Impact	Studies that collect information included in either of the two categories (6) and (7) above, and include an assessment of an intervention, treatment, or new process, but do not have a control or comparison group.
9. Quantitative Comparative Impact	Studies that collect information included in either of the two categories (6) and (7) above, and include an assessment of an intervention, treatment, or new process, and include a control or comparison group.

Table 4. Definitions for the Study Design Categories Used for Evidence Mapping, Tabular and Visualization Analysis

1. Cost Outcomes	Pertains to studies for analyzing administrative, budgetary, financial impact variables, as well as studies that include health economic analyses, such as cost burden, cost-effectiveness and cost utility.
2. Individual Health Outcomes	Includes mortality, morbidity, clinically measured evaluations and assessment, as well as self-reported measures of health status and social, psychological and physical health.
3. Individual non-health Outcomes	Includes assessment as reported by residents as well as members of the workforce carrying out public health tasks. Generally, the workforce outcomes assess the knowledge, skills and attitudes as part of the evaluation of training, drills and professional education programs geared toward individuals involved in delivering public health preparedness and health care services. Outcomes of residents who are part of the jurisdiction in which the disaster or emergency will or has occurred and not involved in delivering public health or health care services, the outcomes include the end result of services offered by the workforce that impact non-mental health related attitudes, perceptions about programs and knowledge or public health and other related areas of interest or concern. These types of questions are used asked as part of a community needs assessment.
4. Process Outcomes	Define how tasks are accomplished and how services are offered including laws, regulations, protocols, standard operating procedure and quality checklists. These types of process outcomes would include public health programs such as non-pharmaceutical interventions (e.g., school closures, educational programs for hand washing, social distancing guidance's, quarantine and isolation) as well as structural processes involving budgeting and the allocations of resources.

5. System-Level Outcome	Typically measures as part of health services and systems research. This type of research examines the mechanisms behind disease prevention and health promotion efforts of the public health system ¹ and focuses to a large degree on system level performance standards, priorities and strategies.
6. Other Specify	When the outcome did not fall into one of the above categories the reviewer could choose to enter a free-text description after choosing the “Other Specify” option.
7. Not Applicable	If the study was not designed to measure or evaluate outcomes, the option “Not Applicable” was specified.

¹ Scutchfield FD, Mays GP, Lurie N. Applying health services research to public health practice: an emerging priority. Health Serv Res. 2009;44(5 Pt 2):1775-1787.

Table 5. Distribution of published articles by primary capability

Capability	All Publications n (%)	Evidence Articles¹ n (%)
01-Community Preparedness	371 (21.9)	221 (20.0)
02-Community Recovery	103 (6.1)	81 (7.3)
03-Emergency Operations Coordination	205 (12.1)	111 (10.0)
04-Emergency Public Information and Warning	89 (5.3)	66 (6.0)
05-Fatality Management	27 (1.6)	15 (1.4)
06-Information Sharing	64 (3.8)	38 (3.4)
07-Mass Care	50 (3.0)	30 (2.7)
08-Medical Countermeasure Dispensing	140 (8.3)	110 (9.9)
09-Medical Materiel Management and Distribution	83 (4.9)	36 (3.3)
10-Medical Surge	122 (7.2)	87 (7.9)
11-Non-Pharmaceutical Interventions	146 (8.6)	112
12-Public Health Laboratory Testing	23 (1.4)	15 (1.4)
13-Public Health Surveillance & Epidemiologic Investigations	140 (8.3)	102 (9.2)
14-Responder Safety and Health	74 (4.4)	51 (4.6)
15-Volunteer Management	55 (3.3)	31 (2.8)
Total	1692	1,106

1. Excludes articles with study designs classified as either “Opinion, Concept, Position Papers” or “Literature/Documents Review” as described above.

Table 6. Distribution of evidence mapping study design categories

Type of Study	All Publications		Evidence Publications	
	Frequency	Percent of Total	Frequency	Percent of Total
Opinion, Concept, Position Papers	508	30.0		
After-Action Report/Review	134	7.9	134	12.1
Literature/Documents Review	78	4.6		
Modeling	162	9.6	162	14.6
Qualitative	148	8.7	148	13.4
Quantitative Non-Impact	567	33.5	567	51.3
Surveys			338	30.6
Not-Surveys			229	20.7
Quantitative Impact	95	5.6	95	8.6
Non- Comparative			22	2.0
Comparative			73	6.6
Total Publications	1692	100.0	1106	100.0

1. Excludes articles with study designs classified as either “Opinion, Concept, Position Papers” or “Literature/Documents Review” as described above.

Table 6.2 Distribution of evidence mapping study design categories by primary capability

Primary Capability	Evidence Mapping Study Design Categories							Total
	After-Action Report/Review	Modeling	Qualitative	Quantitative Surveys	Quantitative Not Surveys	Quantitative Non-Comparative Impact	Quantitative Comparative Impact	
01-Community Preparedness	20	14	48	80	28	4	27	221
	9.0%	6.3%	21.7%	36.2%	12.7%	1.8%	12.2%	100.0%
02-Community Recovery	2	0	7	50	20	0	2	81
	2.5%	0.0%	8.6%	61.7%	24.7%	0.0%	2.5%	100.0%
03-Emergency Operations Coordination	19	14	27	31	16	0	4	111
	17.1%	12.6%	24.3%	27.9%	14.4%	0.0%	3.6%	100.0%
04-Emergency Public Information and Warning	6	4	14	23	17	2	0	66
	9.1%	6.1%	21.2%	34.8%	25.8%	3.0%	0.0%	100.0%
05-Fatality Management	4	0	0	4	6	0	1	15
	26.7%	0.0%	0.0%	26.7%	40.0%	0.0%	6.7%	100.0%
06-Information Sharing	4	4	9	6	7	5	3	38
	10.5%	10.5%	23.7%	15.8%	18.4%	13.2%	7.9%	100.0%
07-Mass Care	2	4	5	8	10	0	1	30
	6.7%	13.3%	16.7%	26.7%	33.3%	0.0%	3.3%	100.0%
08-Medical Countermeasure Dispensing	20	33	7	28	11	3	8	110
	18.2%	30.0%	6.4%	25.5%	10.0%	2.7%	7.3%	100.0%

Table 6.2. Continued. Distribution of evidence mapping study design categories by primary capability

Primary Capability	Evidence Mapping Study Design Categories							Total
	After-Action Report/Review	Modeling	Qualitative	Quantitative Surveys	Quantitative Not Surveys	Quantitative Non-Comparative Impact	Quantitative Comparative Impact	
09-Medical Materiel Management and Distribution	8	15	4	4	2	2	1	36
	22.2%	41.7%	11.1%	11.1%	5.6%	5.6%	2.8%	100.0%
10-Medical Surge	19	9	5	20	26	1	7	87
	21.8%	10.3%	5.7%	23.0%	29.9%	1.1%	8.0%	100.0%
11-Non-Pharmaceutical Interventions	12	50	8	23	6	3	10	112
	10.7%	44.6%	7.1%	20.5%	5.4%	2.7%	8.9%	100.0%
12-Public Health Laboratory Testing	1	1	0	2	11	0	0	15
	6.7%	6.7%	0.0%	13.3%	73.3%	0.0%	0.0%	100.0%
13-Public Health Surveill & Epi Investigation	16	12	5	12	52	0	5	102
	15.7%	11.8%	4.9%	11.8%	51.0%	0.0%	4.9%	100.0%
14-Responder Safety and Health	0	2	6	26	14	0	3	51
	0.0%	3.9%	11.8%	51.0%	27.5%	0.0%	5.9%	100.0%
15-Volunteer Management	1	0	3	21	3	2	1	31
	3.2%	0.0%	9.7%	67.7%	9.7%	6.5%	3.2%	100.0%
Total	134	162	148	338	229	22	73	1106
	12.1%	14.6%	13.4%	30.6%	20.7%	2.0%	6.6%	100.0%

Table 7. Distribution of type of disaster by capability

Capability	No Disaster	Disaster Type Number of Publications (%)		
		Simulated	Real	Total
01-Community Preparedness	155 (70.1)	19 (8.6)	47 (21.3)	221 (100%)
02-Community Recovery	1 (1.2)	0(0.0)	80 (98.8)	81 (100)
03-Emergency Operations Coordination	41 (36.9)	24(21.6)	46 (41.4)	111 (100.0)
04-Emergency Public Information and Warning	15 (22.7)	5 (7.6)	46 (69.7))	66 (100.0)
05-Fatality Management	4 (26.7)	1 (6.7)	10 (66.7)	15 (100.0)
06-Information Sharing	16 (42.1)	3 (7.9)	19 (50.0)	38 (100.0)
07-Mass Care	10 (33.3)	8 (26.7)	12 (40.0)	30 (100.0)
08-Medical Countermeasure Dispensing	42 (38.2)	27 (24.5)	41 (37.3)	110 (100.0)
09-Medical Materiel Management and Distribution	11 (30.6)	14 (38.9)	11 (30.6)	36 (100.0)
10-Medical Surge	27 (31.0)	16 (18.4)	44 (50.6)	87 (100.0)
11-Non-Pharmaceutical Interventions	15 (13.4)	43 (38.4)	54 (48.2)	112 (100.0)
12-Public Health Laboratory Testing	0 (0.0)	9 (60.0)	6 (40.0)	15 (100.0)
13-Public Health Surveillance & Epidemiologic Investigation	27 (26.5)	4 (3.9)	71 (69.6)	102 (100)
14-Responder Safety and Health	18 (35.3)	10 (19.6)	23 (45.1)	51 (100)
15-Volunteer Management	21 (67.7)	4 (12.9)	6 (14.9)	31 (100.0)
Total	403 (36.4)	187 (16.9)	516 (46.7)	1106 (100.0)

Table 8.1 Type of Studies by Outcomes by Capability

Capability	Type of Study Outcome					Total
	Number of Publications (%)					
	Costs	Individual Health Outcome	Process	System-Level Outcomes	Individual Non-Health Outcome	
01-Community Preparedness	1 (0.5)	30 (13.6)	49 (22.2)	65 (29.4)	76 (34.4)	221 (100.0)
02-Community Recovery	0 (0.0)	52 (64.3)	3 (3.7)	8 (9.9)	18 (22.2)	81 (100.0)
03-Emergency Operations Coordination	2 (1.8)	10 (9.0)	36 (32.4)	38 (34.2)	25 (22.5)	111 (100.0)
04-Emergency Public Information and Warning	0 (0.0)	13 (19.7)	23 (34.8)	14 (21.2)	16 (24.2)	66 (100.0)
05-Fatality Management	0 (0.0)	7 (46.7)	5 (33.3)	1 (6.7)	2 (13.3)	15 (100.0)
06-Information Sharing	1 (2.6)	1 (2.6)	17 (44.7)	12 (31.6)	7 (18.4)	38 (100.0)
07-Mass Care	0 (0.0)	10 (33.0)	6 (20.0)	9 (30.0)	5 (16.7)	30 (100.0)

08-Medical Countermeasure Dispensing	2 (1.8)	23 (20.9)	50 (45.5)	17 (15.5)	18 (16.4)	110 (100.0)
09-Medical Materiel Management and Distribution	0 (0.0)	7 (19.4)	13 (36.1)	15 (41.7)	1 (2.8)	36 (100.0)
10-Medical Surge	2 (2.3)	23 (26.4)	33 (37.9)	18 (20.7)	11 (12.6)	87 (100.0)
11-Non-Pharmaceutical Interventions	4 (3.6)	62 (55.4)	10 (8.9)	23 (20.5)	13 (11.6)	112 (100.0)
12-Public Health Laboratory Testing	0 (0.0)	4 (26.7)	8 (53.3)	1 (6.7)	2(13.3)	15 (100.0)
13-Public Health Surveillance & Epidemiologic Investigation	1 (1.0)	60 (58.8)	19 (18.6)	16 (15.7)	6 (5.9)	102 (100.0)
14-Responder Safety and Health	1 (2.0)	28 (54.9)	2 (3.9)	6 (11.8)	14 (27.5)	51 (100.0)
15-Volunteer Management	0 (0.0)	6 (19.4)	3 (9.7)	5 (16.1)	17 (54.8)	31 (100.0)
Total	14 (1.3)	336 (30.4)	277 (25.0)	248 (22.4)	231 (20.9)	1106 (100.0)

1. Bolded cells indicate the maximum percentage value across outcome categories.

Table 8.2 Distribution of Studies by Study Design Categories and Primary Capability

Primary Capability	Evidence Mapping Study Design Categories							Total
	After-Action Report/Review	Modeling	Qualitative	Quantitative Surveys	Quantitative Not Surveys	Quantitative Non-Comparative Impact	Quantitative Comparative Impact	
01-Community Preparedness	20	14	48	80	28	4	27	221
	9.0%	6.3%	21.7%	36.2%	12.7%	1.8%	12.2%	100.0%
02-Community Recovery	2	0	7	50	20	0	2	81
	2.5%	0.0%	8.6%	61.7%	24.7%	0.0%	2.5%	100.0%
03-Emergency Operations Coordination	19	14	27	31	16	0	4	111
	17.1%	12.6%	24.3%	27.9%	14.4%	0.0%	3.6%	100.0%
04-Emergency Public Information and Warning	6	4	14	23	17	2	0	66
	9.1%	6.1%	21.2%	34.8%	25.8%	3.0%	0.0%	100.0%
05-Fatality Management	4	0	0	4	6	0	1	15
	26.7%	0.0%	0.0%	26.7%	40.0%	0.0%	6.7%	100.0%
06-Information Sharing	4	4	9	6	7	5	3	38
	10.5%	10.5%	23.7%	15.8%	18.4%	13.2%	7.9%	100.0%
07-Mass Care	2	4	5	8	10	0	1	30
	6.7%	13.3%	16.7%	26.7%	33.3%	0.0%	3.3%	100.0%
08-Medical Countermeasure Dispensing	20	33	7	28	11	3	8	110
	18.2%	30.0%	6.4%	25.5%	10.0%	2.7%	7.3%	100.0%

Table 8.2. Continued. Distribution of Studies by Study Design Categories and Primary Capability

Primary Capability	Evidence Mapping Study Design Categories							Total
	After-Action Report/Review	Modeling	Qualitative	Quantitative Surveys	Quantitative Not Surveys	Quantitative Non-Comparative Impact	Quantitative Comparative Impact	
09-Medical Materiel Management and Distribution	8	15	4	4	2	2	1	36
	22.2%	41.7%	11.1%	11.1%	5.6%	5.6%	2.8%	100.0%
10-Medical Surge	19	9	5	20	26	1	7	87
	21.8%	10.3%	5.7%	23.0%	29.9%	1.1%	8.0%	100.0%
11-Non-Pharmaceutical Interventions	12	50	8	23	6	3	10	112
	10.7%	44.6%	7.1%	20.5%	5.4%	2.7%	8.9%	100.0%
12-Public Health Laboratory Testing	1	1	0	2	11	0	0	15
	6.7%	6.7%	0.0%	13.3%	73.3%	0.0%	0.0%	100.0%
13-Public Health Surveill & Epi Investigation	16	12	5	12	52	0	5	102
	15.7%	11.8%	4.9%	11.8%	51.0%	0.0%	4.9%	100.0%
14-Responder Safety and Health	0	2	6	26	14	0	3	51
	0.0%	3.9%	11.8%	51.0%	27.5%	0.0%	5.9%	100.0%
15-Volunteer Management	1	0	3	21	3	2	1	31
	3.2%	0.0%	9.7%	67.7%	9.7%	6.5%	3.2%	100.0%
Total	134	162	148	338	229	22	73	1106
	12.1%	14.6%	13.4%	30.6%	20.7%	2.0%	6.6%	100.0%

Table 9. Distribution Studies by the Type of Agency and Primary Capability

Capability	Agency or Organization Type Number of Publications (%)			Total
	SLTT ¹	Healthcare ²	Other ³	
01-Community Preparedness	97 (43.9)	20 (9.0)	104 (47.1)	221 (100%)
02-Community Recovery	43 (53.1)	2 (2.5)	36 (44.4)	81 (100)
03-Emergency Operations Coordination	63 (56.8)	22 (19.8)	26(23.4)	111 (100.0)
04-Emergency Public Information and Warning	23 (34.8)	1 (1.5)	42 (63.6)	66 (100.0)
05-Fatality Management	5 (33.3)	4 (26.7)	6 (40.0)	15 (100.0)
06-Information Sharing	20 (52.6)	5 (13.2)	13 (34.2)	38 (100.0)
07-Mass Care	8 (26.7)	9 (30.0)	13 (43.3)	30 (100.0)
08-Medical Countermeasure Dispensing	52 (47.3)	26 (23.6)	32 (29.1)	110 (100.0)
09-Medical Materiel Management and Distribution	8 (22.2)	6 (16.7)	22 (61.1)	36 (100.0)
10-Medical Surge	8 (9.2)	69 (79.3)	10 (11.5)	87 (100.0)
11-Non-Pharmaceutical Interventions	28 (13.4)	9 (8.0)	75 (67.0)	112 (100.0)
12-Public Health Laboratory Testing	4 (26.7)	3 (20.0)	8 (53.3)	15 (100.0)
13-Public Health Surveillance & Epidemiologic Investigation	48 (47.1)	13 (12.7)	41 (40.2)	102 (100)
14-Responder Safety and Health	11 (21.6)	10 (19.6)	30 (58.8)	51 (100)
15-Volunteer Management	9 (29.0)	5 (16.1)	17 (54.8)	31 (100.0)
Total	427 (38.6)	204 (18.4)	475 (42.9)	1106 (100.0)

State (S), Local (L) = County, Province, Town or City, Territorial (T) and Tribal (T); 2. Hospitals and Clinics; 3. Academic Institutions, Multiple combination of agencies, Country-level government agencies and other National Organizations and Non-Governmental Agencies

Note: Bolded cells indicate the maximum percentage value across outcome types within each capability.

Table 10. Distribution of Studies by Geographic Setting and Primary Capability

Primary Capability	Global	Non-US	United States	Total
01-Community Preparedness	7	61	153	221
	3.2%	27.6%	69.2%	100.0%
02-Community Recovery	0	39	42	81
	0.0%	48.1%	51.9%	100.0%
03-Emergency Operations Coordination	2	24	85	111
	1.8%	21.6%	76.6%	100.0%
04-Emergency Public Information and Warning	7	20	39	66
	10.6%	30.3%	59.1%	100.0%
05-Fatality Management	1	9	5	15
	6.7%	60.0%	33.3%	100.0%
06-Information Sharing	1	9	28	38
	2.6%	23.7%	73.7%	100.0%
07-Mass Care	0	13	17	30
	0.0%	43.3%	56.7%	100.0%
08-Medical Countermeasure Dispensing	1	13	96	110
	0.9%	11.8%	87.3%	100.0%
09-Medical Materiel Management and Distribution	4	13	19	36
	11.1%	36.1%	52.8%	100.0%
10-Medical Surge	1	41	45	87
	1.1%	47.1%	51.7%	100.0%
11-Non-Pharmaceutical Interventions	11	52	49	112
	9.8%	46.4%	43.8%	100.0%
12-Public Health Laboratory Testing	0	5	10	15
	0.0%	33.3%	66.7%	100.0%
13-Public Health Surveillance & Epidemiologic Investigation	4	43	55	102
	3.9%	42.2%	53.9%	100.0%
14-Responder Safety and Health	1	18	32	51
	2.0%	35.3%	62.7%	100.0%
15-Volunteer Management	1	6	24	31
	3.2%	19.4%	77.4%	100.0%
Total	41	366	699	1106
	3.7%	33.1%	63.2%	100.0%

Note: Bolded cells indicate the maximum percentage value across outcome types within each capability

Table 11. Distribution of Studies by Capability and Practice Areas

Capability	Practice	N	Percent
01-Community Preparedness	1. Risk Assessment	20	9.0
	2. Community Partnership Building	34	15.4
	3. Share Information/Social Network	4	1.8
	4. Vulnerable Populations	54	24.4
	5. Household/Individual Preparedness	19	8.6
	6. Mental and Behavioral Health	8	3.6
	7. Training and Education	49	22.2
	8. Pre-Incident Planning	33	14.9
	Total	221	100.0
02-Community Recovery	1. Post-Disaster Needs Assessment	11	13.6
	2. Monitoring and Surveillance	18	22.2
	3. Long-Term Health Outcomes	42	51.9
	4. Public Health System Operations	4	4.9
	5. Evaluating Recovery Efforts	5	6.2
	6. Post Event Risk Communication	1	1.2
	Total	81	100.0
03-Emergency Operations Coordination	1. Planning	12	10.8
	2. Incident Management	20	18.0
	3. Decision-Making	10	9.0
	4. Crisis Leadership	0	0.0
	5. Resources Assets	3	2.7
	6. Workforce Personnel	19	17.1
	7. Finance, Admin, Legal	7	6.3
	8. Data Systems/Information Tech	14	12.6
	9. Exercises and Systematic Learning	26	23.4
	Total	111	100.0
04-Emergency Public Information and Warning	1. Coordination to Facilitate Information Sharing	6	9.1
	2. Community Engagement and Outreach	9	13.6
	3. Communication Channels	20	30.3
	4. Vulnerable Population Outreach	20	30.3
	5. Messaging	11	16.7
	Total	66	100.0
05-Fatality Management	1. Mass Fatality Planning and Operations	10	66.7
	2. Antemortem Data	5	33.3
	Total	15	100.0

Note: Practices shown in blue font indicate the highest number of publications for their corresponding capability.

Table 10 cont'd. Distribution of Publications by Capability and Practice Areas

Capability	Practice	N	Percent
06-Information Sharing	06_1_Stakeholder ID- relationship building	10	26.3
	06_2_Information sharing - data elements	22	57.9
	06_3_Situational awareness	6	15.8
	Total	38	100.0
07-Mass Care	07_1_Mass care assessment	15	50.0
	07_2_Mass care population health	8	26.7
	07_3_Vulnerable populations	5	16.7
	07_4_Shelter considerations	2	6.7
	Total	30	100.0
08-Medical Countermeasure Dispensing	08_1_MCM needs assessment	36	32.7
	08_2_Dispensing system & coordination	65	59.1
	08_3_Communication & coordination	5	4.5
	08_4_Monitor-report adverse events	4	3.6
	Total	110	100.0
09-Medical Materiel Management and Distribution	09_1_Management of medical materials	16	44.4
	09_2_Distribution of medical materials	20	55.6
	Total	36	100.0
10-Medical Surge	10_1_Workforce and system preparations	43	49.4
	10_2_Healthcare system coordination	6	6.9
	10_3_Management during event	38	43.7
	Total	87	100.0

Note: Practices shown in blue font indicate the highest number of publications for their corresponding capability.

Table 10 cont'd. Distribution of Publications by Capability and Practice Areas

Capability	Practice	N	Percent
11-Non-Pharmaceutical Interventions	11_1_Human Surveillance	22	19.6
	11_2_Patient contact = Isolation and quarantine	18	16.1
	11_3_Community social distancing	50	44.6
	11_4 Legal considerations	3	2.7
	11_5_Monitor nonpharm interventions	19	17.0
	Total	112	100.0
12-Public Health Laboratory Testing	12_1 Lab activities	1	6.7
	12_3_Sample Testing	9	60.0
	12_4_Enhance lab comm & coord	5	33.3
	Total	15	100.0
13-Public Health Surveill & Epi Investigation	13_1_Surveillance and detection	37	36.3
	13_2_Investigations	14	13.7
	13_3_Data Analysis	20	19.6
	13_4_Animal-surveillance - vector control	2	2.0
	13_5_Improve Epi/Surveil Systems	29	28.4
	Total	102	100.0
14-Responder Safety and Health	14_1_Occupational health	20	39.2
	14_2_Behavioral health	16	31.4
	14_3_Planning	9	17.6
	14_4_Personal protective equipment	6	11.8
	Total	51	100.0
15-Volunteer Management	15_1_Recruitment and training	17	54.8
	15_2_Coordination and organizing	9	29.0
	15_3_Safety health monitor & Surveil	5	16.1
	Total	31	100.0

Note: Practices shown in blue font indicate the highest number of publications for their corresponding capability.

Supplemental Tables

Table S1. Search flowchart retrieval and classification by search code, target capability and primary capability selected

	Search Code													Total
	1	2	3	4	5	6	7	8	9	10	12	13	14	
	Basket (All) or Target Capability (Number Code) Searched													
Final Capability Classification	All ¹	15	15	11	11	15	5	11	4	14	8	9	All ²	
01-Community Preparedness	234	15	0	66	0	1	2	0	3	5	21	12	35	394
02-Community Recovery	79	5	1	16	0	4	1	0	0	4	1	1	1	113
03-Emergency Operations Coordination	73	8	0	45	0	6	1	0	0	13	25	9	34	214
04-Emergency Public Information and Warning	39	1	0	5	0	0	1	1	29	1	5	0	9	91
05-Fatality Management	3	0	0	4	0	0	21	0	0	0	0	0	0	28
06-Information Sharing	38	1	0	19	0	2	0	0	0	0	1	1	8	70
07-Mass Care	28	4	0	7	0	1	0	0	0	3	11	4	0	58
08-Medical Countermeasure Dispensing	14	5	0	15	0	0	2	0	0	0	117	1	27	181
09-Medical Materiel Management and Distribution	12	0	0	1	0	0	0	0	0	0	43	29	0	85
10-Medical Surge	55	7	0	27	0	4	10	0	0	1	26	5	6	141
11-Non-Pharmaceutical Interventions	12	0	0	48	17	0	2	56	0	0	4	0	12	151
12-Public Health Laboratory Testing	6	0	0	17	0	0	0	0	0	0	2	0	0	25

13-Public Health Surveill & Epi Investigation	84	0	0	29	0	1	12	0	0	0	7	2	13	148
14-Responder Safety and Health	29	2	0	10	0	2	1	0	0	27	15	0	6	92
15-Volunteer Management	3	11	41	2	0	13	0	0	0	0	0	0	1	71
97-None - Use Alternative Areas	8	0	0	1	0	0	0	0	0	0	1	0	0	10
Sub Total: Classified as Capability or Alternate Capability	717	59	42	312	17	34	53	57	32	54	279	64	152	1872
98-Not Preparedness	48	0	0	18	0	0	4	0	0	0	7	3	0	80
99-No Info/Not Appropriate	2	3	0	3	0	0	1	0	0	0	3	0	0	12
Unclassified, Not Suggested, Excluded at the end of the final search³	154	5	0	264	6	36	56	5	659	891	314	1140	7	3537
Total	921	67	42	597	23	70	114	62	691	945	603	1207	184	5526

Notes: 1. Global Search, "Public Health Preparedness". 2. Preparedness and Emergency Response Research Centers (PERRC) publications. 3. Counts will be slightly different than what appears on the Supplemental S1 flow chart because the numbers appearing here were tallied at the end of Search 14.

Figures

Figure 1a. Distribution of published articles by primary capability.

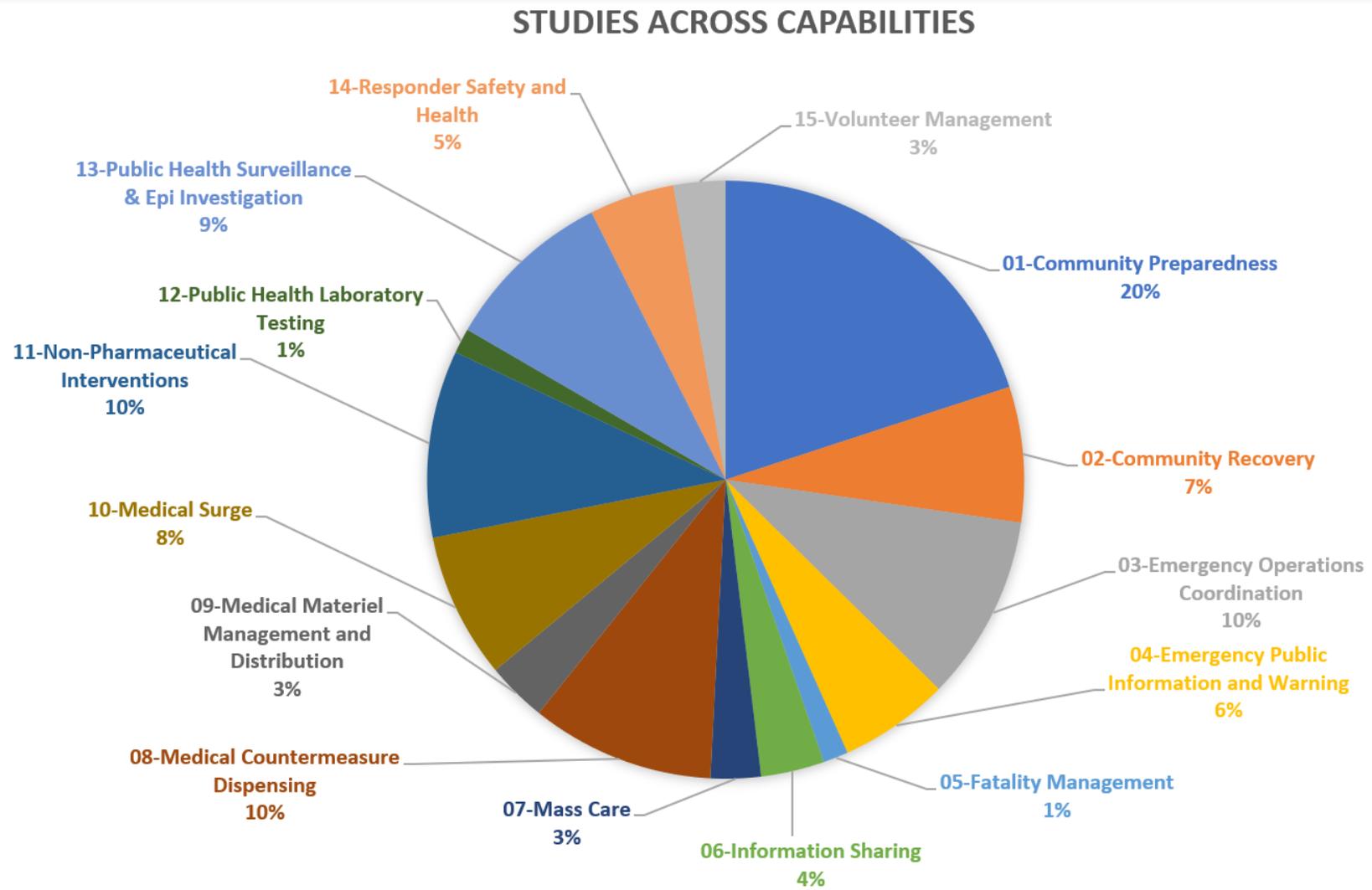


Figure 1b. Number of evidence-based research published articles (N = 1,106) by primary capability

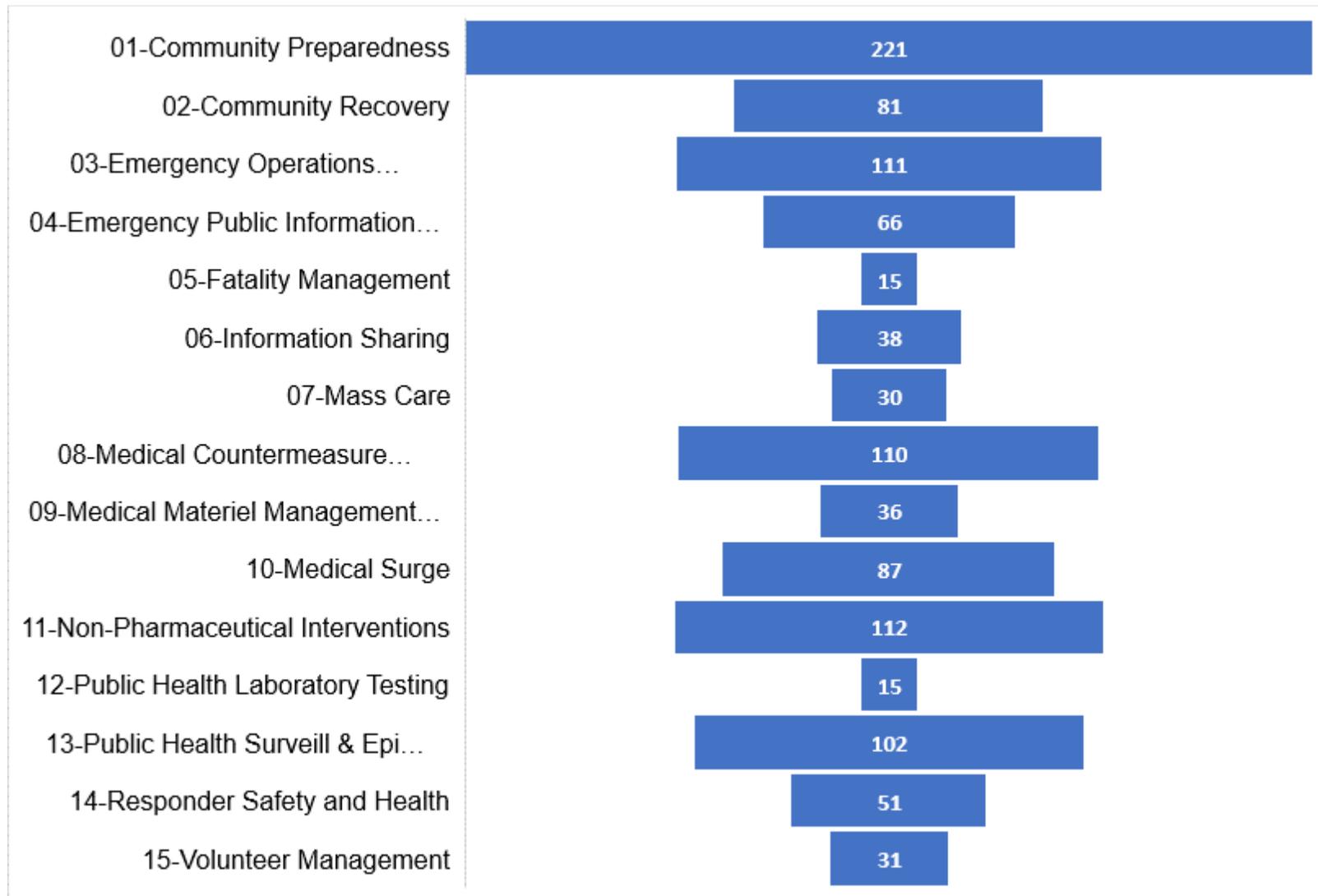


Figure 2. Frequency of publications by study setting and year of publication – All Articles, N = 1,692

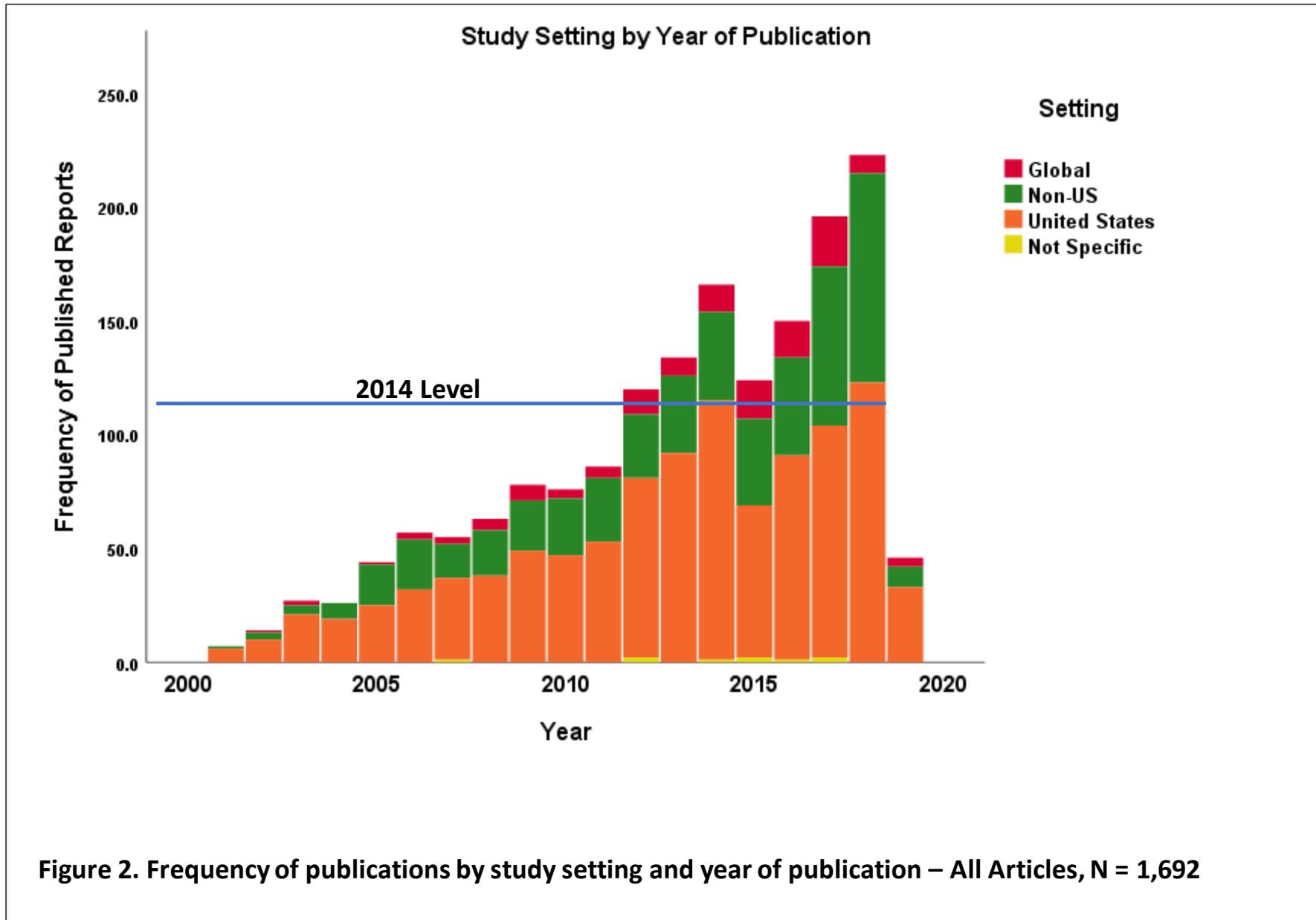


Figure 3. Distribution of publications by study design for the full database, N = 1,692

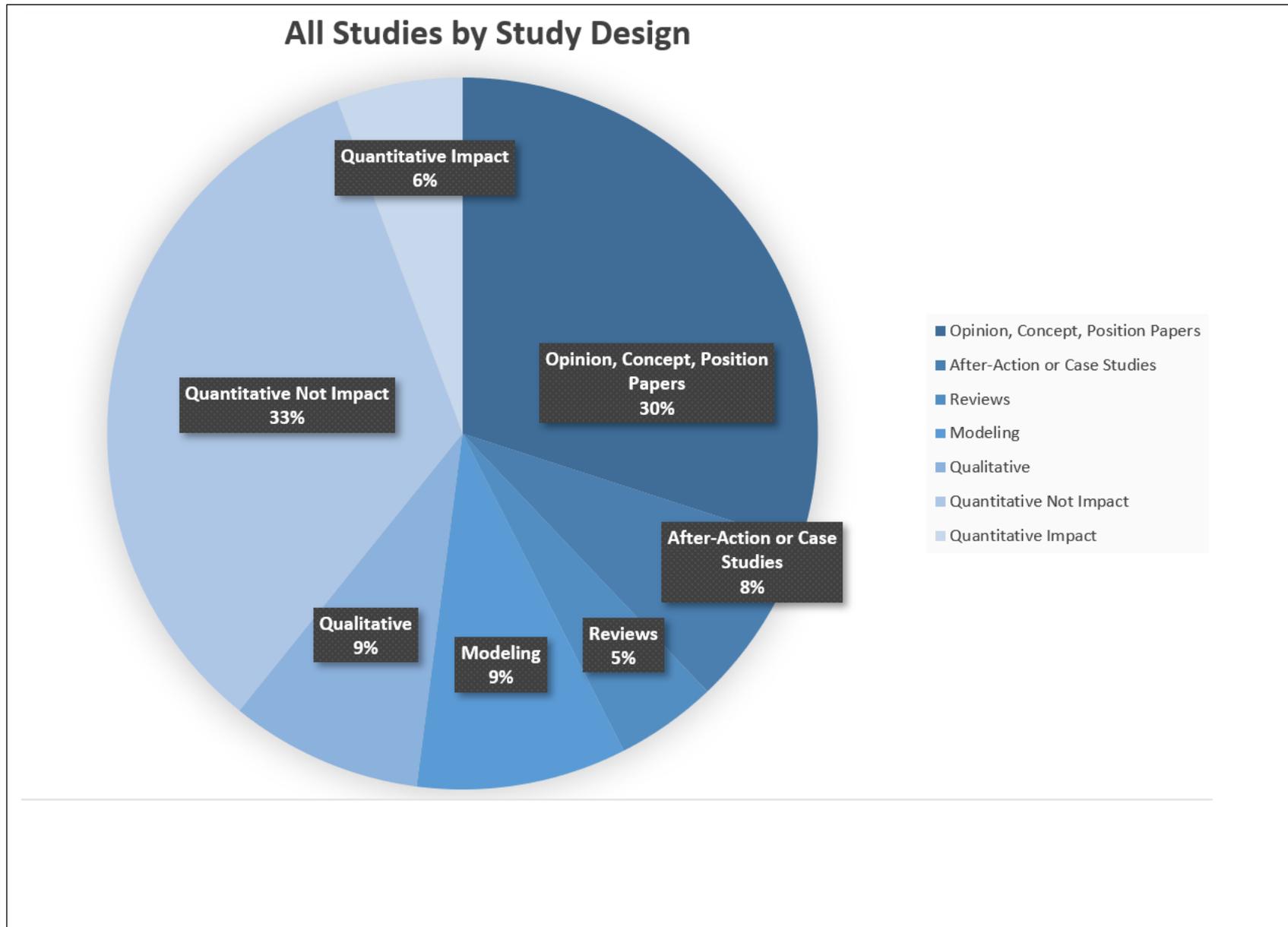


Figure 4. Number of publications by type of disaster and capability

Type of Disaster by Capability

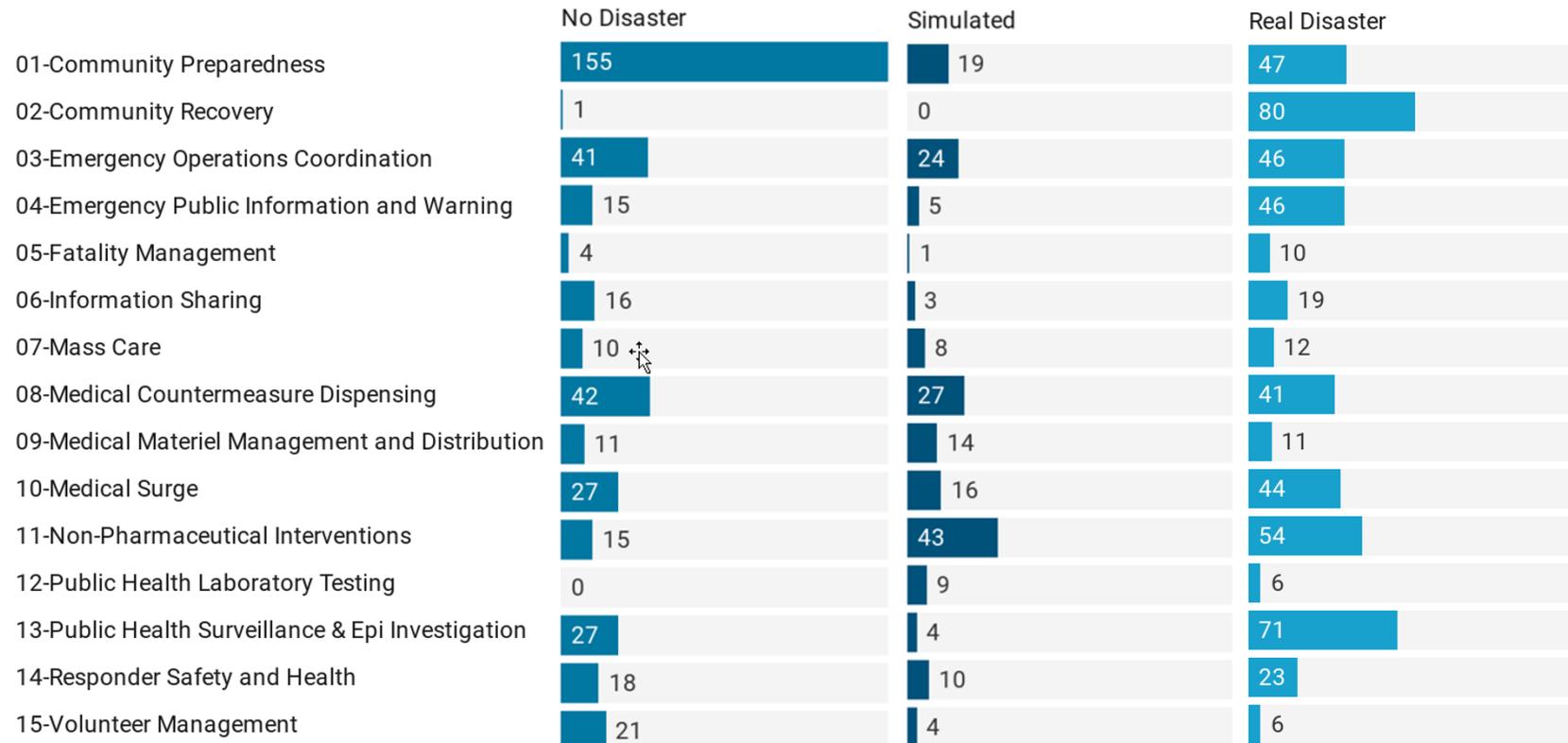


Figure 5. Number of publications by type of outcome and capability

Outcomes by Capability

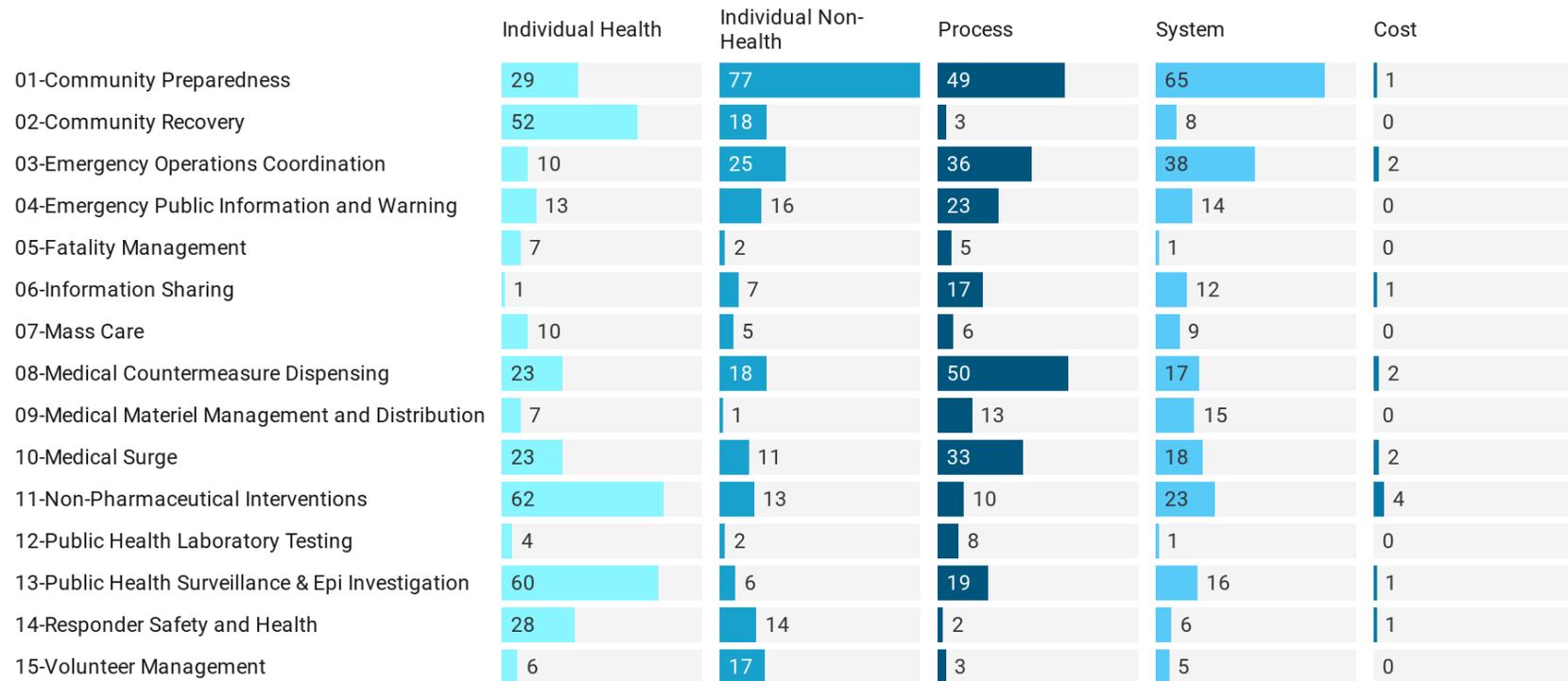


Figure 6. Number of publications by study design

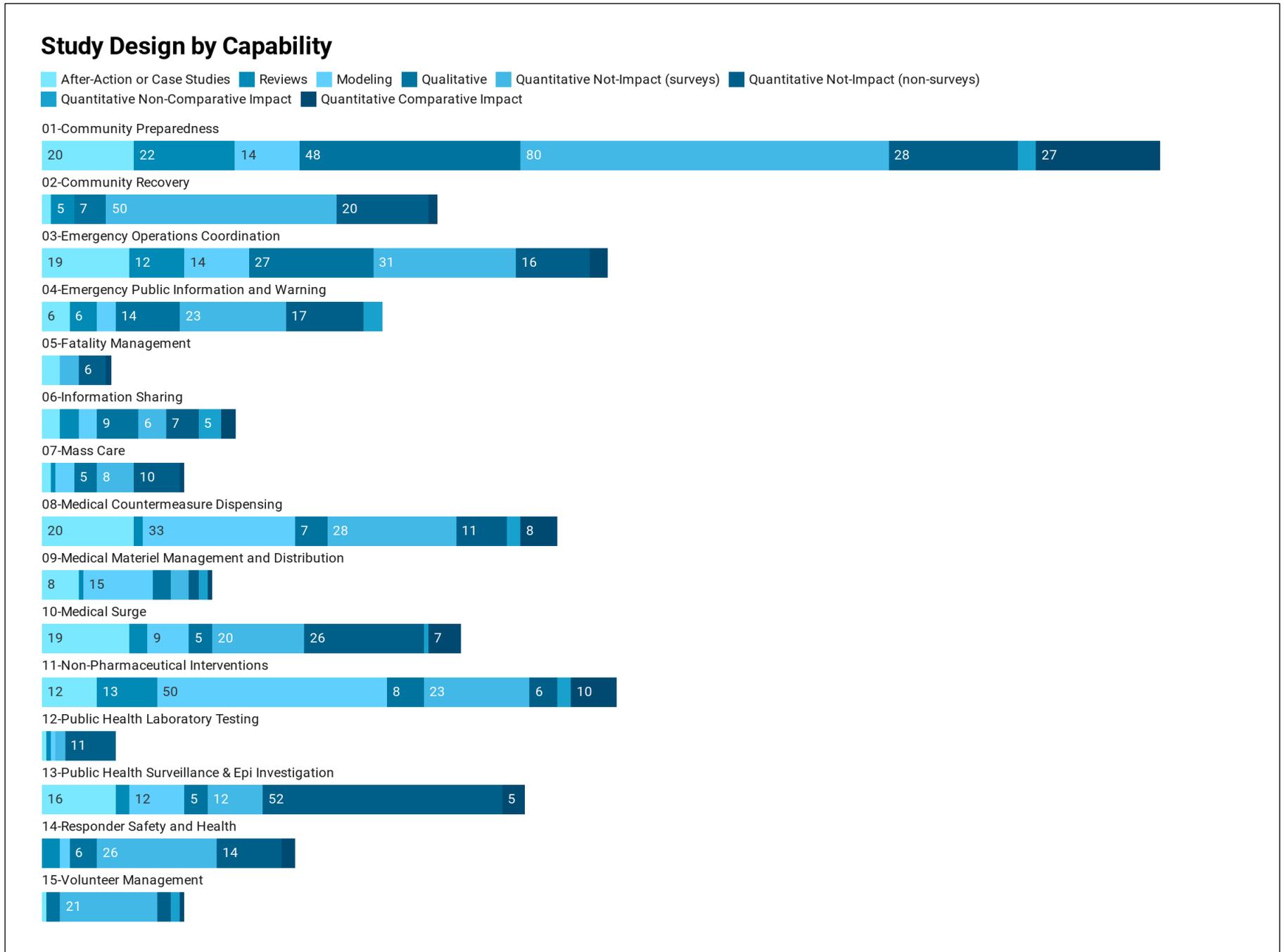


Figure 7. Number of publications by type of agency or organization and capability

Organization by Capability

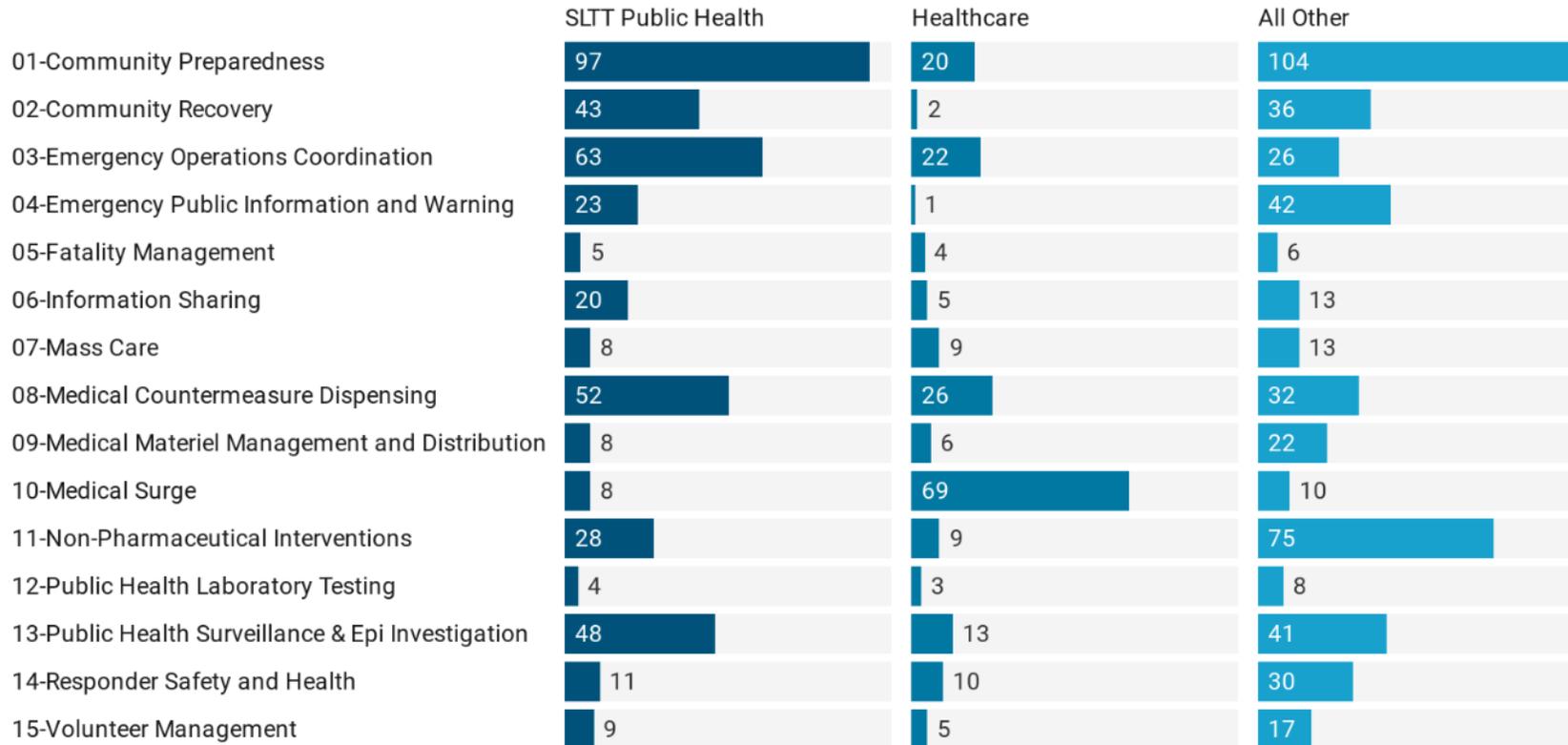


Figure 8. Number of publications by geographical setting and capability

Setting by Capability

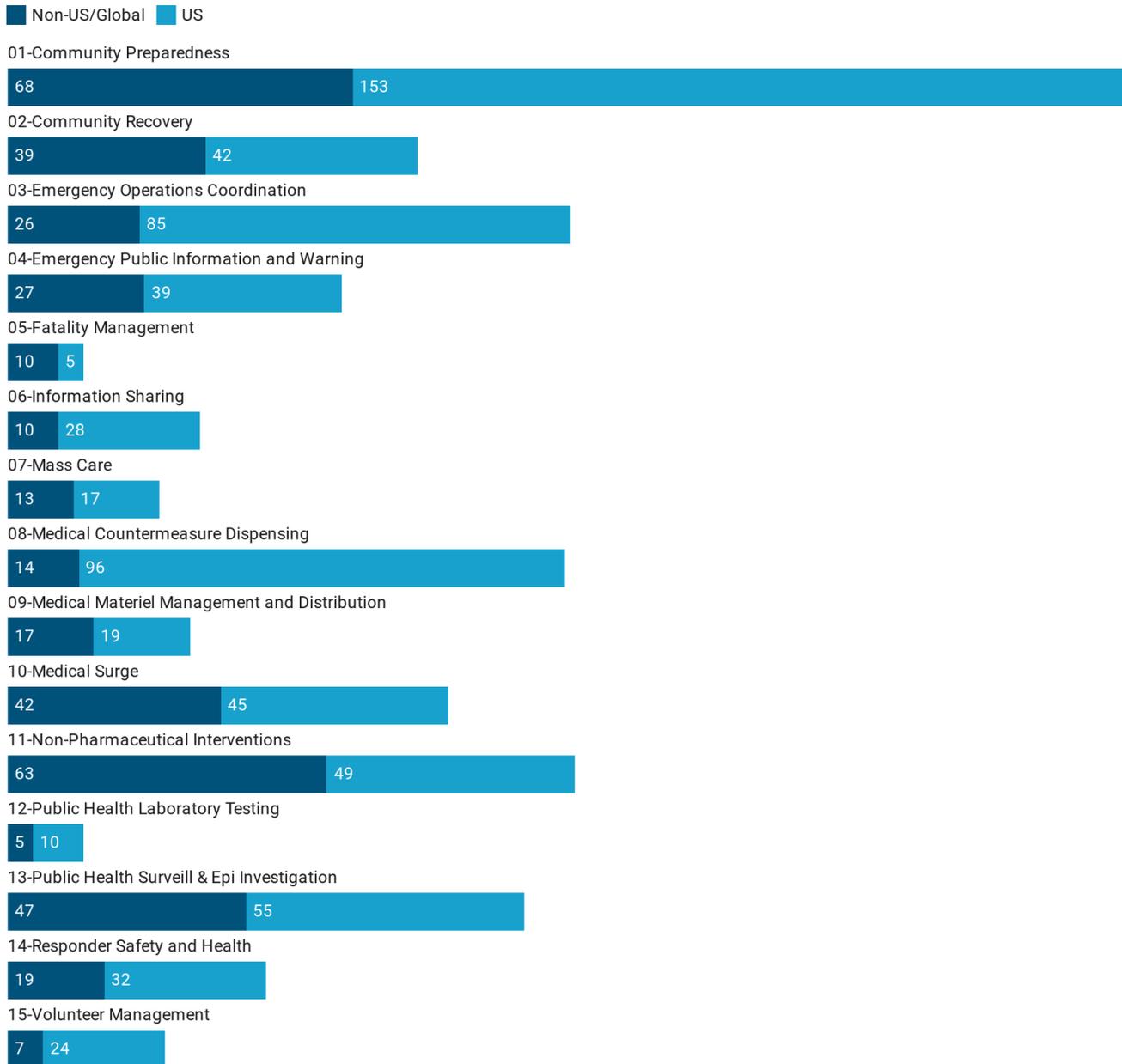


Figure 9. Multidimensional Evidence Maps of U.S. Impact Studies by Capability, Outcome, Sampling Unit, Sample Size and Disaster Type

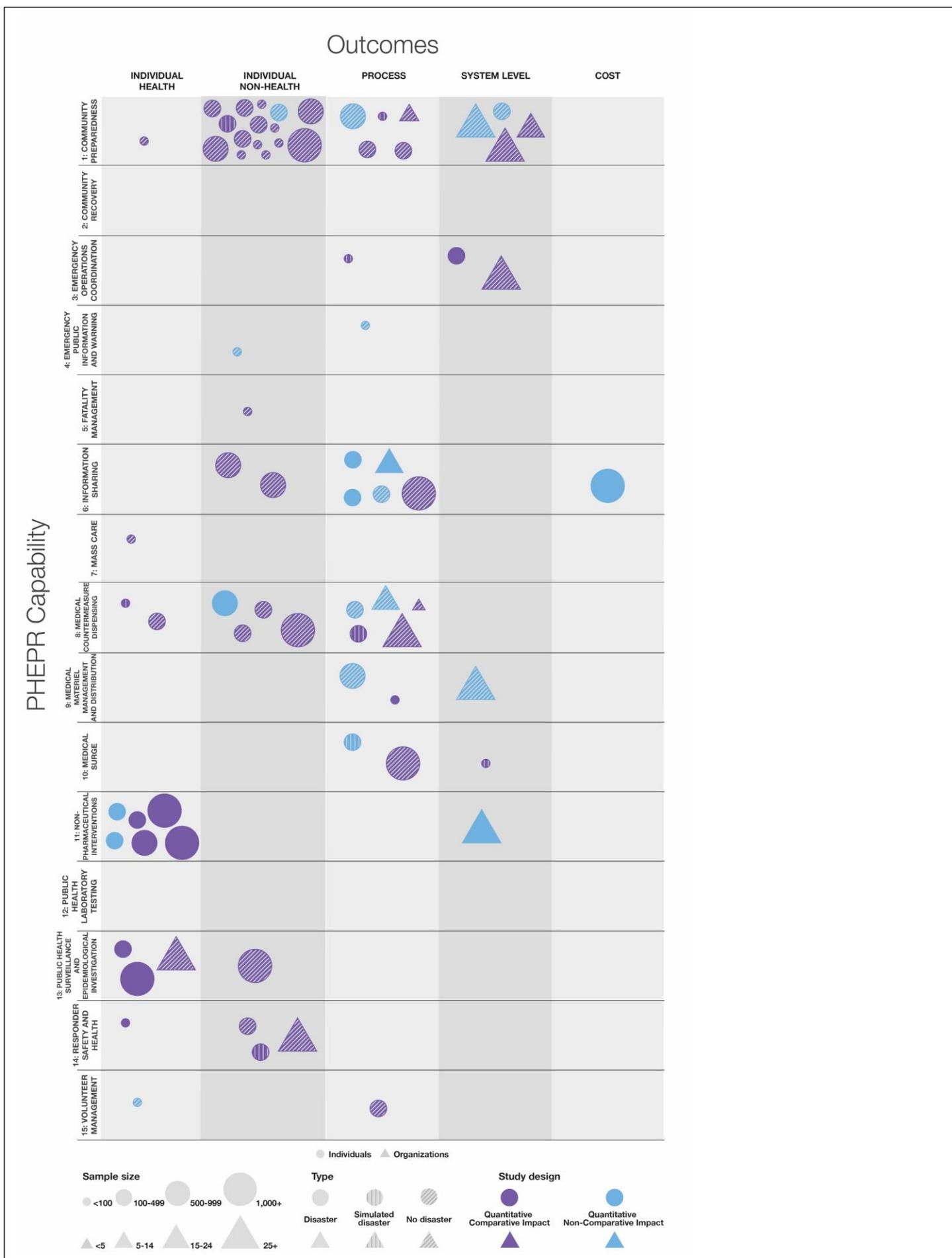
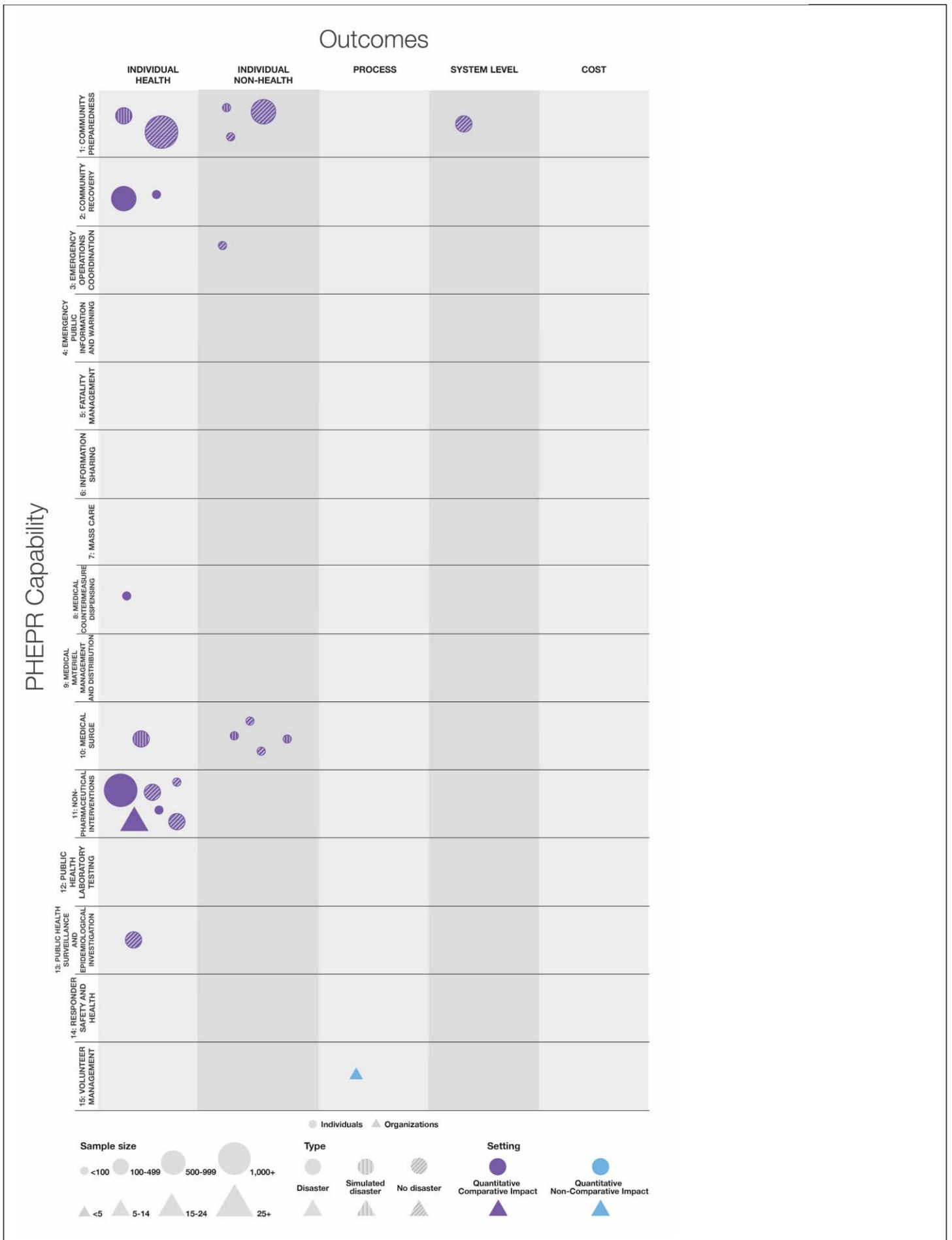


Figure 10. Multidimensional Evidence Maps of non-U.S. Impact Studies by Capability, Outcome, Sampling Unit, Sample Size and Disaster Type



Capability 1-Community Preparedness

Study design

PHEPR Practice Areas

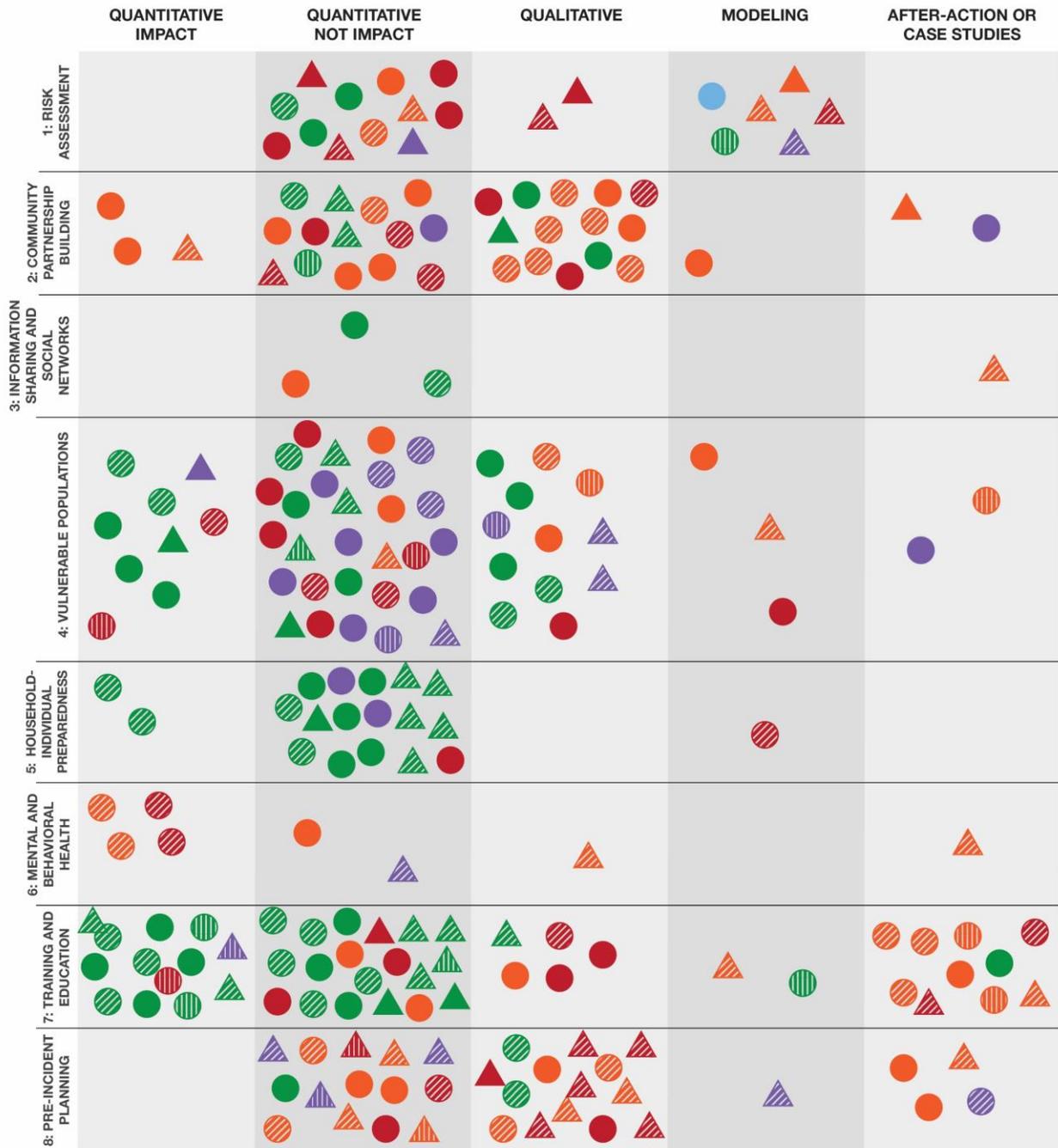
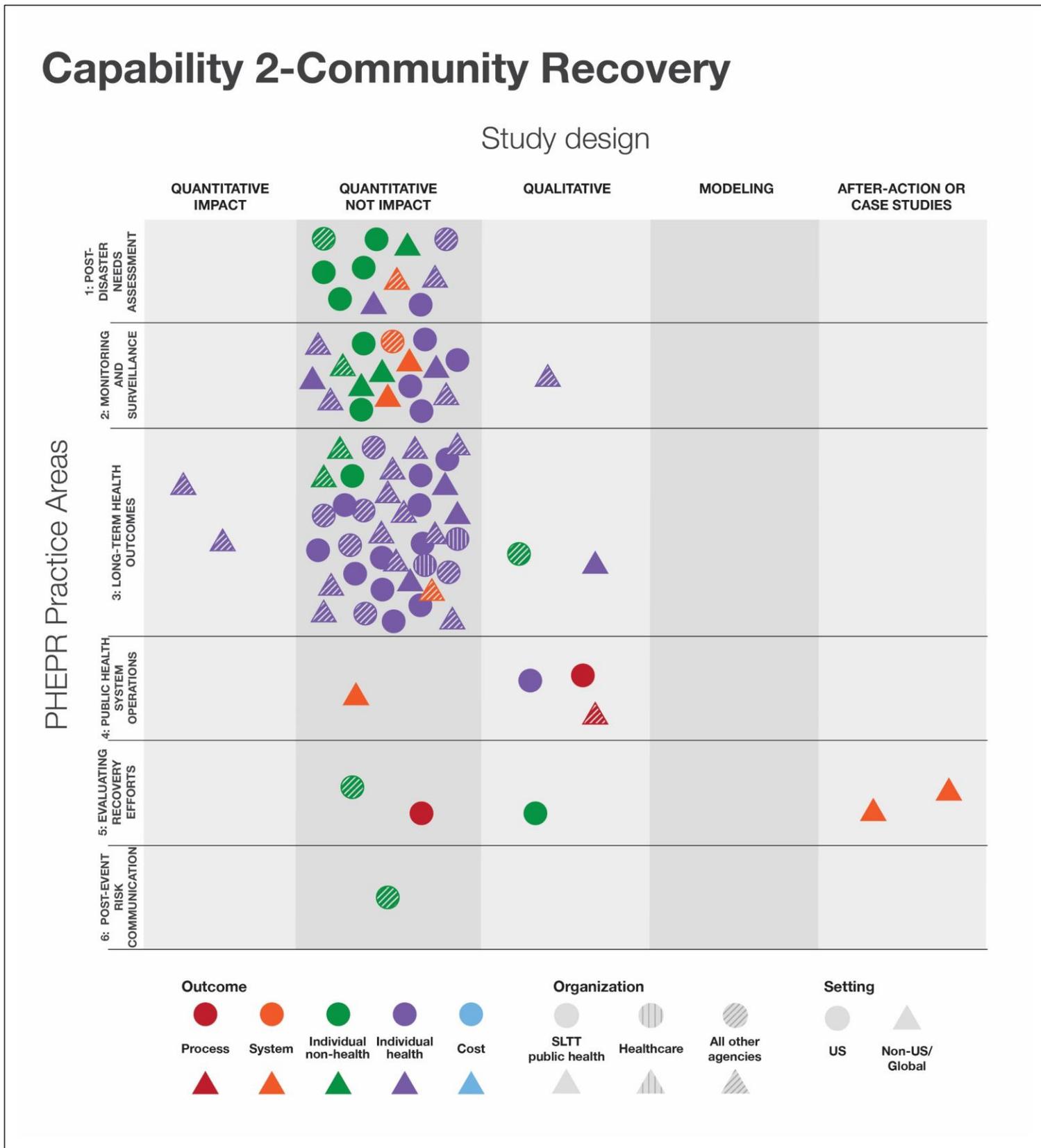


Figure 11.2 – Capability 2 - Community Recovery Practice Matrix



Capability 3-Emergency Operations Coordination

Study design

PHEPR Practice Areas

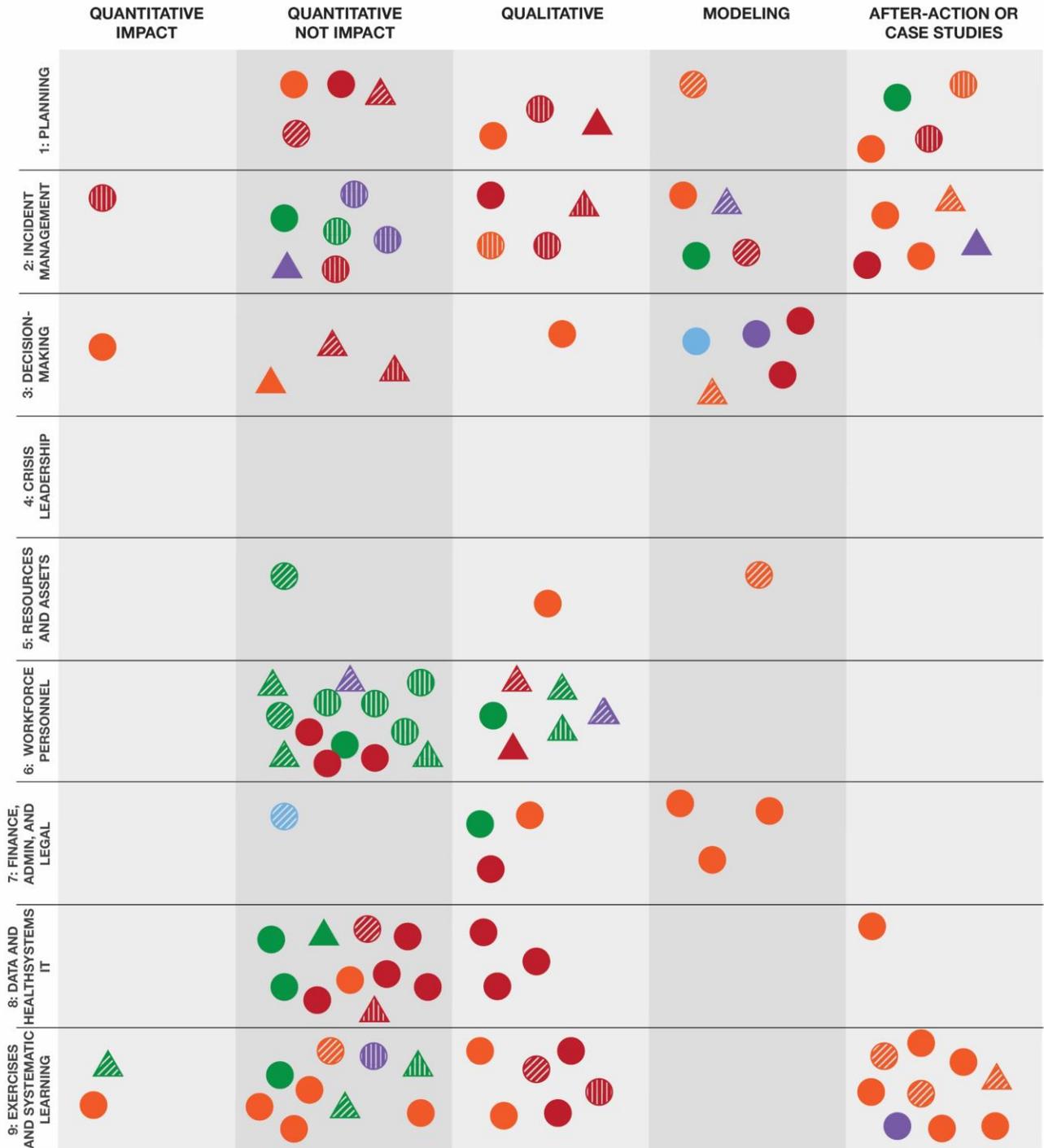


Figure 11.6– Capability 6 -Information Sharing Practice Matrix

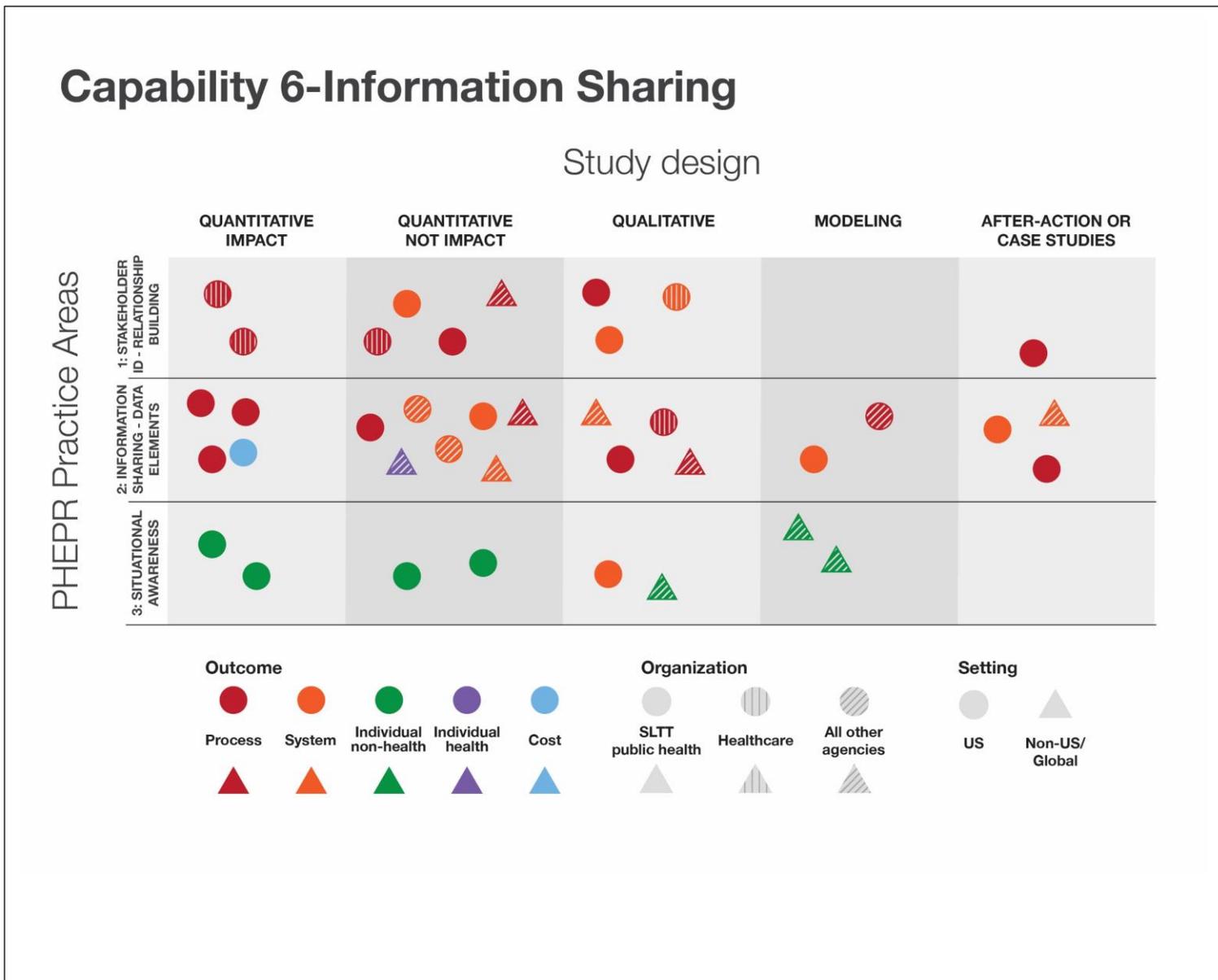


Figure 11.7–Mass Care Practice Matrix

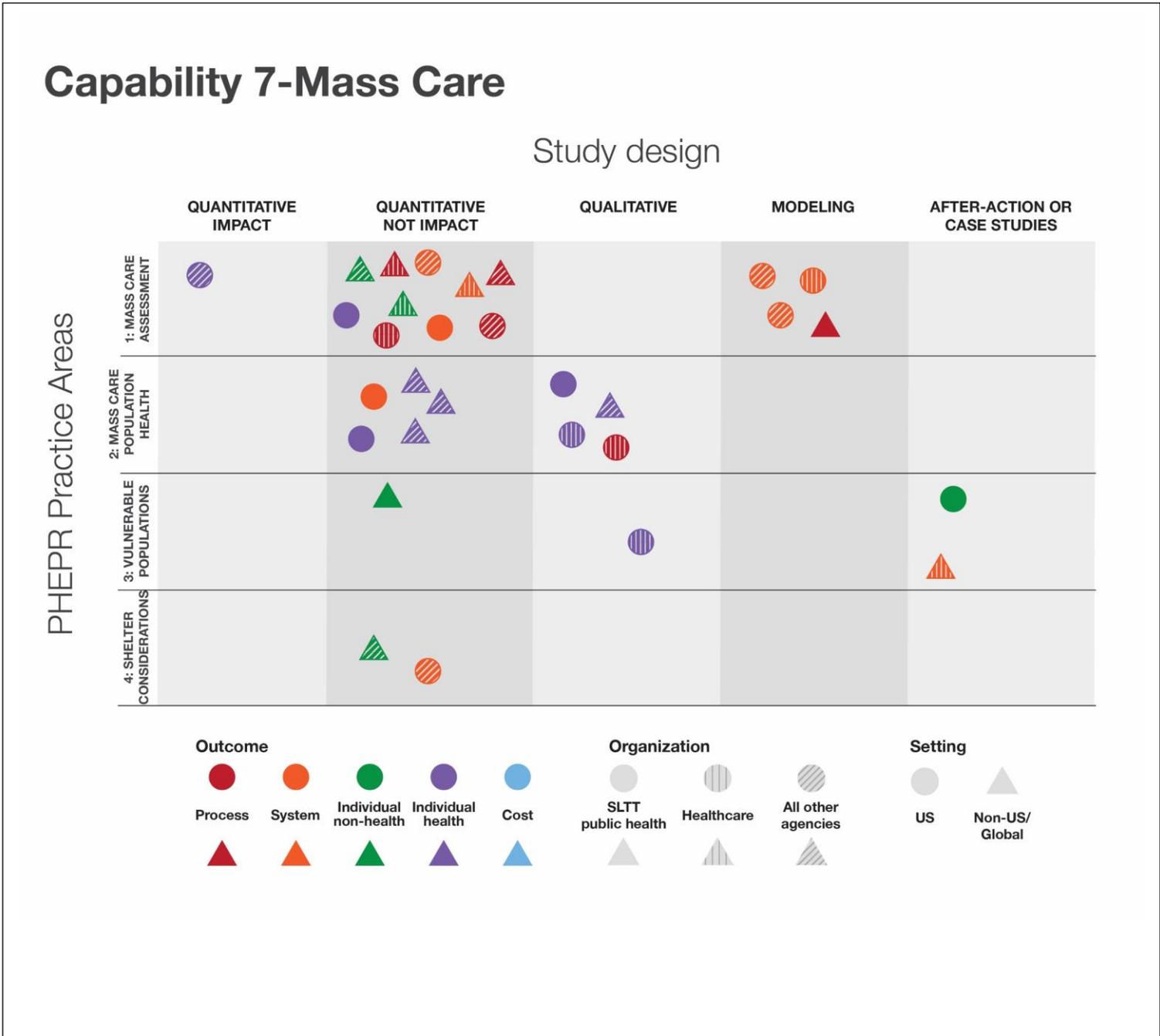


Figure 11.8– Capability 8 -Medical Countermeasure Dispensing Practice Matrix

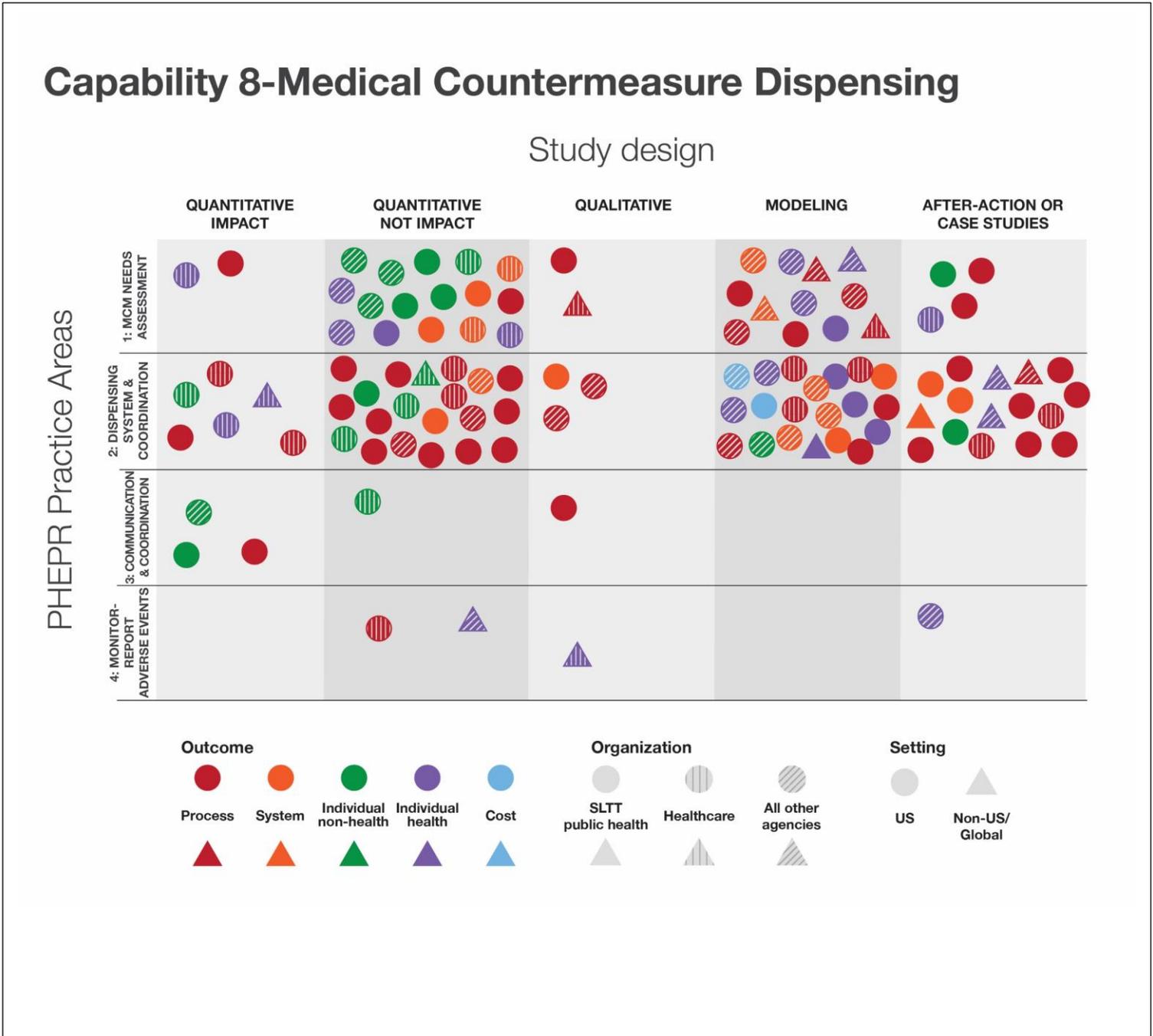


Figure 11.9– Capability 9 - Medical Materiel Management and Distribution Practice

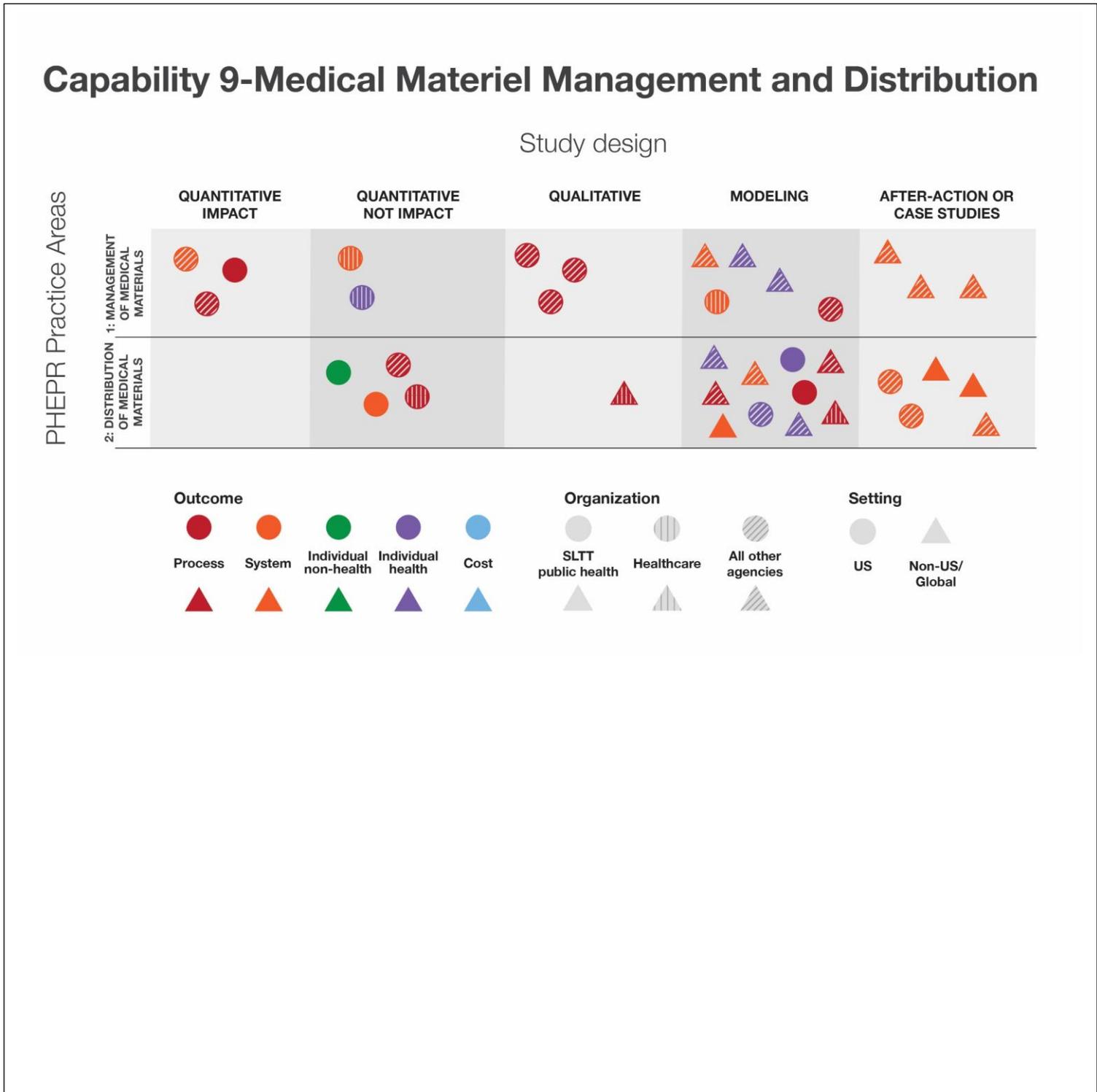


Figure 11.10– Capability 10 – Medical Surge Practice Matrix

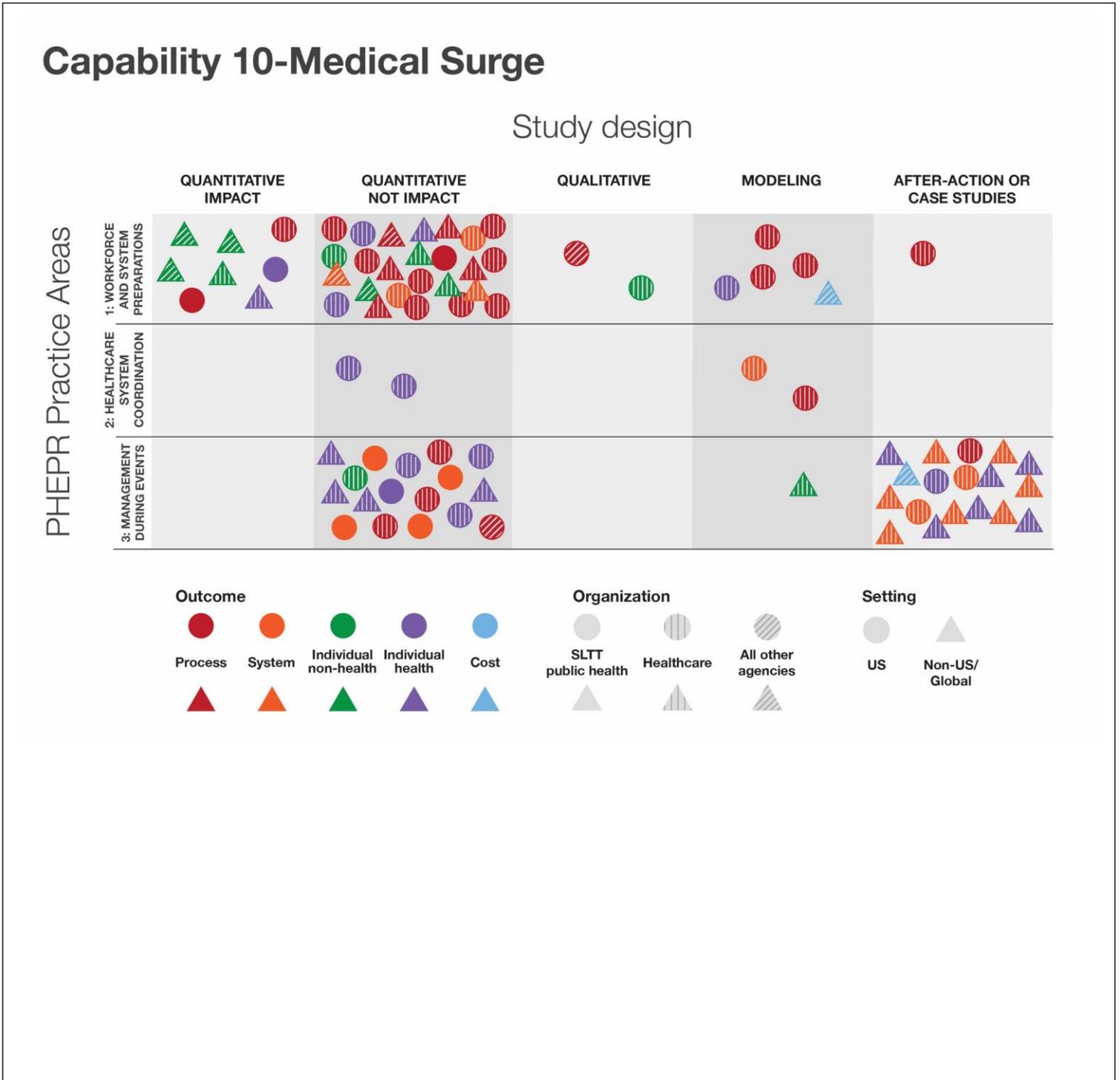


Figure 11.11– Capability 11 – Non-Pharmaceutical Interventions Practice Matrix

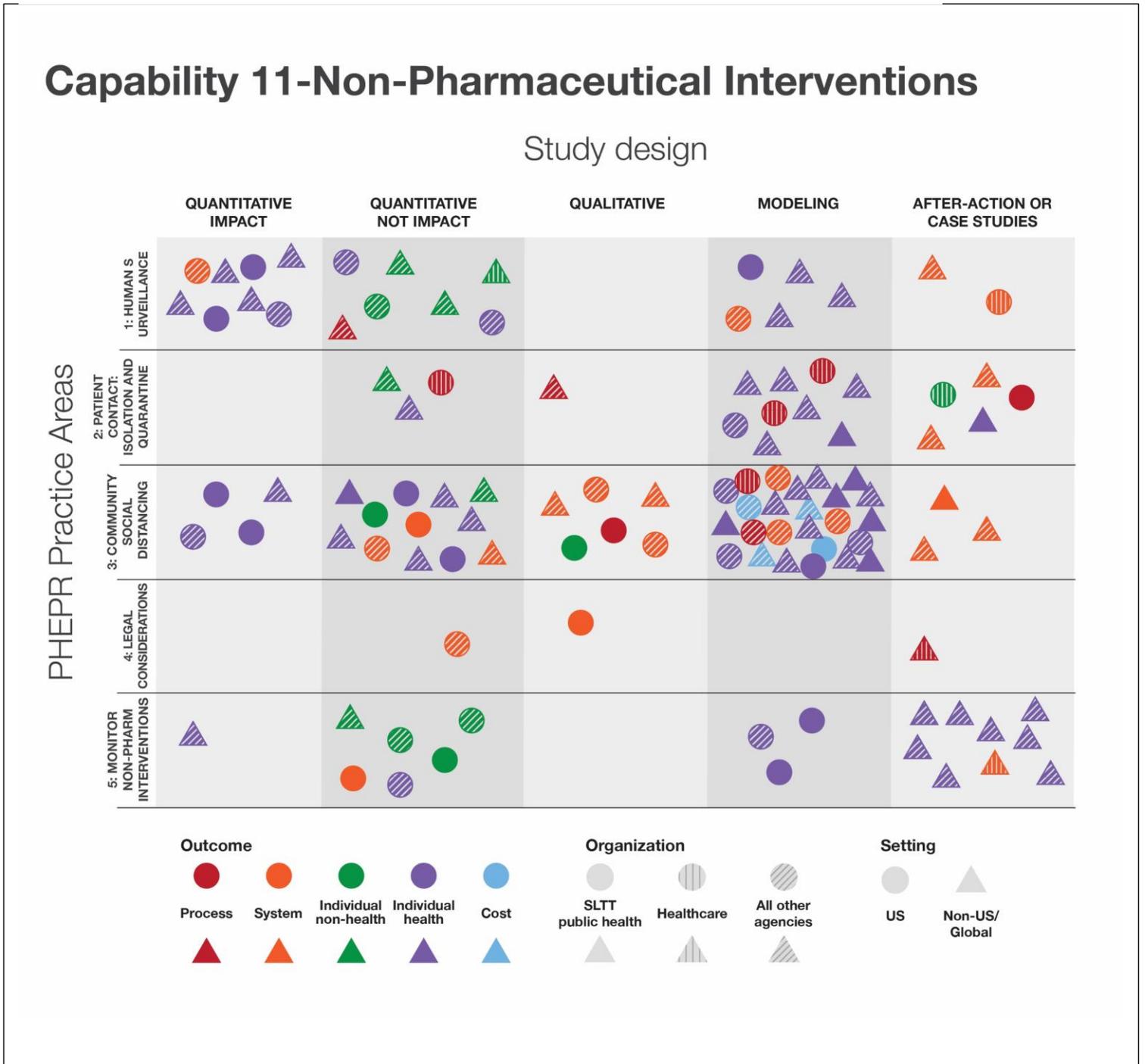


Figure 11.12– Capability 12 – Public Health Laboratory Testing Practice Matrix

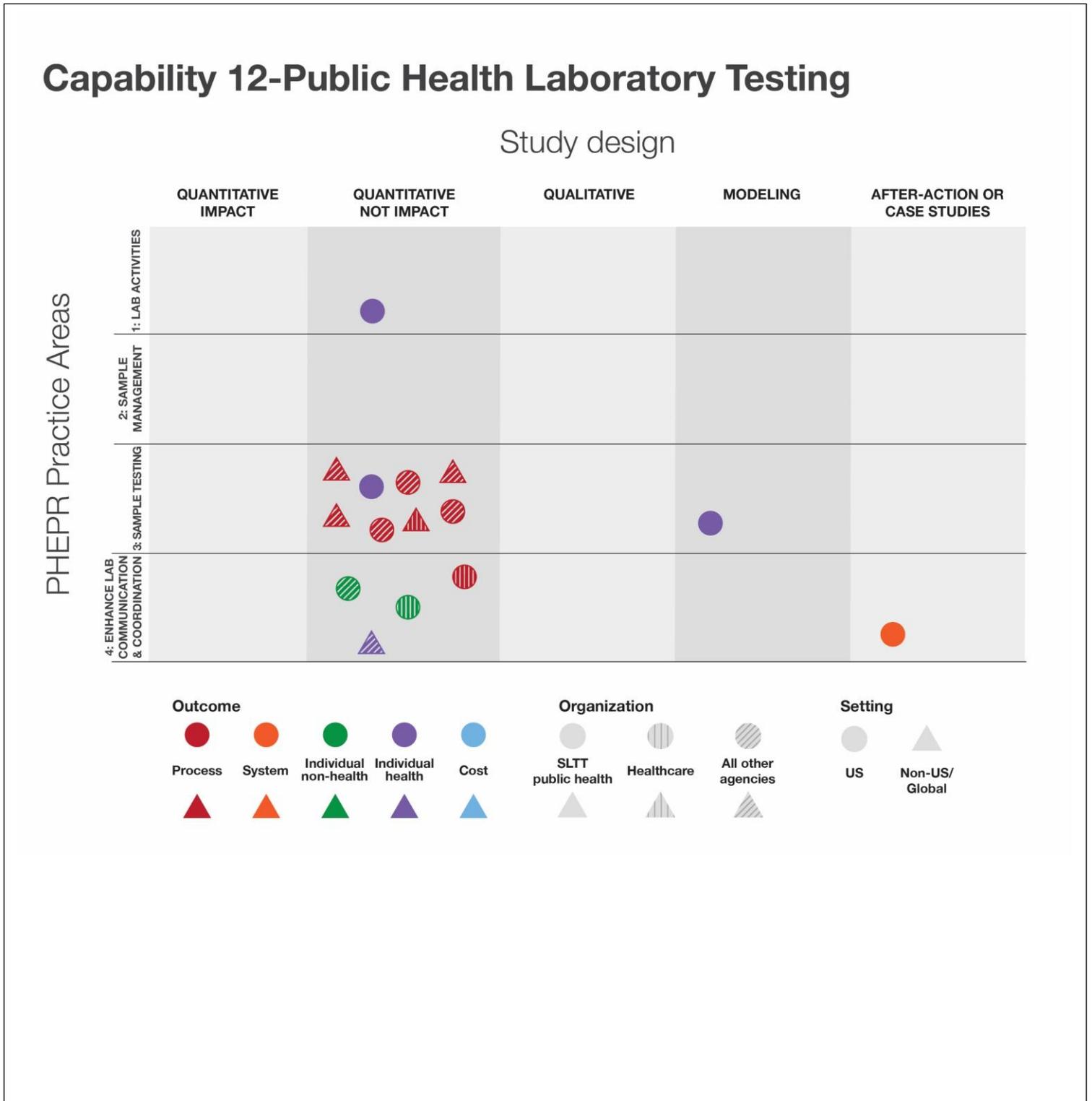


Figure 11.13– Capability 13 – Public Health Surveillance & Epidemiology Investigation

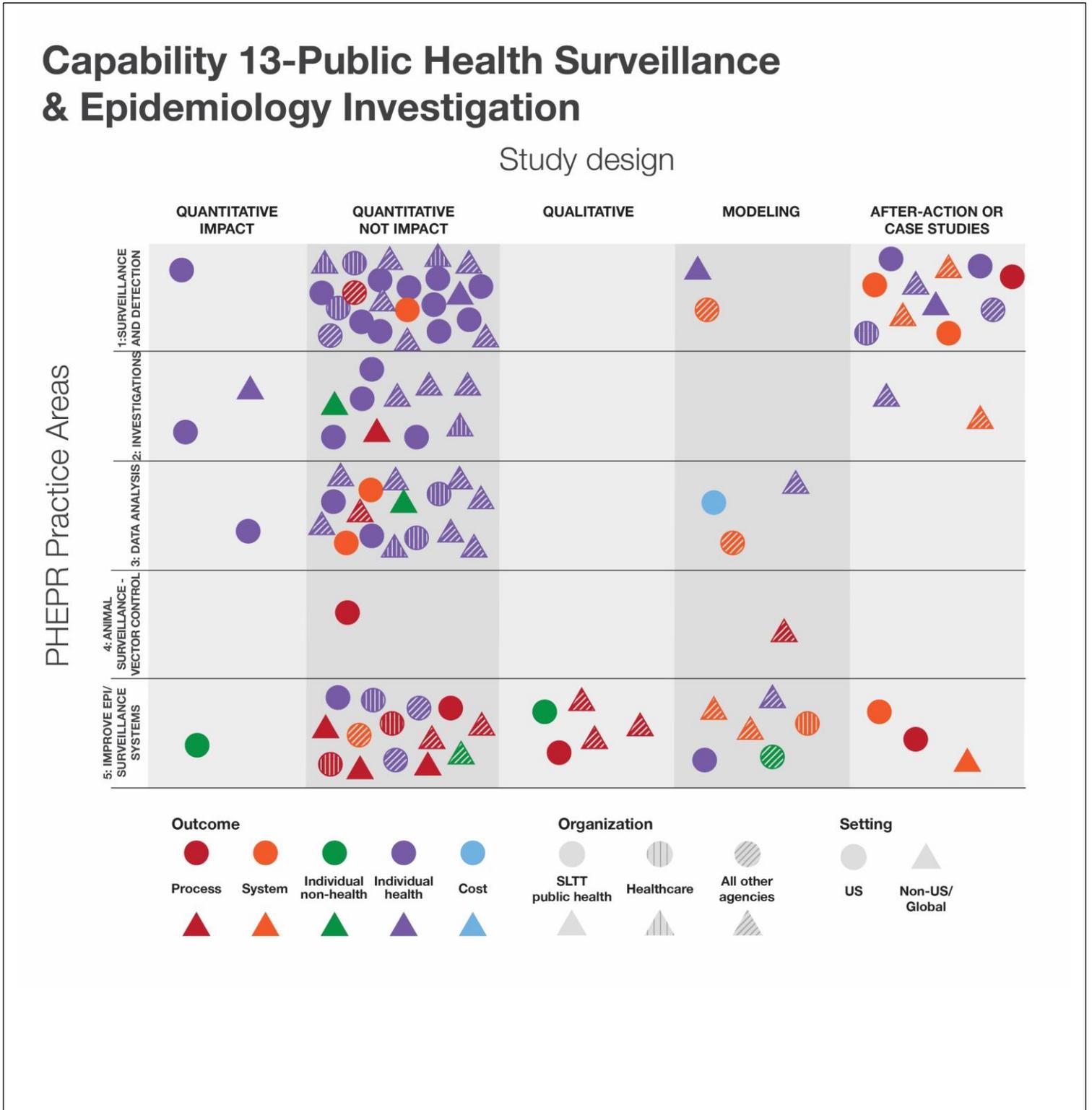
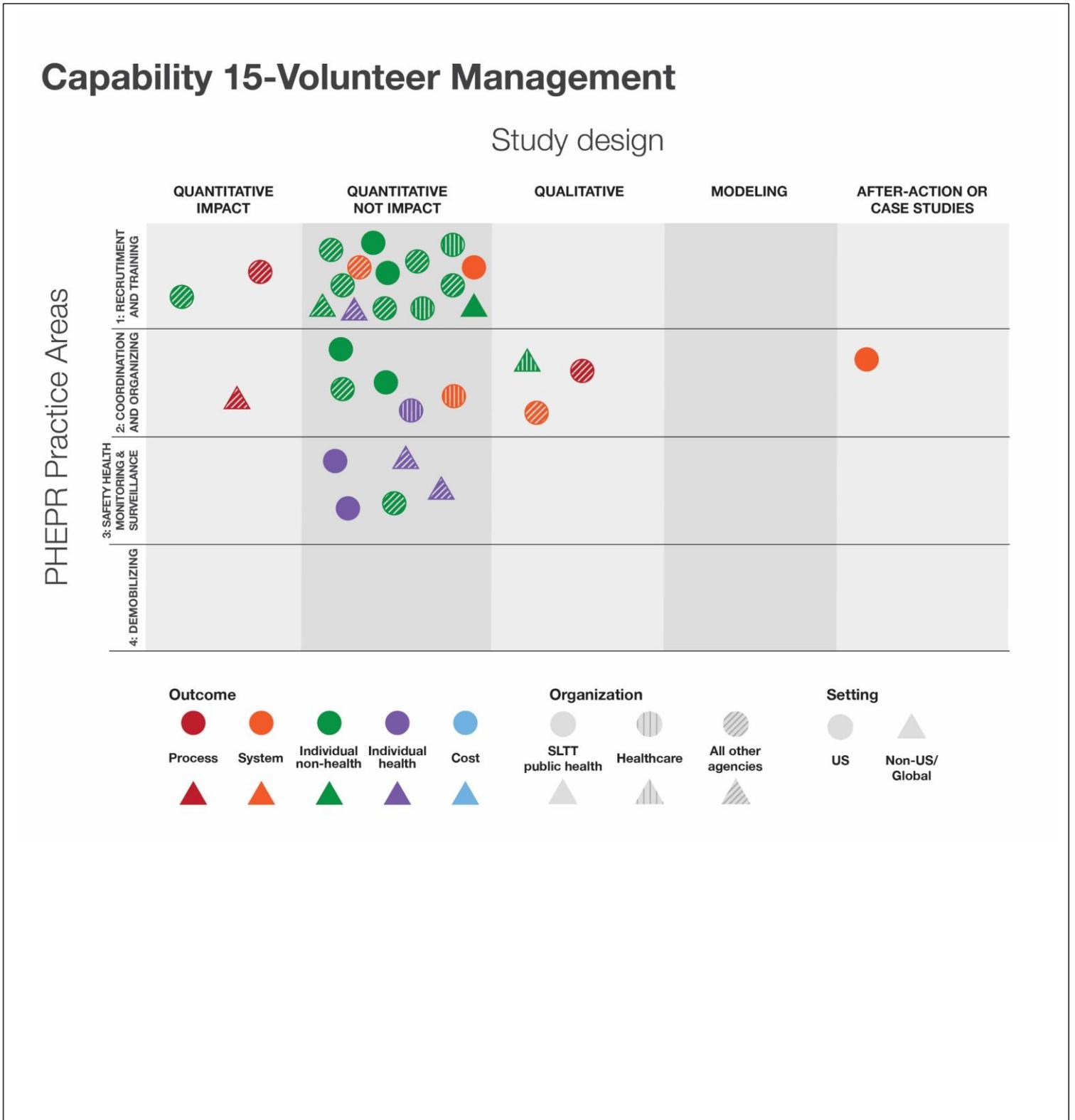


Figure 11.15– Capability 15 – Volunteer Management Practice Matrix



Supplemental Figures

Figure S1 – Panel 1. Search Process Flowchart

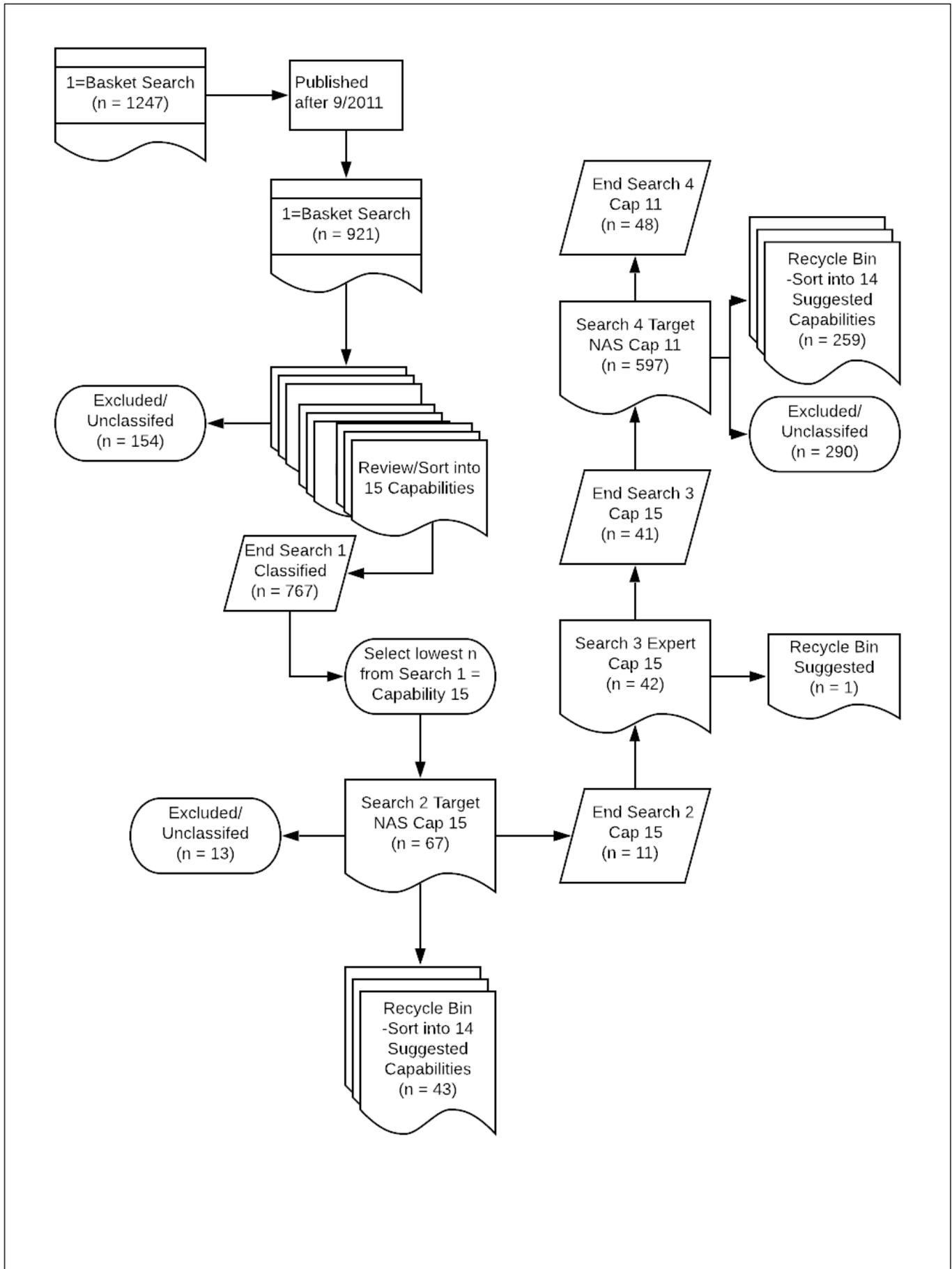


Figure S1 – Panel 2. Search Process Flowchart

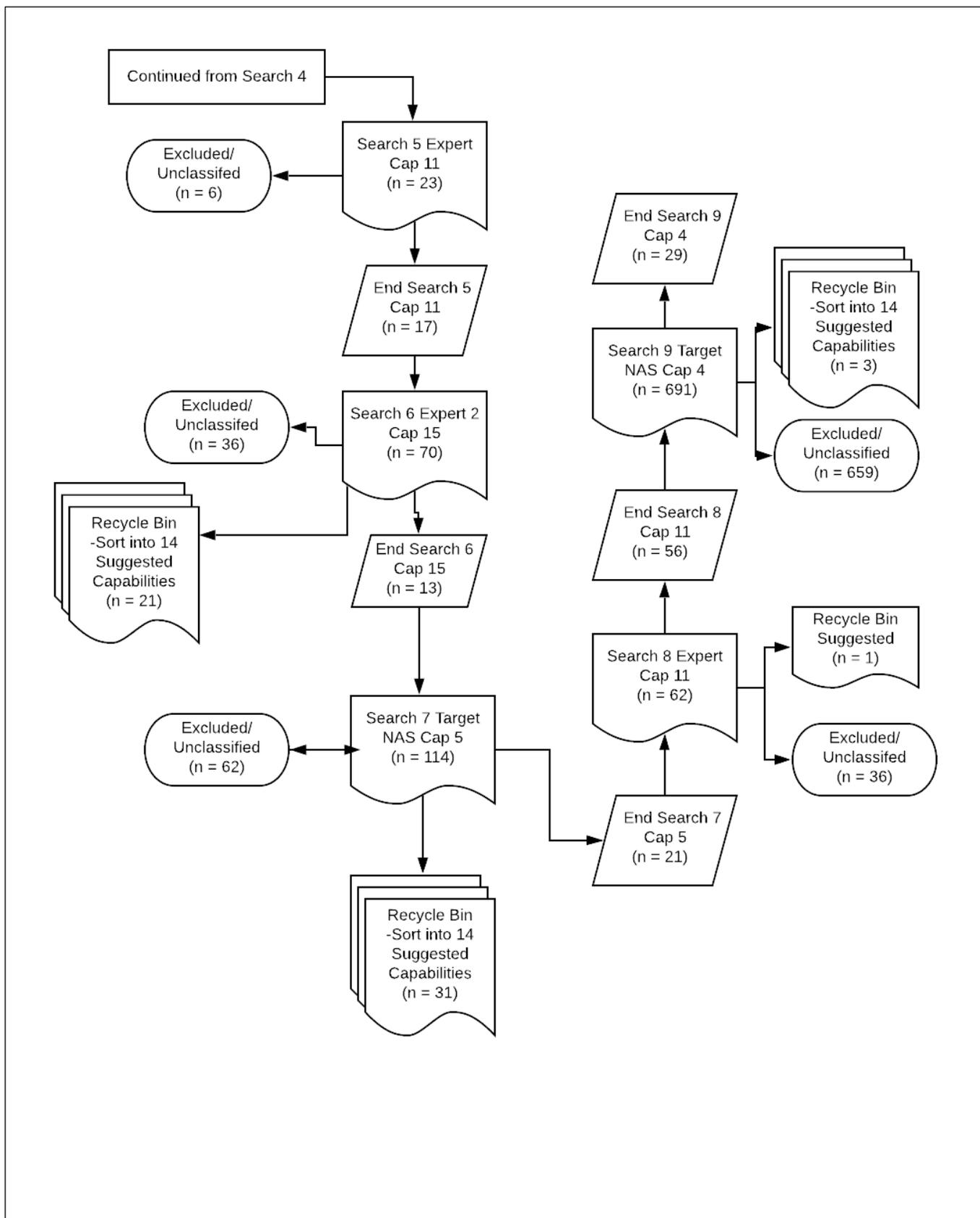
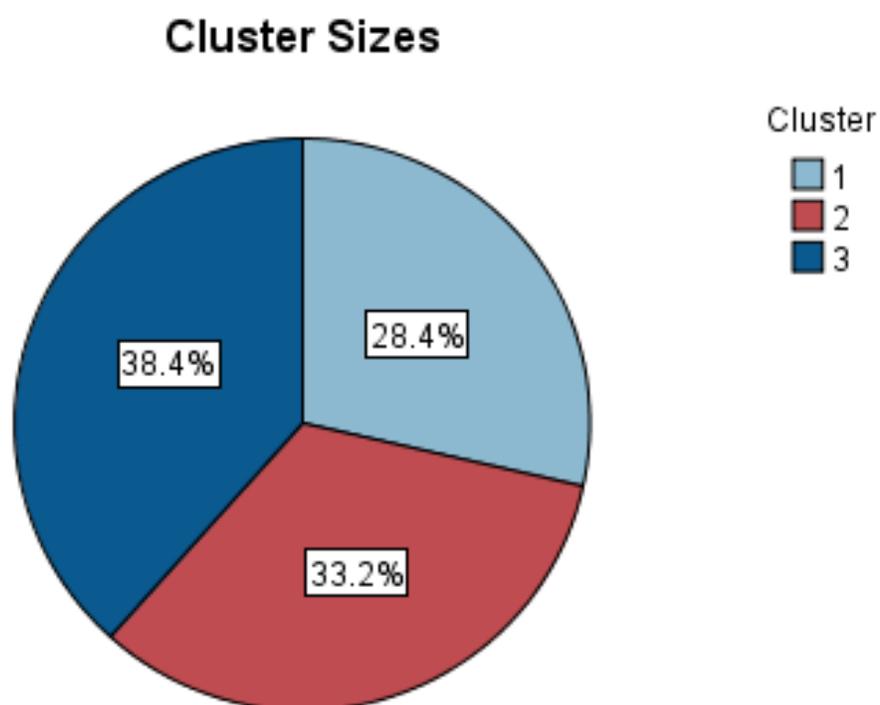
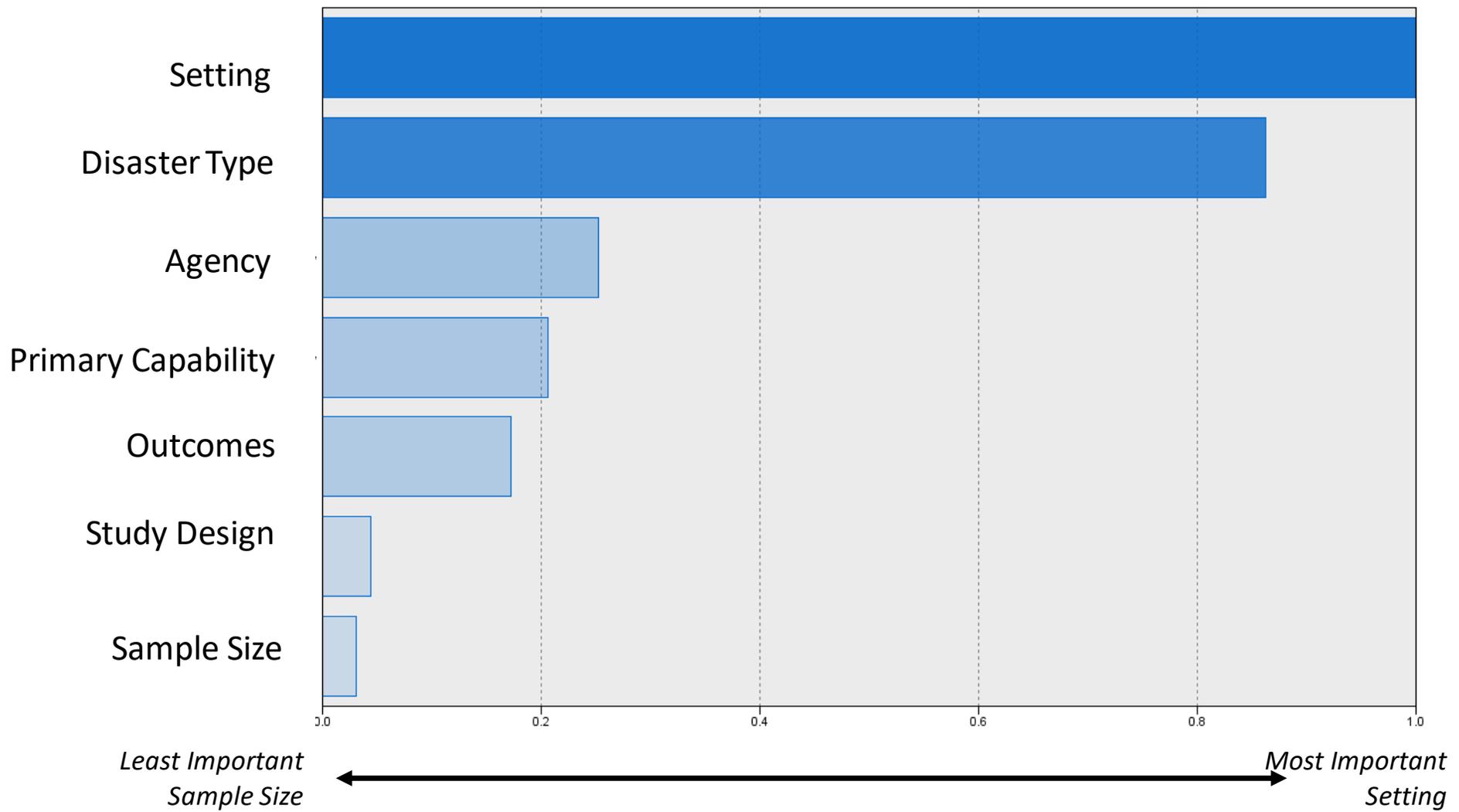


Figure S2. Publications Clustered by Study Characteristics (Evidence studies with Sample Sizes

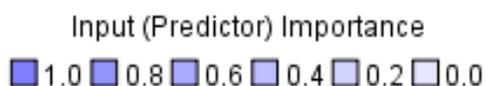


Size of Smallest Cluster	220 (28.4%)
Size of Largest Cluster	297 (38.4%)
Ratio of Sizes: Largest Cluster to Smallest Cluster	1.35

Predictor Importance in Determining Clusters



Clusters



Cluster	3	2	1
Label			
Description			
Size			
Inputs	Setting	Setting	Setting
	Disaster Type	Disaster Type	Disaster Type
	Agency	Agency	Agency
	Outcomes	Outcomes	Outcomes
	Study Design	Study Design	Study Design
	Sample Size	Sample Size	Sample Size
	Evaluation Fields	Capability	Capability

Figure S5.1 Cluster 1 Study Characteristics

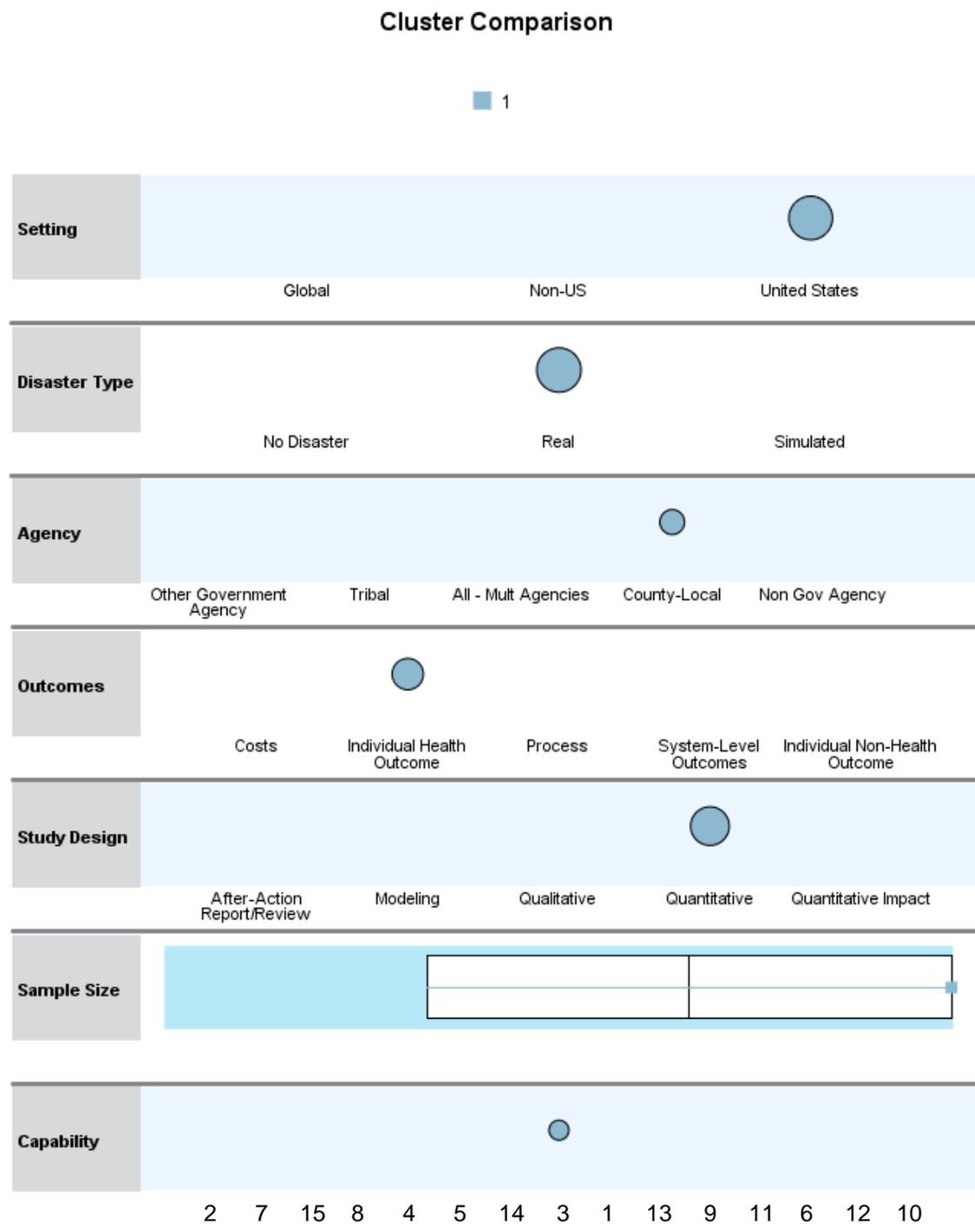


Figure S5.2 Cluster 2 Study Characteristics

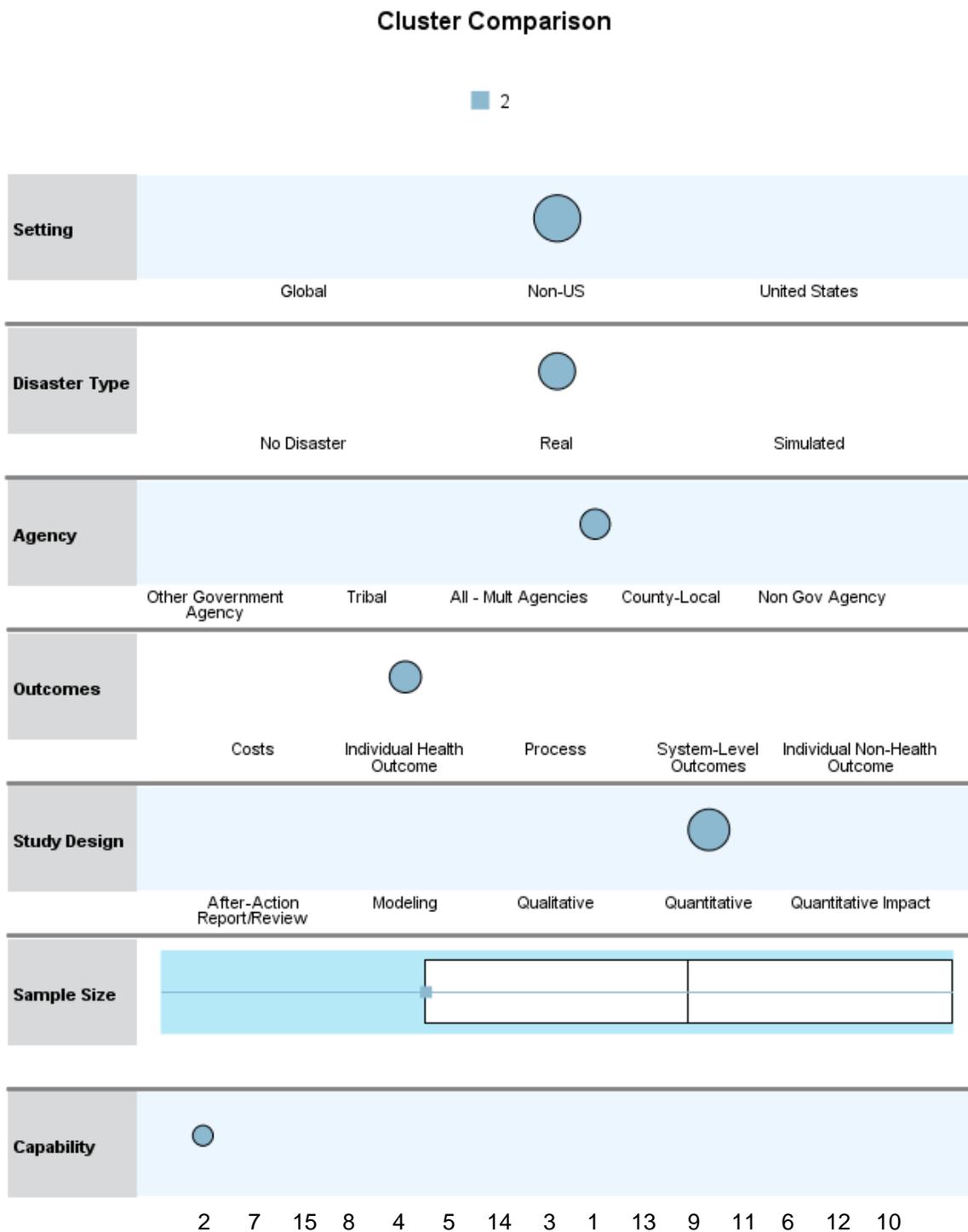


Figure S5.3 Cluster 3 Study Characteristics

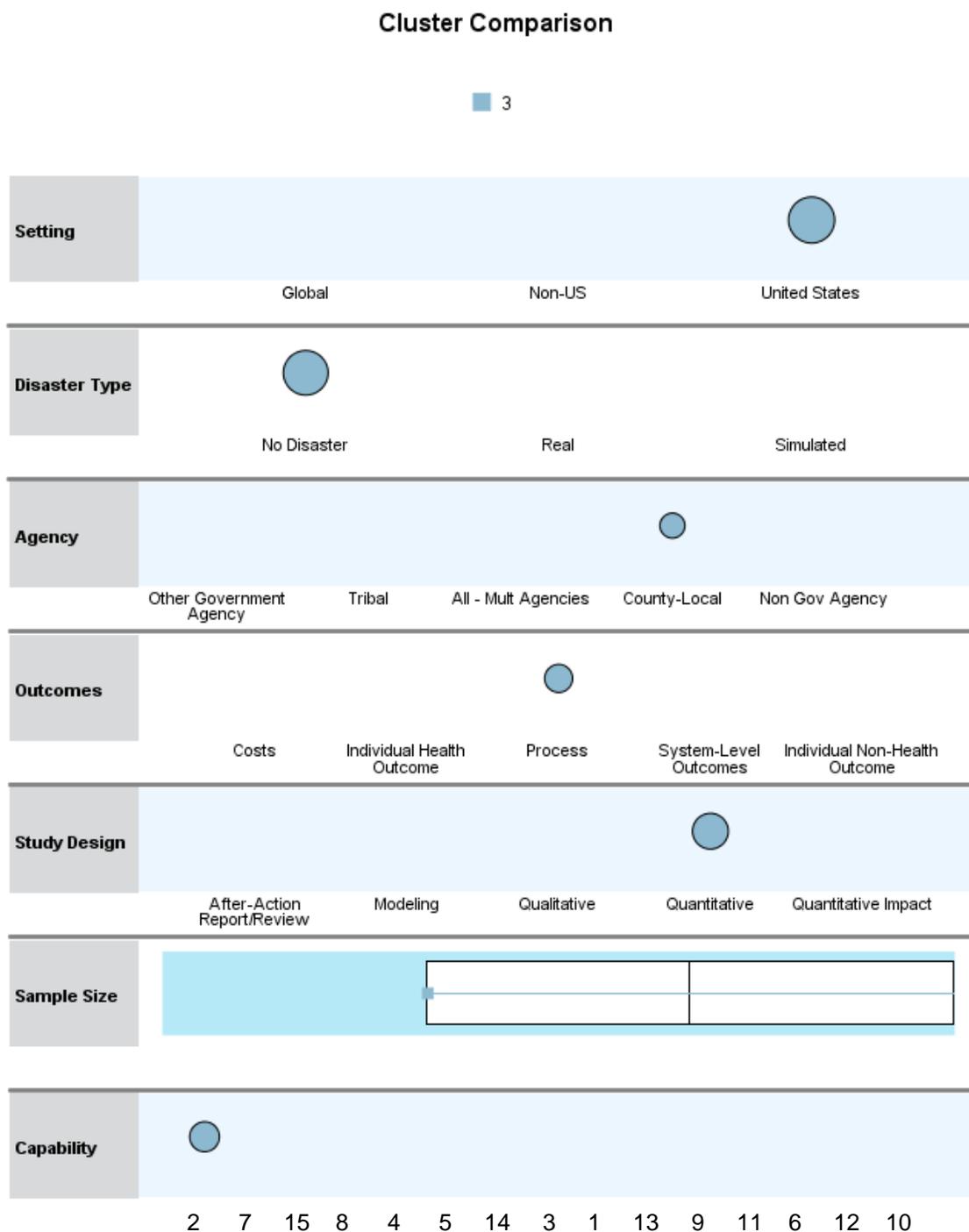


Figure S6. Natural Language Processing: Identifying Studies Involving Outbreaks of Infectious Diseases by Study Type

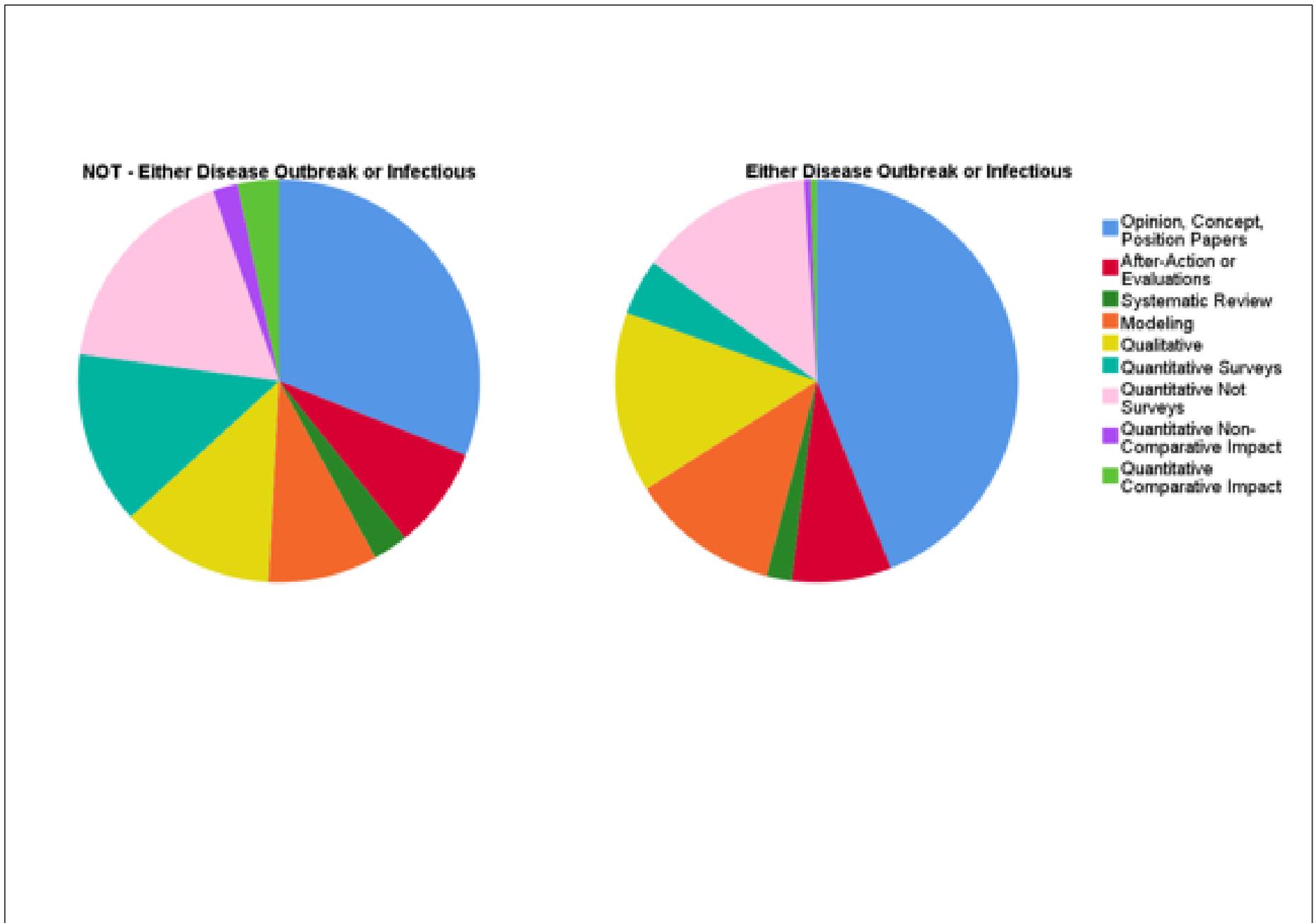


Figure S7. Natural Language Processing - Infectious Disease Outbreak Studies by Primary Capability Practice Area

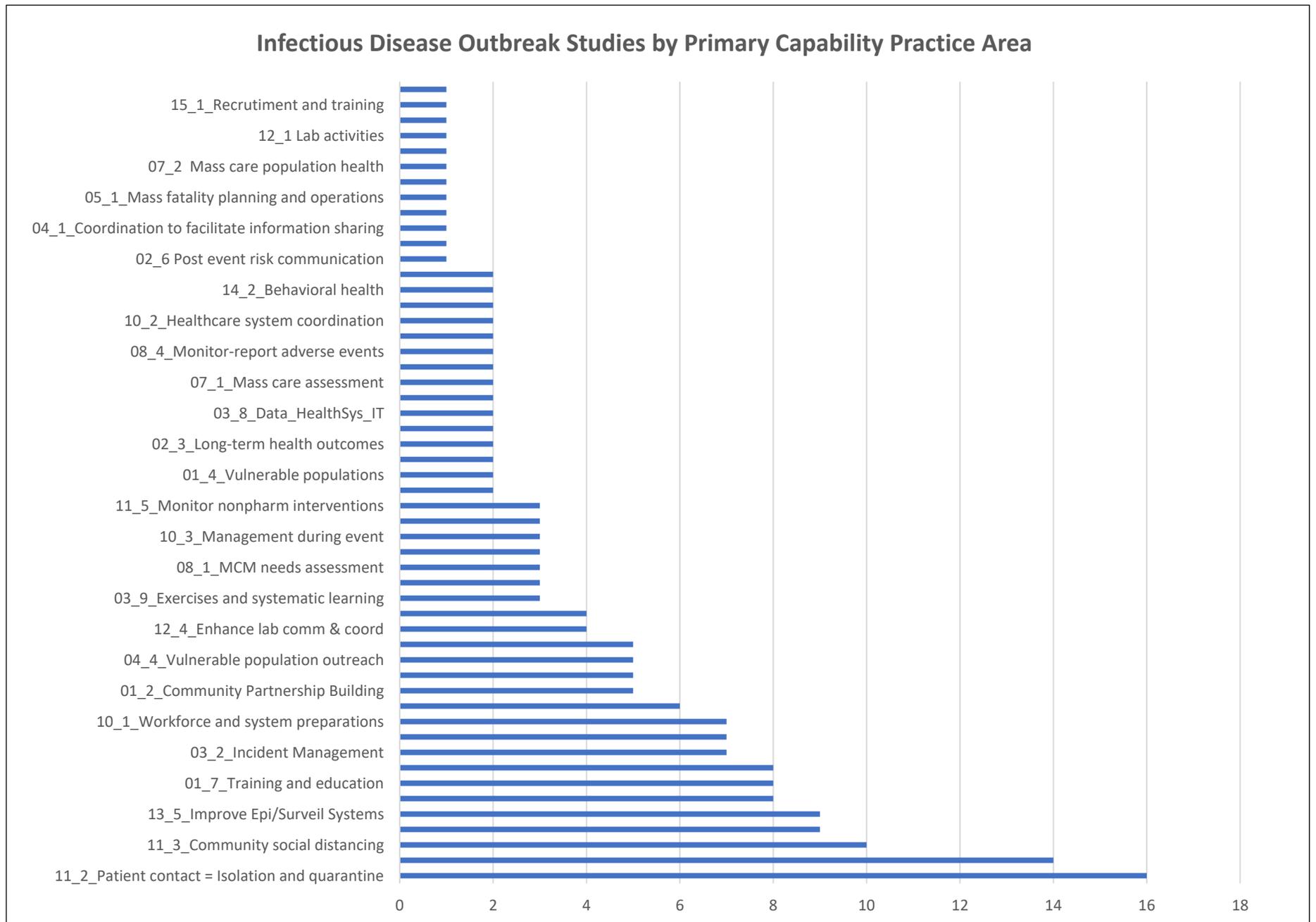
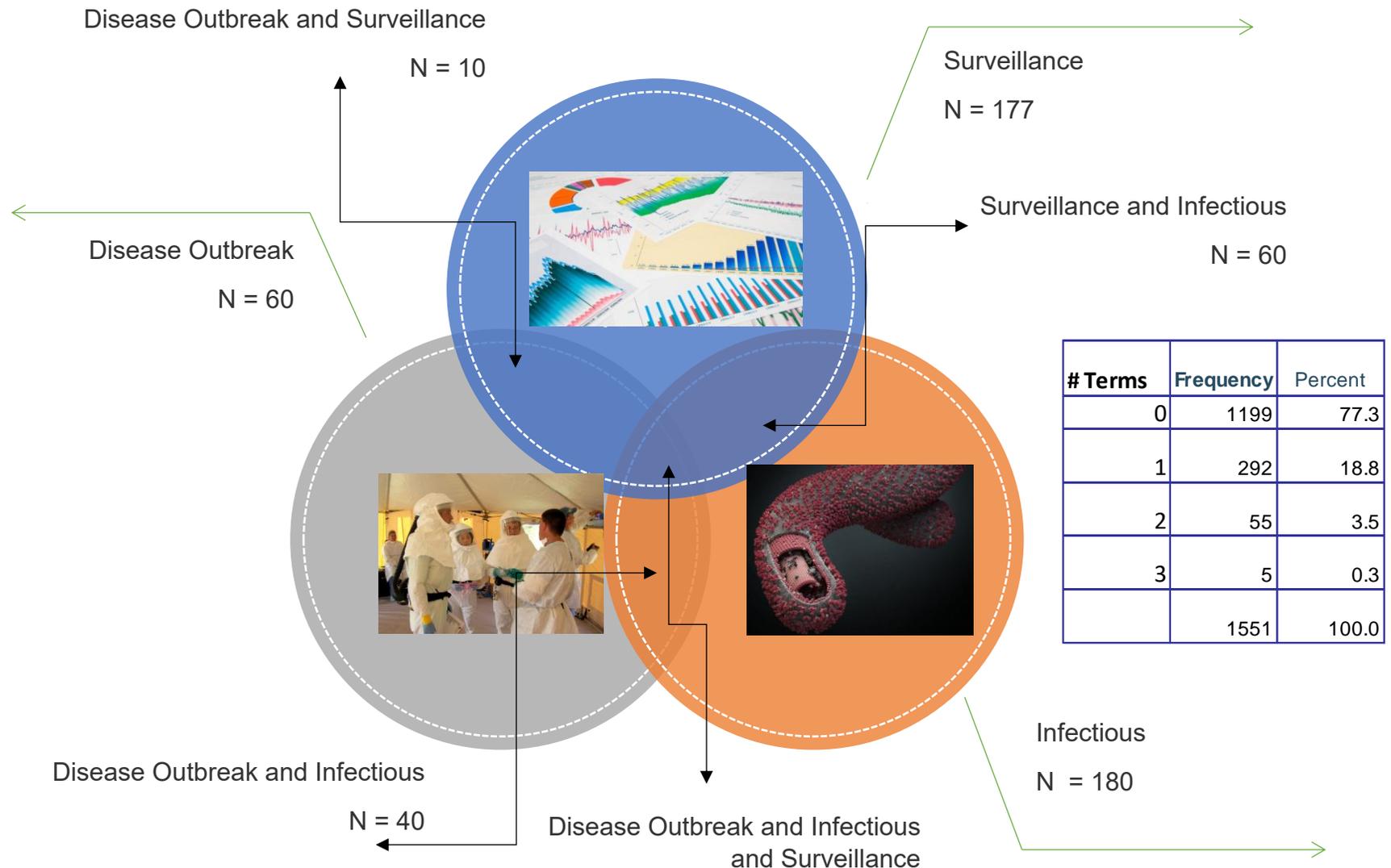


Figure S8. Natural Language Processing - Infectious Disease Outbreak Studies and Surveillance Studies

Targeting Outbreak Preparedness

Three Flags – 4 Combinations



APPENDICES

Appendix 1 - Capabilities and Practices Coding and Descriptions

List of Capabilities Codes in the Publication Abstraction Database

15 PHEPR Capabilities

- 01-Community Preparedness
- 02-Community Recovery
- 03-Emergency Operations Coordination
- 04-Emergency Public Information and Warning
- 05-Fatality Management
- 06-Information Sharing
- 07-Mass Care
- 08-Medical Countermeasure Dispensing
- 09-Medical Materiel Management and Distribution
- 10-Medical Surge
- 11-Non-Pharmaceutical Interventions
- 12-Public Health Laboratory Testing
- 13-Public Health Surveill & Epi Investigation
- 14-Responder Safety and Health
- 15-Volunteer Management

Other Coding Options

- 97-None - Use Alternative Areas
- 98-Not Preparedness
- 99-No Info/Not Appropriate

List of Practices Codes in the Publication Abstraction Database

01-Community Preparedness

- 01_1_Risk Assessment
- 01_2_Community Partnership Building
- 01_3_Share Info_Social_Net
- 01_4_Vulnerable populations
- 01_5_Household/individual preparedness
- 01_6_Mental and behavioral health
- 01_7_Training and education
- 01_8_Pre-incident planning

02-Community Recovery

- 02_1_Post-disaster needs assessment
- 02_2_Monitoring and surveillance
- 02_3_Long-term health outcomes
- 02_4_Public health system operations
- 02_5_Evaluating recovery efforts
- 02_6 Post event risk communication
- 02_7_Community infrastructure

03-Emergency Operations Coordination

- 03_1_Planning
- 03_2_Incident Management
- 03_3_Decision-making
- 03_4_Crisis Leadership
- 03_5_Resources_Assets
- 03_6_Workforce_personnel

03_7_Finance_Admin_Legal

03_8_Data_HealthSys_IT

03_9_Exercises and systematic learning

04-Emergency Public Information and Warning

04_1_Coordination to facilitate information sharing

04_2_Community Engagement and Outreach

04_3_Community Channels

04_4_Vulnerable population outreach

04_5_Messaging

05-Fatality Management

05_1_Mass fatality planning and operations

05_2_Antemortem data

06-Information Sharing

06_1_Stakeholder ID- relationship building

06_2_Information sharing - data elements

06_3_Situational awareness

07-Mass Care

07_1_Mass care assessment

07_2_Mass care population health

07_3_Vulnerable populations

07_4_Shelter considerations

08-Medical Countermeasure Dispensing

08_1_MCM needs assessment

08_2_Dispensing system & coordination

08_3_Communication & coordination

08_4_Monitor-report adverse events

09-Medical Materiel Management and Distribution

09_1_Management of medical materials

09_2 Distribution of medical materials

10-Medical Surge

10_1_Workforce and system preparations

10_2_Healthcare system coordination

10_3_Management during events

11-Non-Pharmaceutical Interventions

11_1_Human Surveillance

11_2_Patient contact = Isolation and quarantine

11_3_Community social distancing

11_4 Legal considerations

11_5_Monitor nonpharm interventions

12-Public Health Laboratory Testing

12_1 Lab activities

12_2_Sample management

12_3_Sample Testing

12_4_Enhance lab comm & coord

13-Public Health Surveill & Epi Investigation

13_1_Surveillance and detection

13_2_Investigations

13_3_Data Analysis

13_4_Animal-surveillance - vector control

13_5_Improve Epi/Surveil Systems

14-Responder Safety and Health

14_1_Occupational health

14_2_Behavioral health

14_3_Planning

14_4_Personal protective equipment

15-Volunteer Management

15_1_Recrutiment and training

15_2_Coordination and organizing

15_3_Safety health monitor & Surveil

15_4_Demobilizing

Other Options

16_1_All or General

17_1_Other_Specify

99_1_NA_Alternative Area Did not fit one of the 15 capabilities so the Alternative Area was selected.

Description of Capability Practices

Below is a brief outline of each capability practice area. Please refer to the Centers for Disease Control and Prevention, U.S. Department of Health and Human Services document entitled “Public Health Emergency Preparedness and Response Capabilities: National Standards for State, Local, Tribal, and Territorial Public Health. Updated 2019” for a full description of the functions, resources, tasks and priorities for each capability.

1: Community Preparedness

Practice

1. Risk Assessment

- a. Incorporating simulation and modeling to inform jurisdictional risk assessments

2. Community Partnership Building

- a. Partnering with healthcare coalitions, medical reserve corps, academic institutions, faith-based institutions, among others
- b. Enhancing capacity of rural response through systems-based partnerships

3. Coordinate with partners and share information through community social networks

4. Vulnerable populations

- a. Engaging vulnerable populations in community preparedness activities
- b. Identifying and mapping vulnerable populations before, during, and after a disaster (at-risk database, GIS mapping, emPOWER)
- c. Connecting vulnerable populations with essential services during and post-disaster

5. Household/individual preparedness

- a. Having a supply of food, water, and medication
- b. Sheltering-in-place

6. Mental and behavioral health

- a. Implementing psychological first aid training for personnel

7. Training and education

- a. Training of tribal community health representatives
- b. Training of health department personnel
- c. Advancing community preparedness through community participatory methods

d. Administering CERT training

8. Pre-incident recovery planning

a. Planning for the restoration of public health services

b. Strategies to integrate preparedness activities into routine public health practice

2: Community Recovery

Practice

1. Post-disaster needs assessment

a. Assessing disaster-related impacts to at-risk individuals

2. Monitoring and

a. Monitoring the health, disease, and injury of the impacted community in order to identify and mitigate health problems

b. Surveillance of the environment in an affected community to determine if post-disaster conditions may cause adverse public health effects

c. Assessing an impacted community's food and water supply networks to ensure food and water safety

3. Long term health outcomes

a. Impact of disaster or emergency on long-term morbidity and mortality

4. Health system recovery operations

a. Public health system operations

5. Evaluating recovery efforts.

a. Providing social services (including education)

i. Implementing coordinated system(s) for referral of individuals and families with unmet disaster-related needs to appropriate social services and strategic leveraging of Federal social services programs

b. Providing mental/behavioral services

i. Supporting state, territorial, tribal, or local government efforts to coordinate enrollment, educational services, and health and social services for students that are homeless and/or displaced

ii. Administering psychological first aid

iii. Mobilizing resilience and emotional support team responders

- iv. Operating field-based mental health resources
- c. Providing social services (including education)
- d. Providing food, shelter/housing
 - i. Preventing unnecessary displacement (e.g., through rapid repair programs) and providing safe temporary housing
- e. Evaluation and assessing recovery efforts

6. Post event risk communication

- a. Developing and disseminating consistent messaging and guidance concerning stress management and mitigation strategies
- b. Developing and disseminating consistent messaging and guidance concerning injury prevention strategies

7. Community infrastructure

- a. Rebuilding public health services

3: Emergency Operations Coordination

Practice

1. Planning

- a. Incorporating the National Health Security Strategy and Crisis Standards of Care for public health activation
- b. Minimizing disruptions from outside impacts and continuing essential services (e.g., implementing a continuity of operations plan)

2. Incident management

- a. Adapting incident command system/incident management system for public health (e.g., PHICS: public health incident command system)
- b. Activating, managing, and demobilizing the emergency operations center (e.g., utilizing web-based command and control platforms, protocols, and trainings for EOC operations)
- c. Use of multifunctional public health strike teams to respond to public health events

3. Decision-making

- a. Incorporating modeling (e.g. epi, systems, etc.) into decision-making

- b. Incorporation of community decision-makers into the EOC
- c. Utilizing a medical decision model in a public health emergency
- d. Integrating data, feedback, and lessons learned from response personnel
- e. Utilizing drills and exercises to improve decision-making
- f. Developing situational awareness, action planning, and using process controls (three sets of decision-making processes)

4. Crisis leadership

- a. Understanding which leadership variables (experience, background, and training) impact the response system's performance and sustainability

5. Resources/assets

- a. Tracking, filling, and deploying resources and assets
- b. Facilitating access to supplies, facilities, and transportation resources to support disaster response

6. Workforce/personnel

- a. Determining usefulness and effectiveness of just-in-time training for personnel whose day-to-day job is not emergency preparedness
- b. Ensuring a fully staffed incident management system during a response (e.g., identifying essential functions and personnel)
- c. Providing a mechanism for submitting, approving, fulfilling, and tracking staffing requests (e.g., staffing database)
- d. Negotiating staffing issues between competing priorities
- e. Communicating with health department employees during a disaster

7. Financial/Administrative-Legal

- a. Using cooperative purchasing agreements
- b. Implementing procurement card policies
- c. Using a host agency to receive funding on behalf of the state
- d. Using term contracts for medical supplies
- e. Using emergency clauses in existing contracts so that the process is expedited, and the contract automatically executed
- f. Integrating funding sources with similar grant deliverables
- g. Legal Issues

- h. Using mutual aid agreements (e.g., activating the Emergency Management Assistance Compact and supporting the development of Mission Ready Packages)
- i. Utilizing emergency use authorization/investigational new drug/investigational device exemption
- j. Ensuring legal protections for the response workforce
- k. Permitting non-jurisdictional personnel to be credentialed to work in emergency situations
- l. Modifying and rescinding legal orders as appropriate
- m. Understanding the impact of specific emergency declarations

8. Data collection and Information Technology

- a. Utilizing resources and tools to capture critical information (e.g., using CASPER to assess population needs in disasters)
- b. Measuring structural and performance aspects of preparedness and response
- c. Learning from disaster responses (AARs/IPs)
- d. Health systems and infrastructure support
 - Assisting the healthcare systems, including hospitals, long-term care facilities, primary care centers, mental health providers, and other emergency medical services with their response efforts
 - Maintaining situational awareness about the impact to the healthcare system
 - Coordinating the delivery of resources and services to impacted components of the healthcare system
 - Utilizing healthcare facility data to support family reunification efforts (e.g., effectiveness of an emergency patient search tool)
 - Developing clinical documents for healthcare workers based on the response and incident
- e. Information technology
- f. Facilitating the use of technology-based resources to support disaster response
- g. Safeguarding sensitive information and data collected during and after an incident

9. Exercises - Exercises and systematic learning.

- a. Conducting tabletop, functional, or full-scale exercises

4: Emergency Public Information and Warning

Practice

1. Coordination and information sharing

- a. Coordinating with external communications partners (joint information center)
- b. Establishing virtual joint information centers
- c. Assessing potential information requests based on available incident information
- d. Determining spokesperson(s) (e.g., public information officer)

2. Community engagement and outreach

- a. Developing a mechanism to engage with the community and answer inquiries (e.g., call center)
- b. Determining community spokesperson(s) (e.g., elected officials, recognized community leaders)

3. Communication channels

- a. Monitoring and utilizing social media for surveillance purposes and for issuing emergency public information and warnings
- b. Monitoring and utilizing media (e.g., coordinating regular briefings with media)
- c. Utilizing other channels (e.g., walkie talkies, ham radios, wireless device, virtual/internet, phone, television)

4. Outreach to vulnerable populations (Message formats)

- a. Providing information to the general public
- b. Providing information to technical audiences (e.g., coordinating the delivery of hazard-specific information, treatment guidance, and surge capacity guidance to the healthcare system)
 - i. Establishing a provider access line to receive questions from providers about the response
- c. Utilizing public information, alerts, warnings, notifications
- d. Determining the most effective message formats for vulnerable populations (populations that rely on oral traditions, limited English

proficiency, individuals without internet access/smartphones)

5. Messaging

- a. Communicating uncertainty
- b. Conducting rumor control (e.g., monitoring media and social media)
- c. Building trust

5: Fatality Management

Practice

1. Mass fatality planning and operations

- a. Coordinating facilities like morgue locations, portable and temporary morgues, decontamination, decedent storage, hospitals, and healthcare facilities
- b. Coordinating family relations like notification, grief services, antemortem information, and call centers
- c. Establishing procedures to acquire death certificates and regulations for crematoriums
- d. Facilitating access to resources to manage fatality operations
- e. Searching, recovering, processing, transporting, storing, identifying, and disposing/releasing of human remains
- f. Providing survivor mental/behavioral health services

2. Antemortem data

- a. Collecting, managing, and disseminating antemortem data (e.g. establishing a record repository, Family Assistance Center Model).

6: Information Sharing

1. Stakeholders Identification and relationship building

- a. Identifying who should be incorporated into the information flow

2. Information sharing systems and data elements (e.g., essential elements of information)

- a. Utilizing information sharing systems to share data between and among jurisdictions
- b. Defining the requirements for information sharing for the purpose of

maintaining situational awareness (e.g., when data is shared, who is authorized to receive the data, what types of data can be shared, what are the data use and re-release parameters, what are the data protections, what are the legal, statutory, privacy, and intellectual property considerations)

- c. Developing protocols for health information exchange depending on the incident (e.g., use of the Public Health Information Network, Information Sharing Access Agreements)

3. Situational awareness

- a. Exchanging information to establish a common operating picture through the use of fusion centers or health alert systems
- b. Maintaining data repositories to support data exchange

7: Mass Care

1. Mass care needs assessment

- a. Coordinating to provide access to health services, medication and consumable medical supplies, and durable medical equipment

2. Mass care population health

- a. Monitoring and decontamination
 - i. Mobilizing community reception centers in the event of a rad/nuke emergency (CDC priority)

3. Vulnerable Populations

- a. Mass care considerations for vulnerable populations

4. Shelter considerations

- a. Conducting a facility-specific environmental health and safety assessment of the shelter location
- b. Identifying and monitoring health threats in shelters (e.g., conducting food and water safety inspections, conducting population health screening)
- c. Communicating control measures to prevent public health threats in shelters
- d. Implementing measures to eliminate environmental and infectious health threats in shelters
- e. Mobilizing resources needed for the shelter (e.g., personal hygiene amenities)
- f. Ensuring proper management of sewage

- g. Coordinating household pet sheltering efforts

8: Medical Countermeasure Dispensing

1. MCM needs assessment

- a. Identifying the MCMs needed for the incident
- b. Assessing the extent to which local MCM inventories can meet needs
- c. Requesting additional MCMs from partners
- d. Identifying and notifying distribution sites

2. Dispensing systems and coordination

- a. Management of points of distribution and other modalities for dispensing
- b. Ensuring resources (e.g., human, technical, and space) are activated to initiate dispensing modalities
- c. Management of site personnel and security

3. Communication and coordination for effective dispensing

- a. Risk communication and information sharing to the public for dispensing
- b. Screening and triaging individuals to determine with MCM is appropriate to dispense
- c. Monitoring dispensing site throughput
- d. Documenting doses of MCMs dispensed
- e. Providing prophylaxis to first responders
- f. Ensuring resources (e.g., human, technical, and space) are activated to initiate dispensing modalities

4. Monitor and report adverse events

- a. Establishing mechanisms for individuals and providers to notify the health department about adverse events
- b. Reporting of adverse events to jurisdictional and federal authorities

9: Medical Materiel Management and Distribution

1. Management of medical materiel

- a. Identifying and coordinating receiving sites, transportation assets, medical materiel suppliers and distributors

- b. Legal considerations to manage materiel (pre-existing resource sharing)
- c. Identifying the MCMs needed for the incident
- d. Assessing the extent to which local MCM inventories can meet needs
- e. Requesting additional MCMs from partners
- f. Identifying and notifying distribution sites

2. Distribution of medical materiel

- a. Dispensing Modalities
- b. Issues of scarcity
- c. Recovering and demobilizing distribution operations
- d. Assessing the extent to which local MCM inventories can meet needs
- e. Requesting additional MCMs from partners
- f. Identifying and notifying distribution sites

10: Medical Surge

1. Workforce and system preparations

- a. Determining metrics for assessing medical surge activities and operations

2. Healthcare system coordination for emergency events

- a. Utilizing information sharing systems to support surge-related needs
- b. Utilizing healthcare coalitions in medical surge
- c. Supporting partners to expand the jurisdiction's healthcare system (e.g., staff, beds and equipment) to provide access to additional healthcare services (e.g., staff, beds and equipment) to provide access to additional healthcare services)

3. Management during events

- a. Scale up and scale down
- b. Supporting activation of alternate care facilities
- c. Assisting in the coordination of healthcare resources
- d. Assisting in the coordination of demobilizing medical surge operations

10: Non-Pharmaceutical Interventions

1. Human surveillance

- a. Drafting case reports to generate current accurate information
 - b. Utilizing new technologies for rapid diagnosis
 - c. Decontamination methods
 - d. Utilizing hospital-based infection control measures such as hand hygiene and respiratory etiquette
 - e. Using personal protective equipment (surgical and N95 masks, gowns, gloves, protective eye covers) for practitioners or the general public
- 2. Patient and contact management (isolation and quarantine)**
- a. Authority and decision-making (e.g., determining criteria to be used by the local health officer to determine when isolation and/or quarantine beyond the capacities of day-to-day communicable disease practices are necessary to minimize health impacts of a disease outbreak)
- 3. Conducting community-wide measures to increase social distancing**
- a. Closing school/day-care
 - b. Closing workplace
 - c. Cancelling event
 - d. Restricting movement /international and domestic travel (advisories/voluntary vs. involuntary restrictions)
 - e. Incorporating the needs of vulnerable populations into isolation and quarantine planning efforts
 - f. Managing the pets, should they be exposed, of those in isolation or quarantine
 - g. Providing resources and support services to isolated or quarantined persons)
- 4. Legal considerations to implementing interventions**
- 5. Monitor nonpharmaceutical interventions**

12: Public Health Laboratory Testing

- 1. Lab activities**
 - a. Exchanging information and data with laboratory networks
 - b. Providing analytical and investigative support to help determine cause and origin of a public health incident
 - c. Providing notification of lab results to agencies as appropriate

2. Sample management

- a. Implementing LRN-established protocols and procedures for sample collection, handling, packaging, processing, transport, receipt, storage, retrieval, and disposal

3. Sample testing

- a. Performing or coordinating testing of CBRNE samples

4. Enhance laboratory communications and coordination**13: Public Health Laboratory Testing****1. Surveillance and detection**

- a. Establishing and maintaining surveillance systems to monitor to the impact of an incident (e.g., syndromic surveillance systems)
- b. Collecting data on morbidity, mortality, and risk exposures to the incident

2. Investigations

- a. Conducting epidemiological investigations as needed
- b. Determining diagnostic testing requirements
- c. Communicating and sharing information for epidemiological response

3. Data analysis

- a. Analyzing data to describe trends, evaluate the situation, and inform intervention decisions

4. Animal-related surveillance and vector control

- a. Identifying and monitoring disease vectors to determine spread of zoonotic and vector-borne disease
- b. Implementing control measures to prevent the spread of zoonotic and vector-borne disease

5. Improve epidemiological and surveillance Systems**14: Responder Safety and Health****1. Occupational health**

- a. Identifying the risks to and safety needs of responder health

- b. Monitoring exposure to safety and hazardous conditions
 - c. Determining which groups of responders should be included in a health care or disease registry program to monitor their long-term physical and behavioral health
 - d. Establishing and implementing long-term tracking of responder health, and the appropriate duration and content of long-term health tracking
 - e. Developing safety plans and protocols
 - f. Identifying and implementing corrective actions and protective measures
- 2. Behavioral Health of Responders**
- a. Mental health consideration which pertain to responders
- 3. Planning for the safety of responders**
- 4. Personal protective equipment**
- a. Distributing PPE and safety-related supplies
 - b. Administering risk-specific training

15: Volunteer Management

- 1. Recruiting and coordinating volunteers**
- a. Coordinating with existing volunteer programs to support recruitment
 - b. Registering volunteers and verifying their credentials
 - c. Supporting ongoing training for volunteers
 - d. Maintaining a volunteer database that is coordinated with other staffing systems
- 2. Notifying, organizing, and dispatching volunteers**
- a. Utilizing redundant communication systems to request the type and number of volunteers needed
 - b. Administer a deployment briefing and incident-specific training
 - c. Tracking and rotating volunteers
 - d. Managing spontaneous volunteers
- 3. Conduct or support volunteer safety and health monitoring and surveillance**

4. Demobilizing volunteers

- a. Identifying resources that can support post-deployment medical screening, stress, and well-being assessment

Appendix 2 – Search Flowchart Descriptions

Search 1 – Basket Search: As shown in [Figure S1- Panel 1](#), the first search was performed to obtain estimates of the proportion of publications stratified by PHEPR capability and practices using the PubMed database under the broad category “public health preparedness”. This search was not targeted to a specific capability and was specified simply as (“public health preparedness”) AND (“2001/09/12”[Date - Publication]: “3000”[Date - Publication])) AND “English”[Language] where the final date was 4/20/2019 resulting in 1,247 retrieved publications. We further separated these publications into the first and last decades since 9/11/2001. The first decade retrieved 326 articles over the ten years of the first decade, and the first seven and one-half years of the second decade (9/12/2011 through 4/20/2019) 921 articles. These two periods were chosen to reflect the decade before and after the initial publication of the PHEPR Capability Standards. The later years were used exclusively for this initial search since that period would be the more relevant timeframe. Next, we performed a review of the titles, keywords and abstracts for the 921 articles, to make recommendations for the practice categories listed in [Appendix 1](#). Alternative areas could also be coded if one of the fifteen capabilities did not fit.

Reviewers were trained on coding as part of a practicum project for the Harvard MPH in Quantitative Methods. The coding data dictionary is given in [Appendix 2](#). As depicted in [Figure S1-Panel 1](#) of the 921 articles retrieved from PubMed, 154 were initially excluded and 767 were manually reviewed and selected for classification into the public health preparedness capabilities. The distribution of the 15 primary public health capability categorizations for each

publication were reviewed by a team of six reviewers. If applicable, publications were also assigned a secondary and tertiary capability classification. If the reviewer thought that the article did not reflect one of the 15 Capabilities, but one of the alternative areas (Environmental Health, Mental/behavioral health, Quality Improvement, -Administrative Preparedness, Leadership or Other -- Please Specify), this coding option was also available. A total of 717 articles were assigned either a primary CDC PHERP capability (n = 709) or an alternative area (n = 8). ([Table S1](#)) Of those, 317 (44.2%) were assigned a secondary capability and 53 (7.4%) a tertiary capability (not shown). As expected, the largest number of publications, regardless of whether the study was classified as data/evidence-based or not, was Capability 1 “Community Preparedness” totaling 32.6% (234/717) of all publications, while the next most frequent was Capability 13 “Public Health Surveillance and Epidemiological Investigation” with 11.7% (84/717). The reviewer also entered the unstructured and structured study characteristic variables into an Excel database. Based upon the observed distributions, targeted capability searches were undertaken in an iterative fashion beginning with the capability that was most underrepresented.

Search 2 – Capability 15 Target Search: We used the results of the initial Basket Search 1 to guide the targeted searches. For these targeted capability searches, we began with the electronic searches conducted by the NASEM librarians undertaken separately for each capability. From the Search 1 results, Capability 15 (Volunteer Management) we found that this capability included only three publications. As this was the lowest yield among the 15 capabilities, Capability 15 was selected for the initial target search using the search algorithms developed by the NASEM librarians as shown in [Appendix 2.1](#). The yield for the Capability 15

target search was better than for Search 1, but was still low. This targeted search with 67 citations produced 11 (7.4%) that were classified as Capability 15. [Figure S1-Panel 1](#) In addition, there were 43 articles that were classified as having PHEPR evidence and were assigned a “suggested” capability category, and placed into the recycle bin to be used for subsequent target searches.

Search 3 – Capability 15 Target Expert Search: Since the cumulative yield for Capability 15 was only 14 articles, the next search again targeted Capability 15. This search was manually guided by one of the Primary Reviewers -- an expert familiar with the capability and practices associated with public health preparedness and in particular volunteer management. That search yielded 42 articles, of which all 42 initially qualified as relating to PHEPR Capability 15 articles, and upon a second review, 41 of those were ultimately classified as Capability 15. The one article that was not classified as Capability 15 was placed back into the recycle bin with the suggestion that it be deemed “Capability – 1 Community Recovery”.

Compiled Search Retrievals for Capability 15: As shown in [Table S1](#), Searches 1 through 3 yielded a total of 55 articles for Capability 15. One additional expert search (Search 6) was conducted that retrieved 13 articles, and one article was retrieved from the PERRC basket Search 14 for a total of 71 Capability 15 articles that were sent for final reconciliation and review.

Search 4 - Capability 11 Target Search: The next lowest yield capability from Search 1 was Capability 11 (Non-Pharmaceutical Interventions) returning only 12 articles fitting the Capability 11 description. As such, Search 4 was a targeted electronic search for Capability 11 as

performed by the NASEM librarians yielding 597 articles, of which 290 were excluded and 307 qualified as PHEPR articles with 48 (15.6%) of those categorized as Capability 11 [Figure S1-Panel 1](#). The remaining 259 articles were given a “suggested capability” and returned to the recycle bin.

Searches 5 and 8– Capability 11 Expert Searches: Two additional expert searches were conducted for Capability 11 that yielded 17 and 56 articles respectively. ([Figure S1 – Panel 2](#)). Together with the Search 1 Basket articles (n = 12), additional articles recaptured from the recycle bin (n = 6) and the Search 14 – PERRC Basket search, a total of 151 was the final tally of Capability 11 articles retrieved.

The target searches continued in this fashion as shown in [Figure S1-Panel 2](#), [Panel 3](#) and [Table S1](#). By that time the target capability electronic searches were returning approximately 50% duplicate items. However, as shown in [Table S1](#), there were a total of 3,537 articles that either were excluded or unclassified. Of these, 3,075 (86.9%) were determined not to be the target capability; however, there was not time to perform a full review of these articles to determine their capability classification. Assuming that the exclusion rate is similar to what had been reviewed, we estimate that an additional 2,644 articles could qualify potentially as one of the 15 capabilities. Of these, it is estimated that more than half would have been replicates, leaving approximately 1,322 potentially eligible articles. If the same proportion as observed in this study qualified as evidence-based studies (34.5%), then the evidence database could potentially be augmented with additional studies.

Search 14 – PERRC Basket Search: The final Search 14 articles were selected directly from the repository of PERRC publications as described by Qari ¹⁷. From this search, an additional 155 articles were entered into the Basket database to be classified into one of the 15 capabilities. At the end of the project time allotted, a total of 5,526 articles had been placed into the search basket. Of these, 1,872 were classified into one of the 15 Capabilities or alternative areas. Due to time constraints for the later searches the recycle bins were not able to receive a full review, but will be kept for future research. As shown at the end of the flowchart ([Panel 3](#)), the final reconciliation and classification of the 1,872 articles ultimately yielded 1,692 articles for descriptive and evidence mapping analysis.

[Abstraction and Database Coding](#)

The abstraction database consisted of the citation data (title, authors, keywords, journal, year of publication, abstract), capability suggestions, primary capability assignment, primary practice assignment, and free-text qualitative descriptive data (e.g., location of the study, aim of the study, type of data collection and evaluation, type of data, location of the study and why you chose the primary capability category). It also consisted of the unstructured and structured variables as listed in [Appendix 3](#).

Appendix 2.1 – Example of a Target Search for Capability 15 – Volunteer Managements

PHEP Capabilities: Volunteer Management

Requested by: Autumn Downey and Lisa Brown

Conducted by: Rebecca Morgan

Date: December 14, 2017

Search Parameters:

Date: 2001 – Present

Language: English

Document Type: Exclude commentaries, editorials, letters and notes

Databases:

- Embase (Ovid)
- Medline (Ovid)
- Scopus
- PubMed

Search Syntax:

Medline (Ovid):

Search No.	Syntax	Results
1	((natural adj (disaster? or hazard?)) or (hurricane? or flood\$ or typhoon? or earthquake\$ or fire? or cyclon\$ or heatwave? or freezing or ((ice or snow or lightning) adj storm?) or blizzard? or "heat wave" or (extreme adj (temperature? or heat or cold)) or tsunami? or "tidal wave")).tw.	78610
2	(firesetting or arson or explosion? or bomb\$ or (explo\$ adj device?) or blackout? or brownout? or ((power or equipment) adj (loss or failure)) or radioactive or radiation or (nuclear adj (disaster or meltdown or catastrophe or fail\$))).tw.	372264
3	(epidemic? or pandemic? or outbreak? or influenza).tw.	218757

4	(terroris\$ or bioterroris\$ or ((chemical or biological) adj warfare)).tw.	9961
5	(riot\$ or (civil adj (disorder? or defense or unrest))).tw.	1092
6	cyclonic storms/ or droughts/ or floods/ or tidal waves/ or tsunami/ or snow/ or rain/ or avalanches/ or volcanic eruptions/ or earthquakes/ or landslides/ or fires/ or ice/ or tornadoes/ or extreme cold/ or extreme heat/ or lightning/ or cold temperature/ or hot temperature/ or wind/	206703
7	firesetting behavior/ or explosions/ or blackout/ or equipment failure/ or radioactive hazard release/	32822
8	epidemics/ or pandemics/ or disease outbreaks/ or influenza/ or disasters/ or emergencies/ or mass casualty incidents/	182680
9	terrorism/ or bioterrorism/ or chemical terrorism/ or "september 11 terrorist attacks"/	10714
10	riots/ or civil disorders/ or civil defense/	3771
11	or/1-10	966838
12	((emergency adj (preparedness or response or management)) or (disaster adj (plan\$ or preparedness or mitigation or recovery or cycle or medicine or resilience))).tw.	7515
13	emergency preparedness/ or emergency response/ or emergency management/ or disaster planning/ or disaster medicine/ or disaster resilience/	15747
14	or/12-13	19742
15	("public health" adj (practice or administration)) or "preventive medicine").tw.	6910
16	public health/ or preventive medicine/ or public health practice/ or public health administration/	105045
17	or/15-16	108738

18	11 and 14 and 17	1817
19	(evidence or evaluat\$ or "lessons learned" or "lessons learnt" or AAR or "after action review" or "after action reviews").tw.	4044692
20	Evidence-Based Medicine/	73786
21	Evidence-Based Practice/	8068
22	Evaluation Studies as Topic/	129845
23	Program Evaluation/	60007
24	or/19-23	4182703
25	volunteer*.tw.	178685
26	Volunteers/ or Hospital Volunteers/	10540
27	or/25-26	183820
28	18 and 27 and 24	23
29	limit 28 to (english language and yr="2001 -Current")	22
30	limit 29 to (comment or editorial or letter)	0
31	29 not 30	22
32	18 and 27	55
33	limit 32 to (english language and yr="2001 -Current")	54
34	limit 33 to (comment or editorial or letter)	3
35	33 not 34	51

Embase (Ovid):

Search No.	Syntax	Results
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1	((natural adj (disaster? or hazard?)) or (hurricane? or flood\$ or typhoon? or earthquake\$ or fire? or cyclon\$ or heatwave? or freezing or ((ice or snow or lightning) adj storm?) or blizzard? or "heat wave" or (extreme adj (temperature? or heat or cold)) or tsunami? or "tidal wave")).tw.	99208
2	(firesetting or arson or explosion? or bomb\$ or (explo\$ adj device?) or blackout? or brownout? or ((power or equipment) adj (loss or failure)) or radioactive or radiation or (nuclear adj (disaster or meltdown or catastrophe or fail\$))).tw.	476572
3	(epidemic? or pandemic? or outbreak? or influenza).tw.	249779
4	(terroris\$ or bioterroris\$ or ((chemical or biological) adj warfare)).tw.	12148
5	(riot\$ or (civil adj (disorder? or defense or unrest))).tw.	946
6	hurricane/ or drought/ or flooding/ or tsunami/ or snow/ or rain/ or ice/ or avalanche/ or volcano/ or earthquake/ or landslide/ or fire/ or tornado/ or cold/ or heat/ or lightning/ or wind/	153369
7	arson/ or explosion/ or device failure/ or nuclear accident/	12087
8	epidemic/ or pandemic/ or influenza/ or disaster/ or emergency/ or mass disaster/	214149
9	nuclear terrorism/ or terrorism/ or chemical terrorism/ or bioterrorism/	8305
10	civil disorder/	1114
11	or/1-10	1065156
12	((emergency adj (preparedness or response or management)) or (disaster adj (plan\$ or preparedness or mitigation or recovery or cycle or medicine or resilience))).tw.	9561
13	emergency care/ or disaster planning/ or emergency medicine/ or emergency health service/ or disaster planning/ or disaster medicine/	154857

14	or/12-13	159234
15	((("public health" adj (practice or administration)) or "preventive medicine").tw.	9613
16	public health/ or preventive medicine/ or public health service/	225721
17	or/15-16	231180
18	11 and 14 and 17	2330
19	(evidence or evaluat\$ or "lessons learned" or "lessons learnt" or AAR or "after action review" or "after action reviews").tw.	5422826
20	evidence based medicine/ or evidence-based practice/ or evaluation study/ or program evaluation/	188655
21	or/19-20	5488621
22	volunteer/ or hospital volunteer/	48071
23	volunteer*.tw.	221818
24	or/22-23	229613
25	or/22-24	229613
26	18 and 25 and 21	23
27	limit 26 to (english language and yr="2001 -Current")	22
28	limit 27 to (editorial or letter or note)	0
29	27 not 28	22
30	18 and 25	72
31	limit 30 to (english language and yr="2001 -Current")	69
32	limit 31 to (editorial or letter or note)	2
33	31 not 32	67

PubMed:

((“natural disaster” OR “natural hazard” OR hurricane* OR flood* OR typhoon* OR earthquake* OR fire* OR cyclon* OR heatwave* OR freezing OR “ice storm” OR “snow storm” OR “lightning storm” OR blizzard* OR “heatwave” OR “extreme temperature” OR “extreme heat” OR “extreme cold” OR tsunami* OR “tidal wave” OR “fire-setting” OR arson OR explosion* OR bomb* OR “exploding device” OR blackout* OR brownout* OR “power loss” OR “power failure” OR radioactive OR radiation OR “nuclear disaster” OR “nuclear meltdown” OR “nuclear catastrophe” OR “nuclear fail” OR epidemic OR pandemic OR outbreak* OR influenza OR terrori* OR bioterroris* OR “chemical warfare” OR “biological warfare” OR riot* OR “civil disorder” OR “civil defense” OR “civil unrest” OR "Chemical Terrorism"[Mesh] OR "Bioterrorism"[Mesh] OR "Pandemics"[Mesh] OR "Epidemics"[Mesh] OR "Avalanches"[Mesh] OR "Extreme Heat"[Mesh] OR "Extreme Cold"[Mesh] OR "Tidal Waves"[Mesh] OR "Tornadoes"[Mesh] OR "Floods"[Mesh] OR "Cyclonic Storms"[Mesh] OR "Earthquakes"[Mesh] OR "Droughts"[Mesh] OR "Terrorism"[Mesh] OR "Volcanic Eruptions"[Mesh] OR "Wind"[Mesh] OR "Snow"[Mesh] OR "Riots"[Mesh] OR "Rain"[Mesh] OR "Lightning"[Mesh] OR "Influenza, Human"[Mesh] OR "Ice"[Mesh] OR "Hot Temperature"[Mesh] OR "Firesetting Behavior"[Mesh] OR "Fires"[Mesh] OR "Cold Temperature"[Mesh] OR "Civil Disorders"[Mesh] OR "Civil Defense"[Mesh] OR "Landslides"[Mesh] OR "Explosions"[Mesh] OR "Mass Casualty Incidents"[Mesh] OR "Radioactive Hazard Release"[Mesh] OR "Disasters"[Mesh] OR "Disease Outbreaks"[Mesh] OR "Emergencies"[Mesh] OR "Equipment Failure"[Mesh] OR "Disease Outbreaks"[Mesh] OR "September 11 Terrorist Attacks"[Mesh]) AND (“emergency preparedness” OR “emergency response” OR “emergency management” OR “disaster plan” OR “disaster preparedness” OR “disaster mitigation” OR “disaster recovery” OR “disaster cycle” OR “disaster medicine” OR “disaster resilience” OR “Disaster Medicine"[Mesh] OR "Disaster Planning"[Mesh] OR "Civil Defense"[Mesh]) AND (“public health practice” OR “public health administration” OR “preventive medicine” OR "Public Health"[Mesh] OR "Preventive Medicine"[Mesh] OR "Public Health Practice"[Mesh] OR "Public Health Administration"[Mesh]) AND (Volunteers OR "Hospital Volunteers"[Mesh] OR "Volunteers"[Mesh]) AND (evidence OR evaluat* OR “lessons learned” OR “lessons learnt” OR AAR OR “after action review” OR “after actions reviews” OR “Evidence-Based Practice"[Mesh] OR "Evidence-Based Medicine"[Mesh] OR "Program Evaluation"[Mesh] OR "Evaluation Studies as Topic"[Mesh])) NOT ("Comment" [Publication Type] OR "Letter" [Publication Type] OR "Editorial" [Publication Type])

Date: 2001 – Present

Language: English

Results: 63

((“natural disaster” OR “natural hazard” OR hurricane* OR flood* OR typhoon* OR earthquake* OR fire* OR cyclon* OR heatwave* OR freezing OR “ice storm” OR “snow storm” OR “lightning

storm" OR blizzard* OR "heatwave" OR "extreme temperature" OR "extreme heat" OR "extreme cold" OR tsunami* OR "tidal wave" OR "fire-setting" OR arson OR explosion* OR bomb* OR "exploding device" OR blackout* OR brownout* OR "power loss" OR "power failure" OR radioactive OR radiation OR "nuclear disaster" OR "nuclear meltdown" OR "nuclear catastrophe" OR "nuclear fail" OR epidemic OR pandemic OR outbreak* OR influenza OR terrori* OR bioterroris* OR "chemical warfare" OR "biological warfare" OR riot* OR "civil disorder" OR "civil defense" OR "civil unrest" OR "Chemical Terrorism"[Mesh] OR "Bioterrorism"[Mesh] OR "Pandemics"[Mesh] OR "Epidemics"[Mesh] OR "Avalanches"[Mesh] OR "Extreme Heat"[Mesh] OR "Extreme Cold"[Mesh] OR "Tidal Waves"[Mesh] OR "Tornadoes"[Mesh] OR "Floods"[Mesh] OR "Cyclonic Storms"[Mesh] OR "Earthquakes"[Mesh] OR "Droughts"[Mesh] OR "Terrorism"[Mesh] OR "Volcanic Eruptions"[Mesh] OR "Wind"[Mesh] OR "Snow"[Mesh] OR "Riots"[Mesh] OR "Rain"[Mesh] OR "Lightning"[Mesh] OR "Influenza, Human"[Mesh] OR "Ice"[Mesh] OR "Hot Temperature"[Mesh] OR "Firesetting Behavior"[Mesh] OR "Fires"[Mesh] OR "Cold Temperature"[Mesh] OR "Civil Disorders"[Mesh] OR "Civil Defense"[Mesh] OR "Landslides"[Mesh] OR "Explosions"[Mesh] OR "Mass Casualty Incidents"[Mesh] OR "Radioactive Hazard Release"[Mesh] OR "Disasters"[Mesh] OR "Disease Outbreaks"[Mesh] OR "Emergencies"[Mesh] OR "Equipment Failure"[Mesh] OR "Disease Outbreaks"[Mesh] OR "September 11 Terrorist Attacks"[Mesh]) AND ("emergency preparedness" OR "emergency response" OR "emergency management" OR "disaster plan" OR "disaster preparedness" OR "disaster mitigation" OR "disaster recovery" OR "disaster cycle" OR "disaster medicine" OR "disaster resilience" OR "Disaster Medicine"[Mesh] OR "Disaster Planning"[Mesh] OR "Civil Defense"[Mesh]) AND ("public health practice" OR "public health administration" OR "preventive medicine" OR "Public Health"[Mesh] OR "Preventive Medicine"[Mesh] OR "Public Health Practice"[Mesh] OR "Public Health Administration"[Mesh]) AND (Volunteers OR "Hospital Volunteers"[Mesh] OR "Volunteers"[Mesh])) NOT ("Comment" [Publication Type] OR "Letter" [Publication Type] OR "Editorial" [Publication Type])

Date: 2001 – Present

Language: English

Results: 150

Scopus:

TITLE-ABS-KEY((((natural W/1 (disaster* or hazard*)) or (hurricane* or flood* or typhoon* or earthquake* or fire* or cyclon* or heatwave* or freezing or ((ice or snow or lightning) W/1 storm*) or blizzard* or "heat wave" or (extreme W/1 (temperature* or heat or cold)) or tsunami* or "tidal wave")) or (firesetting or arson or explosion? or bomb* or (explo* W/1 device*) or blackout* or brownout* or ((power or equipment) W/1 (loss or failure)) or

radioactive or radiation or (nuclear W/1 (disaster or meltdown or catastrophe or fail*)) or (riot* or (civil W/1 (disorder* or defense or unrest)))) AND ((emergency W/1 (preparedness or response or management)) or (disaster W/1 (plan* or preparedness or mitigation or recovery or cycle or medicine or resilience))) AND (("public health" W/1 (practice or administration)) or "preventive medicine") AND (volunteer*) AND (evidence or evaluat* or "lessons learned" or "lessons learnt" or AAR or "after action review" or "after action reviews"))

Limit: 2001 – Present

Document Type: Exclude Editorial, Letter, Note

Language: English

Results: 4

TITLE-ABS-KEY((((natural W/1 (disaster* or hazard*)) or (hurricane* or flood* or typhoon* or earthquake* or fire* or cyclon* or heatwave* or freezing or ((ice or snow or lightning) W/1 storm*) or blizzard* or "heat wave" or (extreme W/1 (temperature* or heat or cold)) or tsunami* or "tidal wave")) or (firesetting or arson or explosion? or bomb* or (explo* W/1 device*) or blackout* or brownout* or ((power or equipment) W/1 (loss or failure)) or radioactive or radiation or (nuclear W/1 (disaster or meltdown or catastrophe or fail*)) or (riot* or (civil W/1 (disorder* or defense or unrest)))) AND ((emergency W/1 (preparedness or response or management)) or (disaster W/1 (plan* or preparedness or mitigation or recovery or cycle or medicine or resilience))) AND (("public health" W/1 (practice or administration)) or "preventive medicine") AND ("volunteer"))

Limit: 2001 – Present

Document Type: Exclude Editorial, Letter, Note

Language: English

Results: 12

Appendix 3 - Publication Characteristics Database

3.1 Full Unstructured and Structured Database

Citation Information from EndNote X9

Author, Year, Title, Journal, Volume, Issue, Pages, Epub Date, Publication Date, ISSN, PMCID, NIHMSID, Accession Number, PubMed ID, PubMed Link, Imported Link, Keywords, Abstract, Author Affiliations.

Capability and Practice Classification Variables

Primary, Secondary and Tertiary Capability (see structured list); Alternative Area; Primary, Secondary and Tertiary Practice (see structured list).

If the reviewer thought that the article did not reflect one of the 15 Capabilities, but one of the alternative areas (Environmental Health, Mental/behavioral health, Quality Improvement, - Administrative Preparedness, Leadership or Other -- Please Specify), this coding option was also available.

Unstructured Variables (free text) for Data Abstraction

Location of Study, Aim of Study, Data Collection Methods, Notes supporting the reasons why the primary capability was chosen

Structured Variables for Data Abstraction

The following questions were answered by the reviewer. A training manual was provided with full details on how to interpret the question.

1. Evidence-based research study?
 - a. Yes
 - b. No
2. If (Q1) = No, select type of study.
 - a. Position Paper
 - b. Opinion-Comments
 - c. Description)

3. If (Q1) = Yes, select the type of study.
 - a. Modeling
 - b. Meeting
 - c. Reviews
 - d. Questionnaires
 - e. Medical-Clinical
 - f. Other Specify
4. Select the type of data analysis used.
 - a. Qualitative
 - b. Quantitative
 - c. Qual and Quant
 - d. Mixed-Methods CitedSystematic Review
None/NA
5. Was there a comparison of groups or regression modeling used to test effects or interventions? If so, select the type of analysis performed.
 - a. Comparative
 - b. Non-Comparative
 - c. Regression Modeling
 - d. None/NA
6. What was the timeframe of the study?
 - a. Longitudinal
 - b. Cross-Sectional
 - c. Event Description
 - d. None-NA
7. Was this an After-Action report?
 - a. Yes
 - b. No
8. Did the analysis include an evaluation of an exercise or drill?
 - a. Yes

- b. No
9. What was the primary type of outcome measures?
- a. NA-No Data
 - b. Process
 - c. Individual Outcomes
 - d. Costs
 - e. System-Level Outcomes
 - f. Other_Specify
10. If answer to Q9 was c. Individual Outcome”, what type of outcome was it?
- a. Mortality
 - b. Morbidity
 - c. Clin-Surgical
 - d. Psychological
 - e. Workforce - KSA
 - f. Residents - Non-Health
 - g. Other - Specify
 - h. Not Applicable
11. Enter the sample size, if applicable.
- a. _____
12. Describe the sampling unit in a few words.
13. Was the sampling unit for an individual measure or was it representative of a larger group (e.g., a health director answering on behalf of a health department)
- a. Individual
 - b. Org_or_OrgProxy
 - c. NA
14. Did the article deal with a real or simulated disaster or emergency?
- a. Real
 - b. Simulated
 - c. No disaster

15. If Real or Simulated were selected, what type of disaster or emergency was it.
- Bioterrorism Attack*
 - Bombing**
 - Other Terrorism*
 - Chemical Emergency
 - Earthquake
 - Extreme Heat
 - Explosion
 - Flood
 - Hurricane
 - Mass Shooting*
 - *Landslides and Mudslides
 - Inf Disease Outbreak
 - Radiation
 - Tornado
 - Tsunami
 - Volcano
 - Wildfire
 - Winter Weather
 - Other – Specify
16. Describe the specific disaster or emergency in a few words, if applicable.
- (e.g., Hurricane Sandy, Australia H1N109 swine influenza pandemic; Tuscaloosa - AL - Hurricane Ivan of September 2004; Major landslide occurred on Mt. Elgon in Eastern Uganda, 2010; 12/2013 Downtown Beirut Bombing)
17. Did this study assess the impact of a treatment or other type of intervention, or was it primarily descriptive?
- NA - No Data
 - Descriptive
 - Impact
18. If this study evaluated the impact of a treatment or other type of intervention, how would you classify the intervention?

- a. NA - No Data
 - b. Descriptive
 - c. Impact
19. Was this study based in the United State, or other country of region (Non-US), or would you classify the study as global – not a particular country, or region – e.g., global pandemic.
- a. United States
 - b. Non-US
 - c. Global
 - d. Not Applicable
20. What type of institution, agency or other organization was the study primarily targeting, if any?
- a. Not Specific
 - b. Hospital or Clinic
 - c. Country-National
 - d. State-Province
 - e. County-Local
 - f. Tribal
 - g. Other Government Agency
 - h. Non Gov Agency
 - i. Academic Institution
 - j. All - Multiple - Non-Specified Agencies
 - k. Not Applicable
21. Choose a primary practice domain for this study.
- a. Not Applicable-None
 - b. Not Specified
 - c. Emergency Operations
 - d. Workforce Ed/Building
 - e. Public Education
 - f. Systematic Learning

- g. Risk Communication
 - h. Stakeholder Coordination
 - i. Healthcare System
 - j. Community engagement
 - k. Capacity Building
 - l. Surveillance/Epi Systems
 - m. Public Health Policy/Management
 - n. Legal Issues
 - o. Other_Specify
22. Choose a secondary practice domain for this study.
- a. Not Applicable-None
 - b. Not Specified
 - c. Emergency Operations
 - d. Workforce Ed/Building
 - e. Public Education
 - f. Systematic Learning
 - g. Risk Communication
 - h. Stakeholder Coordination
 - i. Healthcare System
 - j. Community engagement
 - k. Capacity Building
 - l. Surveillance/Epi Systems
 - m. Public Health Policy/Management
 - n. Legal Issues
 - o. Other_Specify

Appendix 3.2 Transformed Variables for Evidence Mapping

1. **Primary Capability:** See listing in [Appendix 1](#).
2. **Primary Practice:** See listing in [Appendix 1](#).
3. **Study Design:** 1) Opinion, Concept, Position Papers, 2) After-Action Report/Review, 3) Literature/Documents Review, 4) Modeling, 5) Qualitative, 6) Quantitative Surveys, 7) Quantitative Not Surveys, 8) Quantitative Non-Comparative Impact, 9) Quantitative Comparative Impact, 10) Not Preparedness/Practice/Appropriate.

The brief definitions for each of the above study designs can be found in [Table 3](#). It should be noted that in order to reduce the study design variables described in Appendix 3 to the categories listed above, it was necessary to develop a computerized taxonomy algorithm using several of the detailed structured variables described in Appendix 3. In this way a consistent classification rule was applied to all studies. This categorization algorithm prioritized the selected study design option when a study could potentially fall into two or more Study Design categories. For example, modeling studies could also be considered “quantitative”, and they could also be “comparative”. However, if a study used modeling, the study was always categorized as “Modeling” by the algorithm. A quantitative comparative impact study could also be a quantitative study that was not a survey; however, if a study was a quantitative comparative impact study, that study design option trumped all other categories. The general rule of the algorithm was that study designs with a higher level of statistical and design rigor trumped lower levels. This initial categorization was then reviewed and reconciled manually by the NASEM and Harvard teams. Out of the 1,692 articles that were subjected to

the taxonomy Study Design computerized algorithm, there were 270 requested changes (16%) by the NASEM review team.

4. Sample Size Bin:

If the sampling unit referred to an individual, sample size was coded into the following four categories : 1) 1 -99; 2) 100 – 499; 500 – 999; 1000 and higher.

If the sampling unit was for an organization, town state , hospital or other organization the following four categories were used: 1) 1 – 4 2) 5 – 14; 3) 15 – 24; 4) 25 and higher. In this way if a there were 10 hospitals in the study, this would be considered much stronger evidence than if there were 10 patients.

5. Setting: 1) United States, 2) Outside of the United States, 3) Global, 4) Not Applicable

6. Disaster Type: 1) No Disaster, 2) Real Disaster, 3) Simulated Disaster

7. Agency: 1) Academic Institution, 2) All - Multi Agencies, 3) Country-National, 4) County-Local

5) Hospital or Clinic, 6) Non-Government Agency, 7) Not Specified/Indicated, 8) Other

Government Agency, 9) State-Province, 10) Tribal

8. Outcomes: 1) Costs, 2) Individual Health Outcome, 3) Process, 4) System-Level Outcomes, 5)

Individual Non-Health Outcome, 6) Other Specify, 7) Not Applicable

In epidemiology, “outcomes” are usually considered in the context of a causal model where the dependent variable is hypothesized to change either negatively or positively as a function of one or more independent or predictor variables. However, for the purpose of this evidence mapping analysis we classified all studies by a broader definition of outcome including the particular area, factor or measure the study was most generally supposed to influence, modify or change. The brief definitions for the outcome categories listed above can be found in [Table](#)

[4](#). Similar to the Study Design variable, in order to produce these reduced outcome categories, a taxonomy algorithm was employed using several variables in the structured database. A computer algorithm was developed to perform a taxonomy analysis to produce the collapsed categories using the structured variables described in Appendix 3.

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A database of articles included in the scoping review [can be accessed here](#).

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