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A National Agenda for Public Health Systems Research on Emergency Preparedness

Joie Acosta, Christopher Nelson, Ellen Burke Beckjord, Shoshana R. Shelton, Erin Murphy, Kristin L. Leuschner, Jeffrey Wasserman

Prepared for the U.S. Department of Health and Human Services
The lack of frequent opportunities to observe and learn from real-world responses to large-scale public health emergencies has hindered the development of an evidence base for public health emergency preparedness. As a result, efforts to develop performance measures and standards, best practices, program guidance, training, and other tools have proceeded without a strong empirical and analytical basis. To help identify strategies for addressing this gap in evidence, this report presents the findings from an expert panel convened to develop a broad public health systems research agenda for emergency preparedness.

The report will be of interest to federal, state, local, and tribal health officials, as well as a range of funders and research institutions at all levels. This document will help to support decisions about short- and long-term research priorities and provide a basis for coordinating the efforts of funders and researchers inside and outside the federal government.

This work was prepared for the U.S. Department of Health and Human Services Office of the Assistant Secretary for Preparedness and Response (ASPR). This research was conducted within the RAND Health Center for Public Health Preparedness. RAND Health is a division of the RAND Corporation. A profile of the center, abstracts of its publications, and ordering information can be found at http://www.rand.org/health/centers/preparedness/. More information about RAND is available at our Web site at http://www.rand.org.
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Summary

The lack of frequent opportunities to observe and learn from real-world responses to large-scale public health emergencies has hindered the development of an evidence base for public health emergency preparedness (PHEP). As a result, efforts to develop performance measures and standards, best practices, program guidance, training, and other tools have proceeded without a strong empirical and analytical basis.

To identify strategies for addressing the gap in evidence, the Pandemic and All-Hazards Preparedness Act of 2006 (PAHPA) (Pub. L. 109–417, § 101 et seq.) requires the Secretary of Health and Human Services to formulate a broad public health systems research agenda for emergency preparedness. The Office of the Assistant Secretary for Preparedness and Response (ASPR) asked RAND to facilitate the development of this research agenda, identify short- and long-term research priorities, and provide a basis for coordinating funders and researchers inside and outside the federal government. This broad agenda was to build upon a 2008 agenda developed by the Institute of Medicine (IOM) for the seven Centers for Disease Control and Prevention (CDC)–funded preparedness and emergency response research centers (PERRCs). A broad agenda outlining the preparedness-related research needs of public health systems will synthesize the existing evidence, organize future efforts to develop an evidence base, and, if implemented, will prepare us for conducting real-time research during large-scale public health emergencies. It will also serve to broaden our research opportunities by encouraging the use of exercises, data from smaller-scale incidents, and information collected in the course of routine daily activities with a preparedness analog for research purposes.

Developing a Research Agenda

RAND, in collaboration with ASPR, convened a panel of 13 experts representing diverse perspectives (e.g., philanthropic organizations, policymakers, state and local health departments, homeland security, federal agencies, academia, community groups, and private-sector organizations) to guide the development of the research agenda. Through facilitated discussion and consideration of a pre-circulated review paper, the panelists identified 20 research priorities and illustrative research questions in areas related to planning, response, resources and infrastructure, and accountability and improvement.
Public Health Systems Research Priorities

Table S.1 presents the research priorities and research questions organized by research area. During the second day of discussions, the panel was asked to identify up to ten top priority areas that should be pursued aggressively in the short (as well as long) term. For the purposes of this agenda, short-term priorities are those that can be addressed in two or fewer years, and long-term priorities require sustained focus for between two and ten years. Short-term priorities are shown in italics in Table S.1.

Table S.1
Public Health Systems Research Agenda Priorities, by Research Area

<table>
<thead>
<tr>
<th>Priority</th>
<th>Research Question</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Research Area 1: Planning and Other Pre-Incident Activities</strong></td>
<td></td>
</tr>
<tr>
<td>Improving public health emergency preparedness planning and organizational structure</td>
<td>What approaches could improve PHEP planning processes and procedures in a systems-based framework?</td>
</tr>
<tr>
<td>Engagement of diverse groups and populations in PHEP efforts</td>
<td>How can diverse communities (e.g., demographic, geographic, cultural) be best involved in PHEP-related activities, and how can their involvement be sustained?</td>
</tr>
<tr>
<td>Anticipating population behavior during disasters</td>
<td>How do individuals and populations behave during disasters, and what cultural, sociodemographic, and other characteristics affect those behaviors?</td>
</tr>
<tr>
<td>Disaster risk reduction</td>
<td>How can population and public health system vulnerabilities be reduced in an effort to prevent or mitigate adverse impacts ahead of time?</td>
</tr>
<tr>
<td><strong>Research Area 2: Key Response Capabilities</strong></td>
<td></td>
</tr>
<tr>
<td>Improving epidemiology and surveillance in support of PHEP efforts</td>
<td>What approaches can improve the capability to determine the source, cause, incidence, prevalence, and other characteristics of diseases and other health conditions?</td>
</tr>
<tr>
<td>Public health laboratory systems</td>
<td>What approaches can support the improvement of a seamless laboratory network that can detect, characterize, and confirm threat agents in a timely manner?</td>
</tr>
<tr>
<td>Risk communication</td>
<td>What approaches can improve the public health system’s ability to provide messages to the public that lead to appropriate preparedness and response actions?</td>
</tr>
<tr>
<td>Countermeasure delivery</td>
<td>What approaches are effective in decreasing the amount of time needed to distribute and dispense medical countermeasures during a public health emergency?</td>
</tr>
<tr>
<td>Systems for population-level care</td>
<td>What approaches can be used to provide medical and mental health care across the entire continuum of need (e.g., injured, sick, “worried well,” first responders) during and after a public health emergency?</td>
</tr>
<tr>
<td>Special needs populations</td>
<td>What approaches can improve the public health system’s ability to address the varied needs of special needs population groups?</td>
</tr>
<tr>
<td>Displaced populations</td>
<td>What approaches can effectively provide for the medical and public health needs of populations that have to vacate their homes or areas of residence in response to a disaster?</td>
</tr>
<tr>
<td>Recovery</td>
<td>What approaches can improve the public health system’s ability to help the public regain or restore its well-being (e.g., physical, psychological) during and after a public health emergency?</td>
</tr>
</tbody>
</table>
Table S.1—Continued

<table>
<thead>
<tr>
<th>Priority</th>
<th>Research Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strengthening the natural science base for advice provided during public health emergencies</td>
<td>What is the evidence base supporting advice given by public health authorities during public health emergencies?</td>
</tr>
</tbody>
</table>

Research Area 3: Resources, Infrastructure, and Legal Frameworks

| Information technology and infrastructure | How will technology innovation and adoption by the communication and health care fields influence emergency planning and response? How can the public health system best anticipate and plan for these changes? |
| Workforce and training | What training is necessary for the public health workforce to adequately respond to public health emergencies? |
| Legal framework research | How can legal and liability barriers to public health emergency preparedness and response be addressed? |
| Economics of PHEP | How can principles of economics be applied to encourage nongovernmental organizations and individuals to engage in and maintain involvement in preparedness-related activities? |

Research Area 4: Accountability and Quality Improvement

| Standards, metrics, and quality improvement | What approaches can be used to ensure that the public health system has access to standards, metrics, and quality improvement tools? |
| Data sources and data collection | What approaches can be used to develop data sources to support PHEP research and evaluation, either by leveraging existing data or by creating new data sources or repositories? |
| Tools and templates to promote the transfer of research findings into practice | What approaches can support health departments and other system actors in selecting, adapting, and implementing research? |

Given the scope of the task, an initial research agenda is necessarily general in nature, and additional effort will be needed to further refine potential research topics in each of the 20 areas. Also, the agenda will need to evolve over time with changes in our understanding of public health threats and vulnerabilities and as the existing knowledge base grows. By encouraging interest in an agenda among diverse groups of partners, the U.S. Department of Health and Human Services can help build a strong evidence base to improve the preparedness and response of the public health system, as well as the recovery of the nation’s public.
We would like to thank the many experts who contributed to the conceptualization and content of the research agenda and recommendations by participating in the expert panel meeting or pre-panel interviews, reviewing documents, and providing valuable comments.

At ASPR’s Office of Policy and Strategic Planning, we extend our thanks to Brian Kamoie, deputy assistant secretary and director; Lara Lamprecht, project officer; and Matthew Minson, senior medical officer and director of strategic initiatives.

Finally, we benefited from the contributions of RAND colleagues who assisted us in our review of the relevant literature, policies, and statutes and provided logistical support for the expert panel meeting. Thanks to our administrative support team, including Michelle Horner, Christina Dozier, and Darlette Gayle, who provided logistical support at the expert meeting and helped prepare the final report.
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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</thead>
<tbody>
<tr>
<td>ASPR</td>
<td>Assistant Secretary for Preparedness and Response</td>
</tr>
<tr>
<td>CBO</td>
<td>community-based organization</td>
</tr>
<tr>
<td>CBRNE</td>
<td>chemical, biological, radiological, nuclear, and explosive</td>
</tr>
<tr>
<td>CDC</td>
<td>Centers for Disease Control and Prevention</td>
</tr>
<tr>
<td>DAF</td>
<td>data abstraction form</td>
</tr>
<tr>
<td>DHHS</td>
<td>U.S. Department of Health and Human Services</td>
</tr>
<tr>
<td>DOC</td>
<td>department operations center</td>
</tr>
<tr>
<td>EOC</td>
<td>emergency operations center</td>
</tr>
<tr>
<td>FEMA</td>
<td>Federal Emergency Management Agency</td>
</tr>
<tr>
<td>GIS</td>
<td>geographic information system</td>
</tr>
<tr>
<td>HSPD</td>
<td>Homeland Security Presidential Directive</td>
</tr>
<tr>
<td>ICS</td>
<td>Incident Command System</td>
</tr>
<tr>
<td>IOM</td>
<td>Institute of Medicine</td>
</tr>
<tr>
<td>NGO</td>
<td>nongovernmental organization</td>
</tr>
<tr>
<td>NIMS</td>
<td>National Incident Management System</td>
</tr>
<tr>
<td>PAHPA</td>
<td>Pandemic and All-Hazards Preparedness Act of 2006</td>
</tr>
<tr>
<td>PERRC</td>
<td>preparedness and emergency response research center</td>
</tr>
<tr>
<td>PHEP</td>
<td>public health emergency preparedness</td>
</tr>
<tr>
<td>PTSD</td>
<td>post-traumatic stress disorder</td>
</tr>
<tr>
<td>STS</td>
<td>science of team science</td>
</tr>
</tbody>
</table>
The lack of frequent opportunities to observe and learn from real-world responses to large-scale public health emergencies has hindered the development of an evidence base for public health emergency preparedness (PHEP). As a result, efforts to develop performance measures and standards, best practices, program guidance, training, and other tools have proceeded without a strong empirical and analytical basis.

To identify strategies to address the gap in evidence, the Pandemic and All-Hazards Preparedness Act of 2006 (PAHPA) (Pub. L. 109–417, § 101 et seq.) requires the Secretary of Health and Human Services to formulate a broad public health systems research agenda for emergency preparedness. Specifically, the act states that,

In consultation with relevant public and private entities, the Secretary shall define the existing knowledge base for public health preparedness and response systems, and establish a research agenda based on Federal, State, local, and tribal public health preparedness priorities.

A national research agenda could identify, organize, and prioritize research needs and questions for public health systems and how those systems affect emergency preparedness, encourage preparation for conducting real-time research, and promote the use of exercises, smaller-scale incidents, and routine daily activities with a preparedness analog for research purposes. Implementation of such a research agenda would facilitate growth of the knowledge base and analytical infrastructure needed for the ongoing development of guidance, effective practices, measures, and standards.

In response to the PAHPA legislation, there have been efforts to think systematically about developing the evidence base for PHEP. Many U.S. Department of Health and Human Services (DHHS) activities to develop the PHEP evidence base have focused on seven preparedness and emergency response research centers (PERRCs), mandated by the PAHPA legislation to help build an adequate research infrastructure for PHEP research. In 2008, the Centers for Disease Control and Prevention (CDC) commissioned the Institute of Medicine (IOM) to convene an expert panel to develop a set of recommended priorities for the PERRCs. The IOM panel’s task was to define a set of near-term research priorities for emergency pre-

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1 As a point of departure, the panel was given the following definition of PHEP: “... the capability of the public health and health-care systems, communities, and individuals to prevent, protect against, quickly respond to, and recover from health emergencies, particularly those whose scale, timing, or unpredictability threatens to overwhelm routine capabilities. Preparedness involves a coordinated and continuous process of planning and implementation that relies on measuring performance and taking corrective action” (Nelson et al., 2007, p. S9).
paredness and response in public health systems that were relevant to the expertise resident at schools of public health and that would accommodate an estimated allocation of funds (Altevogt et al., 2008).

Recognizing the need for a PHEP research agenda, designed for a full range of funders and research institutions (including, but not limited to, the PERRCs), the Office of the Assistant Secretary for Preparedness and Response (ASPR) asked RAND to convene an expert panel to facilitate the development of a broad research agenda. This broad agenda was to build upon the agenda developed by IOM for the PERRCs to identify short- and long-term priorities and was to provide a basis for coordinating funders and researchers inside and outside the federal government.

Throughout, ASPR has recognized that PHEP involves participation by a wide range of governmental and nongovernmental actors and determined that a systems approach to preparedness and PHEP research was needed. As the IOM and others have noted, public health systems include a wide range of actors, both governmental public health agencies (federal, state, and local) and a range of nongovernmental actors: “[the] community, the health care delivery system, employers and business, the media, and academia” (IOM, 2003). Thus, public health systems research on emergency preparedness must focus on (1) individual system components, both public and private (e.g., health departments, hospitals, community organizations, businesses); (2) how to facilitate and support the interactions among them; and (3) the governance, fiscal, and organization context in which those components operate.

The intent of the process was to define a set of high-level research priorities. Additional efforts will be required to develop more detailed research agendas for each priority area.
RAND, in collaboration with ASPR, identified and convened an expert panel to guide the development of a research agenda and to identify short- and long-term priorities. To prepare for the meeting, RAND staff reviewed existing literature on public health systems and emergency preparedness. Prior to the meeting, panelists received a background paper, which included the panel’s objectives and tasks as well as initial thoughts on how those tasks might be addressed. The paper was developed from the literature review, a review of relevant statutes and policies, and discussions with key stakeholders inside and outside government and across professional disciplines involved in PHEP. The paper served as a point of departure for discussion, and panelists were advised to use the information only to the extent that they found the ideas relevant.

**Literature Review**

RAND staff conducted a review of PHEP literature to examine the existing evidence base for PHEP and identify studies that used a systems approach. Because of time constraints, our review focused on peer-reviewed literature and did not systematically include “gray” literature (e.g., literature from organizational Web sites, federal agencies, and other sources that are not formally peer-reviewed). In the course of conducting the review, we consulted with a number of thought leaders on PHEP and other disciplines to help ensure that we did not miss important publications or ideas. Although panelists received the literature review in advance of the panel meeting, it had limited impact on the priorities selected by the panel. This may have been due, in part, to the limited evidence base for PHEP and our exclusion of unpublished or “gray” literature. The literature review, along with a detailed discussion of our methods, is provided in Appendix C.

**Expert Panel**

The expert panel was convened at the Marriott Crystal Gateway in Arlington, Virginia, on September 22 and 23, 2008. Panelists were nominated by RAND, ASPR, and CDC and represented diverse perspectives (e.g., philanthropic organizations, policymakers, state and local

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1 Short-term priorities were defined as those that can be addressed in two or fewer years. Long-term priorities were defined as those that require a sustained focus for two to ten years.
health departments, homeland security, federal agencies, academia, community groups, and private-sector organizations). Of the 19 nominees, 13 people participated in the panel. Staff from ASPR and CDC also attended the meeting. Appendix A provides a complete list of the participants.

The meeting began with several brief presentations to outline the panel’s purpose, review panel tasks and the definition of PHEP, and describe a public health systems approach to emergency preparedness and limitations of the current evidence base. The remainder of the two-day meeting consisted of facilitated discussion (led by a panel chair and RAND staff) to identify research priorities and associated research questions. The discussion paper provided a menu of candidate research areas and criteria for prioritization, but panelists were encouraged to use it as a point of departure and come up with their own research areas and criteria.

To identify research priorities, panelists used the following criteria:

- **Need to know**: Which research is most critical to advancing PHEP?
- **Transfer to practice**: Which research findings may result in interventions and strategies for improving preparedness, response, and recovery that can be readily implemented?
- **Sustainability of the outcome of the research**: Which research priorities would result in programs or interventions that can be sustained over the long term?
- **Scalability of improvements/interventions**: Which research priorities have broad applicability (greater than just a single jurisdiction) and could be implemented on a large scale?

During the second day, panelists sought to identify up to ten top priority areas that should be pursued aggressively in the short term. To generate this list, panelists voted for their top three research priorities, based on the criteria described above. When the votes were tallied, nine items were identified as “most important”:

- standards, metrics, and quality improvement
- improving public health emergency preparedness planning and organizational structure
- systems for population-level care
- special needs populations
- displaced populations
- data sources and data collection
- recovery
- engagement of diverse groups and populations in PHEP efforts
- economics of PHEP.

The next four chapters of this report summarize these nine priority areas, as well as 11 additional priority areas and sample research questions, beginning with those related to planning and other pre-incident activities, moving to response activities and various support functions (e.g., resources, infrastructure, legal frameworks), and concluding with priorities related to accountability and improvement. The priorities are organized by theme rather than by priority level. For each research priority, we provide a general research question, rationale, illus-
Panelists suggested that the first step in studying many of the research priorities would be to conduct a comprehensive synthesis of existing work in that area. As noted earlier, timeline considerations limited the project’s literature review to peer-reviewed publications. However, government reports and other gray literature contain a wealth of insights that should be leveraged. Furthermore, efforts should be made early on to capture insights (in both the peer-reviewed and gray literatures) from other fields that have experience with similar issues and face similar challenges. For instance, the literature on marketing might contain important insights relevant to risk communication and community engagement. Similarly, the literature on international humanitarian operations might contain insights on planning, logistics, and incident management.

Due to timing and the complexity of the priority areas identified, in many instances the sample research questions were substantially refined through panelist feedback via email, telephone conversations, and two conference calls. In addition, we further developed content to introduce the priorities and fill in areas where gaps remained.

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3 As a result, some of the examples were provided by a small group or individual panelists and were not vetted by all panelists.
CHAPTER THREE

Research Priorities Related to Planning and Other Pre-Incident Activities

The priorities presented in this chapter involve planning and other pre-incident activities, including engaging diverse groups, organizations, and communities; anticipating likely population behavior during disasters; and reducing population and health system vulnerabilities.

Improving Public Health Emergency Preparedness Planning and Organizational Structure

Summary

What approaches could improve PHEP planning processes and procedures in a systems-based framework?

Sample Research Questions

• What are the characteristics of effective systems-level planning for scalable responses (i.e., those that incrementally increase routine capabilities) and catastrophic responses (i.e., those that require rapid deployment of nonroutine capabilities)? Are there differences in the characteristics of planning for each?

• What factors drive variations in planning and coordination across response disciplines and jurisdictions?

• Do the quality and characteristics of public health emergency operation plans improve the quality, timeliness, and effectiveness of an emergency response and, ultimately, health outcomes?

• How do responders in different sectors, such as health and emergency operations, utilize emergency operation plans? Are differences in utilization associated with different outcomes?

• How might changes in the organization of the health care system (e.g., those brought about by new technologies) affect the conditions that the public health system should anticipate, shape, and respond to?

• Are different incident management structures associated with different public health emergency responses and population health outcomes?

Advanced planning is critical in delineating key roles and responsibilities, establishing trigger points and decisionmaking processes, ensuring that response partners approach responses with common assumptions, and establishing processes and procedures. Planning for multijurisdictional, multiagency responses can be difficult, given the need to coordinate among health departments, between public health and other first responders (e.g., emergency management), and among public, private, and nonprofit actors and to harmonize the work of different organizational structures, cultures, and operations.

The panel identified a number of important research topics that address both planning and organizational structure. In the short term, there is a need for research that characterizes existing planning practice, including variations within and across response disciplines. With this as a starting point, further research could identify and evaluate emerging technologies
(e.g., Wikis or other collaboration tools) and practices that could streamline interjurisdictional, cross-disciplinary planning.

Moving beyond planning processes, long-term research is needed to explore whether variations in the characteristics of planning relate to variations in the quality of actual responses and, ultimately, population health outcomes. Such research can stimulate the development of better measures of the quality and effectiveness of planning efforts.

The panel also called for research on the organizational structure of PHEP planning and response. In particular, the panelists felt that long-term research is needed to determine whether different planning processes and organizational structures are needed to support scalable (i.e., building upon routine practices) versus catastrophic responses (i.e., those involving singular capabilities).

### Engagement of Diverse Groups and Populations in Public Health Emergency Preparedness Efforts

**Summary**

How can diverse communities (e.g., demographic, geographic, cultural) be best involved in PHEP-related activities, and how can their involvement be sustained?

**Sample Research Questions**

- What is the central tendency and variation in the personal preparedness actions that people are willing to take ahead of time? What are the psychological, socioeconomic, and other drivers of variation in willingness to take such actions?

- What strategies are associated with sustained engagement of the public and private sectors in PHEP planning, response, and recovery?

- What are successful models for sustained engagement of multiple partners (e.g., nonprofits, community organizations, businesses)?

Engaging diverse groups and populations in preparedness and planning activities is critical for a successful response. Large-scale emergency responses involve participation by the public (whether through willingness to adhere to guidelines about hand-washing, reporting to points of dispensing, or simply not panicking). Citizen volunteers are often the first to respond and create a critical support network when a large-scale incident overwhelms the public health system. Involving citizens in PHEP planning activities helps build the skills and knowledge needed during a response operation and adds legitimacy to the planning process. Building population resilience before incidents (e.g., stockpiling supplies in the home, developing family emergency plans, checking on the well-being of elderly neighbors) can reduce the health consequences of threats, thus reducing the need for response interventions.

However, differences in languages, cultures, and practices across communities can create challenges to building population resilience. As a basis for developing sound strategies for engagement, research should seek to determine the drivers of engagement (e.g., information, incentives, sociodemographics) and identify which community and individual-level attitudes and skills are most amenable to change. The panel noted that existing literature on marketing might provide valuable insights into practices that might be applicable to research on public health preparedness. Similarly, panelists highlighted the advisability of considering experiences from recent disasters, such as the Gulf Coast hurricanes.
In the **short term**, research should examine the best way to include community members in the creation and implementation of emergency preparedness plans. Further, studies should focus on how to build neighborhood response networks and how such networks can be successfully activated for immediate response and long-term recovery efforts.

Throughout planning efforts, attention should be paid to strategies for sustaining engagement over a long period, including the specific communication channels through which officials can effectively engage communities. In the **long term**, studies need to evaluate the benefits of community engagement over time, with attention to how these strategies have resulted in greater citizen participation and collective action and decisionmaking. Measures of community engagement should take into account the potential consequences of sustained participation.

### Anticipating Population Behavior During Disasters

**Summary**

How do individuals and populations behave during disasters, and what cultural, sociodemographic, and other characteristics affect those behaviors?

**Sample Research Questions**

- What can the history of individual and population responses to catastrophic events tell us about how the public health system can better prepare and respond (e.g., by recognizing variability across populations, including special needs populations)?
- What factors (e.g., cultural constructs, sociodemographic characteristics) explain variations in willingness to adhere to public health guidance?
- What factors increase the likelihood that individuals, families, or other groups will adhere to public health guidance during public health emergencies?
- What factors increase the likelihood that public health workers and volunteers will report for and remain on duty during public health emergencies?

As noted earlier, the public must participate in most response activities if they are to be effective (e.g., by going to points of countermeasure dispensing, by complying with social distancing recommendations). While engagement and education efforts might help shape individual and community behavior during emergencies, it is also important to begin with realistic planning assumptions about how people are likely to behave. Thus, the panel recommended that researchers explore what has been learned from population behaviors during past disasters and what those experiences might imply for large-scale public health emergency planning and response. Panelists noted that there is considerable literature on behavioral responses to natural disasters, but relatively little pertains to biological threats and what exists offers conflicting information. For example, some experts recommend planning for widespread panic among the public, while others indicate that widespread panic is unlikely (see Stein et al., 2004). Unlike earthquakes, storms, or explosions, biological threats may not be immediately visible (i.e., there is often no clear incident scene). In addition, biological agents may be spread by multiple individuals, perhaps creating greater threats to social solidarity and widespread psychological problems than other types of incidents.

**Short-term** research should determine the impact of public response on the spread of an epidemic. For example, how do patterns of evacuation, help-seeking, collective action, rumor- ing, and volunteerism relate to the extent of an epidemic?
In the **long term**, panelists noted the particular importance of identifying the most salient predictors of variations in the behavior of both the general public and the public health workforce or volunteers. For instance, is there evidence that incentives or interventions designed to address concerns about family safety can increase the likelihood that public health workers and volunteers will report for and remain on duty during a public health emergency? Similarly, can incentives, education, or other approaches increase the likelihood that members of the general public will adhere to public health guidelines? Researchers might also explore whether there are “social contagion effects”¹ or “tipping points”² evident in such behaviors.

## Disaster Risk Reduction

### Summary

How can population and public health system vulnerabilities be reduced in an effort to prevent or mitigate adverse impacts ahead of time?

### Sample Research Questions

- How can human population vulnerabilities to public health emergencies be effectively measured, mapped, and addressed?
- How can potential vulnerabilities and failure points in public health emergency response systems be identified and addressed?
- What approaches to building resilience in different populations are likely to be associated with better outcomes in public health emergencies?

Public health emergencies result from both threats (e.g., infectious disease agents, storms) and vulnerabilities in the population. In most instances, it is difficult or impossible to eliminate the threat. However, it is often possible to reduce human vulnerability to threats. For instance, in the context of flood control, while dikes and levees cannot prevent the occurrence of floods, they can reduce their consequences for humans by reducing the likelihood that they or their property come into contact with floodwaters.

The panel suggested research to identify and develop approaches to disaster risk reduction that apply more directly to public health emergencies. In the **short term**, further research in the field of research disaster epidemiology could support the development of tools and protocols for identifying (perhaps through mapping techniques) those prior health and socioeconomic conditions that leave individuals particularly vulnerable to threats. Similarly, research could identify and evaluate the effectiveness of health promotion and educational interventions that can help make individuals more resilient to such threats (e.g., stockpiling chronic-disease medications, family preparedness planning) and help officials effectively target those interventions to specific populations.

In the **long term**, panelists called for research that supports the identification and mitigation of vulnerabilities in public health response systems (e.g., failure of staff to report to duty, lack of interoperability in communication systems). **Long-term** research should also evaluate

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¹ Social contagion effects can be either emotional, the spread of mood and affect through populations, or behavioral, the spread of particular behaviors through populations (Levy and Nail, 1993).

² A tipping point has been defined as the point at which a shift in momentum becomes unstoppable (Gladwell, 2002).
community capacity-building efforts (e.g., developing leadership and increasing trust in public officials) to determine their impact on community resiliency.
CHAPTER FOUR
Research Priorities Related to Key Response Capabilities

The research priorities described in this chapter involve many of the core elements required for responses to public health emergencies, including epidemiology, public health laboratory networks, crisis and emergency risk communication, countermeasure delivery, providing health care to large populations during and after disasters, caring for special needs and displaced populations, and activities needed during the recovery phase.

Improving Epidemiology and Surveillance in Support of Public Health Emergency Preparedness Efforts

Summary
What approaches can improve the capability to determine the source, cause, incidence, prevalence, and other characteristics of diseases and other health conditions?

Sample Research Questions

• How can the coverage, quality, and timeliness of surveillance systems be improved to better ensure detection of public health emergencies?

• To what extent should surveillance systems be uniform across locations or tailored to specific communities’ risk profiles?

• What data and other systems are needed to support timely decisionmaking (e.g., when to initiate active surveillance, case investigations, or control measures)?

• What technologies, systems, training regimens, and other investments are required to establish a universal outbreak management information system?

• What are the most effective protocols for detecting exposure to airborne contagions (e.g., inhalational anthrax)?

• How can individuals outside the traditional public health workforce be used to collect reliable information to support epidemiologic investigation and outbreak management?

While epidemiology is a well-developed field, additional research is needed to ensure early detection of public health risks and to support ongoing situational awareness and decisionmaking during public health emergencies. Timely detection triggers response operations, such as disease investigation and implementation of control measures, and ultimately contributes to reduced morbidity and mortality.

In the short term, research should seek to support the development of better data sources on environmental conditions, including improved tests for airborne contaminants (such as aerosolized anthrax); increased surveillance coverage through more and different sources of data
on the occurrence of unusual health events; streamlined near-real-time data-reporting systems; and rapid administration of diagnostic tests. In the long term, research is needed to define the requirements of a universally applicable outbreak management information system.

Public Health Laboratory Systems

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<td>What approaches can support the improvement of a seamless laboratory network that can detect, characterize, and confirm threat agents in a timely manner?</td>
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Sample Research Questions

- How well do current laboratory networks support the detection, characterization, and response to threat agents? What strategies are needed to improve their capabilities and capacities?
- What approaches could be used to decrease the time needed for detection and reporting?
- What approaches could be used to improve interoperability across laboratory networks?
- What are the key components of effective laboratory networks? What constitutes an optimal mix and geographic distribution of those components for PHEP?
- How can the capacity for radionuclide detection best be increased and maintained?
- What are the laboratory workforce and infrastructure or equipment surge requirements under various threat scenarios?

A strong and well-integrated public health laboratory network is essential to early threat detection and ongoing decision support during public health emergencies. The panel identified a number of research priorities that could help strengthen lab capacity. In the short term, the panel recommended that researchers seek to better understand current public health lab capacities as a basis for further research in that area. Panelists also called for additional research to address the system’s ability to provide information to decisionmakers during a large-scale and rapidly spreading emergency. Such research should include strategies for decreasing detection and reporting time and increasing lab throughput, as well as strategies to improve interoperability and integration across the nation’s public health laboratories. In the long term, the panel suggested that research is needed to assess and improve the lab system’s ability to detect radionuclides, given gaps in current lab testing procedures.
Risk Communication

Summary

What approaches can improve the public health system’s ability to provide messages to the public that lead to appropriate preparedness and response actions?

Sample Research Questions

• What lessons from the broader health communication and marketing literatures could improve current risk communication practices in PHEP?

• What is the relative effectiveness of alternative messengers during public health emergencies? What guidelines should inform selection of messengers for specific populations?

• Is variation in risk communication practices associated with variation in outcomes from public health emergencies?

• How does the 21st-century public actually get information and decide whether to take personal action? Does this provide any lessons for how risk messages might be effectively and quickly disseminated during public health emergencies?

Risk communication is a core capability in emergency preparedness, response, and recovery. Without a strong understanding of effective ways to communicate with the public about risks—and necessary actions—interventions across the public health system will not exert their full impact on the behavior and outcomes of the general public. Research on risk communication addresses how best to provide messages to the public about emergency preparedness, response, and recovery and the modes of delivery that facilitate the public’s ability to act on the content of those messages. Research can identify ways to use both new and traditional media to achieve the best outcomes in public health emergencies. Panelists suggested that short-term research use routine health incidents to identify strategies that have resulted in effective risk communication and that can be scaled up, when needed, in the context of a large-scale emergency. They also suggested synthesizing research on health communication, marketing, and the broader communication literature to determine what strategies, interventions, and lessons learned are applicable to public health.

Long-term research should examine the relative effectiveness of risk communication using alternative modalities (e.g., text messaging, social networking sites). Further, research in the long term should determine how recipients’ understanding, concerns, and overall perspectives affect their decision to take action based on risk communication.
Countermeasure Delivery

**Summary**

What approaches are effective in decreasing the amount of time needed to distribute and dispense medical countermeasures during a public health emergency?

**Sample Research Questions**

- To what extent could nontraditional distribution and dispensing modalities increase throughput?
- What implications would use of nontraditional modalities have for the accuracy of dispensing?
- What are the practical, legal, and other barriers to the use of nontraditional distribution and dispensing modalities?
- Can smaller-scale incidents be used to understand and improve countermeasure distribution and dispensing?

Panelists identified efficient and rapid distribution and dispensing as the key challenges for countermeasure delivery. They noted that research is needed to determine whether countermeasure dispensing can be made more efficient through “nontraditional” modalities, such as drive-through dispensing sites. Panelists emphasized the need to focus on efficiency, which involves not only speed and throughput, but also concern for accuracy and standards of care.

The panel noted that, in the *short term*, researchers should seek to develop a strong data foundation by developing better ways to capture capacities and operational capabilities through exercises and/or simulation studies and routine health incidents (e.g., influenza vaccination). In the *long term*, researchers should use these and other data to address the aforementioned questions about efficiency.

Systems for Population-Level Care

**Summary**

What approaches can be used to provide medical and mental health care across the entire continuum of need (e.g., injured, sick, “worried well,” first responders) during and after a public health emergency?

**Sample Research Questions**

- What types of systems for population-level care are most amenable to use in nonhospital settings (e.g., tele-health or alternative care sites)? For what types of health conditions (e.g., non-life-threatening chronic conditions, routine care for certain age groups or conditions) are they appropriate?
- How can redundancies be built into the medical care system (e.g., cross-training of workers) to increase surge capacity?
- What processes best prepare organizations and individuals outside the traditional health care system (e.g., faith-based organizations, YMCAs) to help provide care for populations during public health emergencies?
- What types of decisionmaking systems and processes are most effective for medical decisionmaking in mass-casualty events?
- What systems are necessary to effectively organize, allocate, and utilize unsolicited resources (i.e., volunteers and donations)?
- What are the workforce surge requirements for scenarios varying in duration, type of injury/illness, and number of affected individuals?
- How effective is “just-in-time” training during disasters, and what is the most effective way to prepare ahead of time to deliver it?
Public health systems need to maintain the capability to provide acute health care (medical care and psychological or mental health care) to affected individuals during and in the wake of a disaster while also providing routine care to meet the needs of the population at large. Research must include alternative care centers and strategies for engaging a broad range of actors (e.g., community-based organizations) to provide or support the mass delivery of health care.

In the short term, research should examine the effectiveness of decisionmaking systems as well as workforce surge requirements for mass-casualty events of varied duration, type, and volume. Simulation models have often been used in predicting mass hospital and emergency care needs under different scenarios; in the short term, these models may yield useful information by adapting them to nonclinical settings.

In the long term, research should determine the effectiveness of alternative systems for population-level care that best take advantage of nonhospital resources (e.g., tele-health or alternative care sites). Long-term study should also examine the feasibility and impact of cross-training workers to perform essential health care functions.

### Special Needs Populations

**Summary**

What approaches can improve public health system’s ability to address the varied needs of special needs population groups?

**Sample Research Questions**

- What is the variation in need within and between special needs population groups?
- How do special needs populations’ needs differ from those of the general population, and where are there overlaps with the needs of the general population?
- How are special-needs individuals and populations within a community best identified?
- What prevention-focused systems for early identification of special needs populations are most appropriate in advance of and during a disaster?
- What practical strategies can be used to build resilience among special needs populations in communities?

The responses to hurricanes Katrina and Rita revealed considerable gaps in the nation’s readiness to protect particularly special needs populations during large-scale emergencies. Panelists felt that research on this topic should address how the needs of particularly special needs populations (e.g., children, the elderly, those with chronic disabilities or medical conditions) differ from those of the general population, how those needs can best be identified, and what interventions can be used to ensure their protection during public health emergencies.

In the short term, they felt that research that builds on existing work to further define variation in the way in which special needs populations are defined, as well as variations in experiences in planning, response, and recovery, would be helpful in further defining the capabilities required to promote positive health outcomes for special needs populations. Such research could also help determine the best methods for identifying and meeting the medical and mental health care needs of special needs populations.

In the long term, studies should explore approaches to ensure access to quality preventive health care and address the social and economic needs that often accompany risk for these populations during a disaster. We know that ensuring quality and access to basic preventive
and curative care can help leave people “healthier” at the start of an event and better able to confront the challenges imposed by an event (Tekeli-Yeşil, 2006). Further, all aspects of vulnerability are exacerbated by poverty and inequality. For example, lack of material resources affects access to transportation, low education affects communication, and poor housing in some neighborhoods increases the chances that an event will result in greater homelessness for low-income populations.

### Displaced Populations

**Summary**

What approaches can effectively provide for the medical and public health needs of populations that have to vacate their homes or areas of residence in response to a disaster?

**Sample Research Questions**

- What are the short- and midterm health needs of displaced populations?
- How can health care and related services (e.g., mental health services, housing) best be provided to large numbers of displaced persons?
- What approaches can help ensure that displaced populations have shelter and housing that supports their health needs?
- What public health issues are most relevant to the long-term management of displaced populations after a disaster?
- What is the impact of geographical shifts in the public health or health workforce after an emergency event?

Population displacement might result from major public health emergencies. However, there has been little system-level research on the short- and midterm health and public health needs of displaced populations, including the long-term effects of displacement, or preferred strategies for reintegrating such persons back into their communities—or integrating them into new communities during recovery.

Current models for caring for displaced populations focus on shelter and assume that most people are self-reliant. However, recent experiences (e.g., the Gulf Coast hurricanes) have confirmed that chronic medical and behavioral health issues or other conditions leave many people dependent on others or on other resources for basic functions.

Panelists felt that short-term studies are needed to identify requirements for infrastructure used to accommodate displaced populations (e.g., shelters and temporary housing) to ensure that it supports people with special health needs (e.g., need for refrigeration or storage of medication, availability of oxygen, transport to dialysis). One way to develop this area of research is to identify the variation in needs of displaced populations during real incidents and in later stages of recovery. This can strengthen the public health system’s ability to anticipate those needs and to improve the way in which needs are met over time.

Additionally, short-term research should take into account significant changes regarding the role of voluntary organizations in assisting displaced populations. For example, in the 2008 National Response Framework, the Federal Emergency Management Agency (FEMA) officially assumed responsibility for coordinating mass care, including gathering information from shelters, a role formerly held by Red Cross. The reasoning behind this change was that FEMA can direct federal resources to meet mass care needs, while the private Red Cross
cannot, a factor that added to the confusion in the aftermath of Hurricane Katrina. While this move is seen as a positive one in terms of logistics, the U.S. Government Accountability Office issued a report (2008) around the same time expressing concern that FEMA may not have the manpower necessary to take on the role of coordinating mass care, and that neither FEMA nor the Red Cross has adequately addressed the needs of special needs populations in disasters. Research on displaced populations should also investigate the impact of this change on the care provided to displaced populations to ensure that new roles are clearly documented and that services meet the needs of all displaced individuals affected by disaster.

Finally, panelists noted that the members of the medical and public health workforce are often among those displaced during emergencies. This limits medical and public health systems’ abilities to provide support.

In the long term, systems research and modeling can potentially identify strategies for reducing redundancy and increasing surge capacity in such situations. Long-term research should also evaluate strategies for the long-term management of displaced populations after a disaster, as well as the impacts of geographical shifts in the public health or health care workforce after an emergency event.

Recovery

Summary

What approaches can improve the public health system’s ability to help the public regain or restore its well-being (e.g., physical, psychological) during and after a public health emergency?

Sample Research Questions

• What public health approaches are associated with effective prevention or mitigation of the long-term psychological impacts of disasters on children and adults?

• What defines the transition from response to recovery mode? How should the public health system’s role change as incidents move from response to recovery?

• What is the public health system’s role in preventing post-event injuries or illnesses?

• What approaches can improve the public health system’s ability to mitigate environmental hazards after an event?

• What safety-related questions from the public should the public health system be prepared to address during recovery?

• What protocols and procedures need to be in place to ensure the safety of food and water after an emergency?

• How does the emotional impact of a public health emergency or disaster affect individuals’ abilities to participate in recovery? What can be done to improve the population’s psychological resiliency?

There was a consensus among panelists that recovery is an area in need of considerable research. A successful recovery effort must address the impact of both the physical and social environment on individuals and populations.

The panel identified several sets of questions related to recovery. First, there is a need to more clearly define the triggers that should prompt a transition from the response to the recovery phase of an incident, and there is a need to better define how public health operations should evolve during that transition. Second, panelists noted that governmental public health
agencies must often field numerous public inquiries during recovery. Thus, some panelists suggested, research might begin with compiling the types of questions public health agencies are frequently asked to answer and determine whether the state of the science is sufficient to answer them. This may, in turn, identify an additional set of research priorities.

Panelists made two recommendations for short-term research: (1) synthesize existing research on the emotional impact of trauma and resiliency from social science fields, such as psychology, focusing on findings relevant to recovery, and (2) identify key recovery issues (e.g., information requests, threats, and vulnerabilities) encountered during recent emergency events (e.g., Hurricane Katrina, World Trade Center, the recent storms in Bangladesh). In the long term, there are still limited data on how to sustain social support networks in the recovery phase. There is a need for more research on how to engage traditionally isolated populations to ensure that their needs are adequately accounted for in the economic and social infrastructure rebuilding plans. Further, studies are needed to identify the best way to manage recovery financially, administratively, and politically.

**Strengthening the Natural Science Base for Advice Provided During Public Health Emergencies**

**Summary**

What is the evidence base supporting advice given by public health authorities during public health emergencies?

**Sample Research Questions**

- How clean or safe does a previously or potentially contaminated environment need to be before people can return to it?

- After an outbreak of an infectious disease, when is it safe to go back to school or work? What level of disease exposure risk will be tolerated if people who are ill or potentially contagious return to work so that institutions can resume operations?

As noted earlier, the public health system must be prepared to respond to queries from the public and to support decision-making with science-based judgments. However, panelists noted that the science base that is relevant to such communication is often ambiguous and that answers to questions such as “how clean is clean” often require a mix of scientific evidence and professional judgment. Thus, the panel suggested that short-term research should (1) summarize the different scenarios, categories of potential events, and types of questions that need scientific support and (2) synthesize relevant existing science into a PHEP-type format that can be applied to answer public health questions.

In the long term, research should address some of the most pressing unanswered questions and evaluate practical approaches for science-based communication to determine which are most effective.
CHAPTER FIVE

Research Priorities Related to Infrastructure, Resources, and Legal Frameworks

This set of priorities includes elements of preparedness needed to support the full range of planning and response activities, including information technology and infrastructure, workforce and training, and legal framework research.

Information Technology and Infrastructure

Summary

How will technology innovation and adoption by the communication and health care fields influence emergency planning and response? How can the public health system best anticipate and plan for these changes?

Sample Research Questions

- What are the barriers to adoption of information technology in public health?
- What are the new opportunities that might be opened up through new communication and health care technology, and how might they affect the public health system over time?
- What is the impact of technology on individual components of the public health system (e.g., surveillance, communication, individual behavior)?
- How can new technologies be applied to improve the training and education of the public health workforce?
- What is the role of technology in creating cyberinfrastructure to support public health preparedness, response, and recovery (e.g., interoperability of biosurveillance, including laboratories)?
- What level or type of connectivity among responders improves the management of emergencies?
- How can cyberinfrastructure help create a robust information supply chain for emergency response?

New technology will have a future impact on the public health system and how the system prepares for and responds to emergency events. Panelists identified the need to understand what the most relevant technologies are, how those technologies will likely affect the public health system, and how public health agencies will respond given the impacts of technology on the system.

For example, cyberinfrastructure is one type of technology that would inform the answers to these questions. Cyberinfrastructure allows for data acquisition, storage, and management. Most importantly, it allows integration over the Internet and provides a technological platform to connect data, computers, and people. Research on how to develop and improve cyberinfrastructure to support public health will help the field better integrate information technologies with one another and will allow data to be tracked over time. To help guide the development of cyberinfrastructure, short-term research needs to identify the decisionmaking requirements
that can be supported by technology (e.g., vertical and horizontal exchanges among domestic and international stakeholders). *Long-term* research should focus on developing the cyberinfrastructure to support decisionmaking and evaluating how users relate to the interface.

Research on technology diffusion might also help the public health system better respond to changing health technologies and modes of communication. Panelists also suggested that information technology might change the face of public health and health care moving forward; the public health system needs to be positioned to understand the impact and identify strategies to maximize the application of new information technologies. Research is needed over the short and long terms to evaluate the impact of changing technologies on the public health system and, as appropriate, their effectiveness as modes of communication.

Information technology can also be used to improve the training and education of the public health workforce. Many education institutions rely heavily on technologies such as Blackboard and other virtual classrooms; training for public health staff through Webinars and online courses is becoming more popular. Understanding how to use these new technologies to improve learning is an important *short-term* priority for the field of public health.

**Workforce and Training**

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<td>What training is necessary for the public health workforce to adequately respond to public health emergencies?</td>
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**Sample Research Questions**

- Does competency-based education in PHEP lead to improvements in public health response during emergencies?

- If so, what education or training strategies best prepare the public health workforce for emergencies?

- How can the impact of training programs be evaluated?

- How can nonphysician medical staff and nonmedical personnel be best utilized (both within and outside their usual scope of work) to improve medical and public health surge capacity during an emergency event?

- Can crisis leadership skills relevant to public health systems be assessed and taught? How can such skills be maintained?

- Are the traditional roles of public health workers and the present workforce mix aligned with recent increased demands on the public health system, changes in public health practice, and current educational trends? If not, how should roles be redefined and the workforce mix revised to better enable the public health system to respond to emergencies?

The public health workforce is the foundation of the public health system’s ability to improve emergency preparedness, response, and recovery. Panelists felt that research on workforce and training should address training models and their impact on operational capabilities as well as the role and composition of the workforce needed to respond to large-scale emergencies. The panel called for research to determine whether focusing training on competencies and capabilities, rather than on situation-specific knowledge, is more effective in preparing workers to respond. Developing a competent workforce can help improve PHEP as well as advance the field of public health.

In the *short term*, research needs to focus on the connections among training, competency and capability, and outcomes. Although numerous articles have assessed the self-reported
impact of training on worker knowledge and attitudes, few are methodologically strong or connected to training outcomes. In the long term, research should inform the development and evaluation of interoperable training modules that can be disseminated widely at low cost to promote a core set of response capabilities among the public health workforce.

Legal Framework Research

Summary

How can legal and liability barriers to public health emergency preparedness and response be addressed?

Sample Research Questions

- When is it permissible, under current law, to modify standards of care?
- When can licensing requirements be waived under current law?
- What changes in legal frameworks are needed for credentialing?
- What changes in laws are necessary to protect first responders and volunteers?
- What are the legal frameworks (e.g., human-subjects protections) for studying real-time incidents?
- What changes in legal frameworks would enable people to perform duties outside their professional scope of work and day-to-day responsibilities?
- What model statutes or agreements would enhance the private sector’s participation in preparedness efforts?

Past incidents in which liability concerns have limited the willingness of critical actors to engage in response (e.g., H1N1 flu virus, smallpox) demonstrate the need for legal frameworks to support PHEP capabilities. Examples of other relevant legal issues, broadly stated, include standards of care, isolation and quarantine, licensing, documentation of care, civil liability for volunteers, compensation, intellectual property, and appropriation of property. Research is needed to better understand current laws and their impact on PHEP capabilities, and changes in legal frameworks that might better enable emergency responders to function effectively and reasonably to prevent, prepare for, respond to, and recover from public health emergencies.

In the short term, researchers could build upon existing efforts to identify current laws, regulations, provisions, and legal constraints at the local, state, national, and federal levels related to public health emergency preparedness and response. Over the long term, research should evaluate how emerging legislation and changes to existing legislation affect behavior (e.g., Do changes in legislation determine what types of plans and partnerships get developed?). Building an evidence base that empirically connects legislation to behavior will also, in the long term, support the development of a standard legal framework.
Economics of Public Health Emergency Preparedness

Summary

How can principles of economics be applied to encourage nongovernmental organizations and individuals to engage in and maintain involvement in preparedness-related activities?

Sample Research Questions

• What is the return on investment to nongovernmental organizations and individuals from engaging in and maintaining preparedness?

• Can economic incentives be developed or market forces stimulated to encourage preparedness? Do different groups of individuals and organizations respond to different types of incentives?

• How does public health system financing (how governmental public health entities are financed or the level of financing) affect nongovernmental investments in preparedness and response?

• How does the return on PHEP investments compare with that of other security or preparedness investments? Are there lessons to be learned from other domains related to security and preparedness or from other countries?

As noted elsewhere, a large share of the responsibility for PHEP falls on nongovernmental organizations (NGOs), individuals, and governments. However, so do the benefits. Panelists called for research to better understand how to develop incentives and other policies that incentivize individuals and NGOs to engage in and maintain their involvement in preparedness activities.

At the heart of the matter is the return on investment for PHEP perceived by individuals and organizations. Thus, in the short term, such research might seek to determine the return for various types of individuals, organizations, and firms, perhaps taking into account investment practices in other areas of security and prevention (e.g., health promotion).

Addressing this question might, in the long term, provide a basis for studies that determine how incentives (announced, e.g., through the publication of an industry standard) could be delivered via government program funding structures, insurance, or other mechanisms. Such research might consider whether different sets of individuals and organizations are more responsive to certain types of incentives than to others, seek to determine how strong the incentives need to be to induce behavior changes, and explore whether and how the level of public financing of preparedness affects private investment decisions. Additionally, long-term research should examine investments in areas in which routine and emergency public health infrastructure and capabilities for emergency preparedness overlap in order to identify how dual use might improve the efficiency of public health investments across both areas.
This final set of priorities relates to systems for defining, measuring, and improving the quality of public health preparedness and for holding the public health system accountable for the use of public funds.

Standards, Metrics, and Quality Improvement

Summary

What approaches can be used to ensure that the public health system has access to standards, metrics, and quality improvement tools?

Sample Research Questions

• What methods (including the study of real incidents) can be used to inform benchmarks that can be built into a continuous quality improvement system for public health preparedness?

• How can existing science on measurement development be applied to the development of PHEP measures?

• What methods can be used to validate public health system preparedness metrics?

• Which components of PHEP measurement can be embedded in day-to-day public health system practices, and which require additional personnel, processes, and systems?

• What lessons for public health preparedness might be learned from quality and safety initiatives in other sectors (e.g., clinical medicine, aviation, occupational safety)?

• How can public health systems become “learning” organizations?

• How can a “science” of lessons learned be developed to inform the public health system and ensure that all relevant actors are informed of what works and what does not?

• Can monetary incentives, accreditation, or other inducements be used to encourage quality improvement?

A pervasive and cross-cutting theme in the panel discussion was the need for performance standards, measures, and quality improvement tools that can help those responsible for public health preparedness assess, evaluate, and improve preparedness at all levels of government and across all participating organizations.

Standards provide an answer to the question, “How good is good enough?” Yet, the development of standards has been limited by the absence of a clear evidence base. As more evidence becomes available, approaches to developing standards will be needed. Moreover, there is a need for sound methods of standards development that can function in the absence of a strong evidence base.
The absence of a clear evidence base has slowed the development of performance metrics. While some effort has been made to formulate approaches to developing PHEP metrics, the field lacks accepted strategies for validating them. In the short term, research should examine existing methods of measurement development and validation from other fields and explore their applicability to PHEP. Given the infrequency of large-scale health emergencies, short-term research should also explore opportunities to embed the measurement of PHEP capabilities in smaller-scale, more routine emergencies, such as food- and waterborne disease outbreaks and seasonal influenza, and day-to-day activities in which components of PHEP are tested (e.g., risk communication messages). In the long term, simulation modeling to determine the types of strategies and capacities that have the greatest impact on preparedness and response would help ensure that standards and metrics focus on those most strongly linked to outcomes. Long-term research that factors cost into standards development could also sharpen decision-making about how much preparedness is needed to be “prepared enough.”

To be effective in closing performance gaps, standards and metrics must be accompanied by effective and feasible quality improvement tools. While there have been initial efforts to adapt “plan-do-study-act” and other aspects of quality improvement to public health preparedness, the practice is far from widespread, and additional research is required to explore the feasibility and effectiveness of the approach. Finally, research could examine whether monetary incentives, accreditation, or other inducements might help encourage organizations to develop and maintain robust quality improvement programs.

Data Sources and Data Collection

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<td>What approaches can be used to develop data sources to support PHEP research and evaluation, either by leveraging existing data or by creating new data sources or repositories?</td>
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Sample Research Questions

- What existing data sets can be modified, used, and linked to support research on preparedness and its outcomes?
- What approaches and systems are needed to collect data on disasters in real time?
- What methods can be used to develop valid data on performance from after-action reports, including both real incidents and exercises and to pool data to form a national level data set?
- What are the important ethical, legal, and social considerations when collecting data in real time during actual events? How can human subjects protection be ensured?

Measurement, standards, and quality improvement require a strong data collection infrastructure. Panelists were concerned about an undersupply of data that are critical for a prepared public health system. Panelists highlighted two issues, in particular. First, disasters are rare and often unpredictable. To capture data as a disaster unfolds, more effective strategies are needed to collect those data in real time. In the short term, research should help identify critical data points to be captured during a real-time event and inform the development and evaluation of real-time data collection systems.
Second, existing data sources (such as data collected through federal grants) must be better leveraged and linked. There are several ways in which data sources could be linked or leveraged:

- increasing the availability of primary databases for shared use by identifying relevant data and improving the robustness of existing data sets so that they are available to a broad community of PHEP researchers
- leveraging and linking existing data sets
- developing data sets that encode critical variables from after-action reports on both exercises and real incidents
- studying approaches and systems to conduct research in real time during an incident.

In the long term, research is needed examine the feasibility of developing critical-incident registries that capture lower-level or small-scale events. Similar to aviation close-call reports, these data sources could describe cracks in the core building blocks needed to respond to a public health emergency and offer a more routine and consistent source of information about the capacity of the public health system.

Tools and Templates to Promote the Transfer of Research Findings into Practice

<table>
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<tr>
<th>Summary</th>
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<tr>
<td>What approaches can support health departments and other system actors in selecting, adapting, and implementing research?</td>
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<table>
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<tr>
<th>Sample Research Questions</th>
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<tr>
<td>What are the most important barriers to the adoption of research-based practices in PHEP? Do these barriers vary by sector (public versus nonpublic), governmental structure (centralized versus decentralized public health system) or level of government (federal, state, local)?</td>
</tr>
<tr>
<td>Are there existing approaches from public health or other fields that have been shown to be effective? How can these approaches be adapted and spread in a cost-effective way?</td>
</tr>
<tr>
<td>What organizational factors are associated with enhanced uptake and implementation of research-based practices?</td>
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</table>

Variations in public health, emergency management, and other response agencies across states and regions suggest that “best practices” will often need to be adapted to meet the needs of specific locales. There have been some efforts to develop such tools and templates. For example, templates for after-action reports, crisis communication checklists, standard operating procedures for isolation and quarantine, local activation charts, training needs assessments, and plans can be found on the National Association of City and County Health Officials Web site. However, further research could help facilitate the selection, adaptation, and implementation of research findings by explicitly studying the successful adoption of practices (in public health and in other fields), identifying key barriers, and identifying successful approaches from a variety of disciplines.

In the short term, research should identify and examine the impact of tools and templates from other sectors and disciplines (e.g., organizational and implementation science) on
PHEP practice. Additionally, short-term research should determine the characteristics of practices that are more likely to be disseminated and the characteristics of organizations that more frequently adapt best practices.

**Long-term** research should determine the methods (e.g., quality improvement approaches) that promote the implementation of “best practices” and cost-effective ways to promote these approaches. **Long-term** studies should also examine the efficacy of practices to improve outcomes (e.g., response time, communication, coordination).
This report described the results of an expert panel process to define a comprehensive public health systems research agenda for emergency preparedness. Based on a review of published literature, consultation with key experts, and an expert panel meeting, the agenda includes 20 priority areas, nine of which were identified by the panelists as top short-term priorities. Many of the priority areas describe steps needed to build a more robust research infrastructure. PHEP efforts need to synthesize relevant research and leverage practical and applied knowledge (i.e., knowledge and research not found in peer-reviewed publications). As noted in the agenda, measures and criteria are needed to better study the public health system and permit a comparison of preparedness and response approaches to determine what works the best and what would be cost-effective.

Metrics accounted for one of several areas (e.g., training, risk communication, engaging diverse populations in PHEP) in which the research agenda overlapped with the IOM panel’s near-term research recommendations for CDC’s PERRCs. However, this report emphasized several unique areas not included in the research recommendations for the PERRCs (i.e., epidemiology, public health lab systems, and a science base for public health advice). In addition, several of the research priorities expand on ideas mentioned but not fully articulated by the IOM recommendations:

- Research on information technology and infrastructure should focus not only on how technology can be used for data sharing and decision support, but also on how to anticipate and plan for the impact of technology adoption in communication and health care in terms of PHEP planning and response.
- Although cost-effectiveness is critical in comparing approaches (e.g., different training modules and modalities as mentioned by the IOM panel), it is also necessary to understand how economics can be applied to encourage NGOs and individuals to engage in and maintain participation in preparedness-related activities and to encourage sustainability of efforts.
- More and higher-quality data and data sources are needed to develop standards and comply with performance measure reporting, underscoring the importance of research in terms of leveraging existing data sources or developing new ones.
- Although the IOM panel suggested that resilience and legal and ethical issues be emphasized throughout the PERRC research, there was not a specific emphasis on research in these areas. The current agenda recommends research on disaster risk reduction, special needs and special populations, displaced populations, and recovery—all of which have
a specific focus on resiliency—and lays out a specific direction for research on legal and liability issues.

Given the scope of the task, this proposed initial research agenda is necessarily general in nature, and additional effort will be needed to further refine potential research topics in each of the 20 areas. Recommendations for a more specific implementation plan for DHHS/ASPR should include, among other guidance, how to

- secure adequate funding and research capabilities, including—but not limited to—those in DHHS, to execute the research by establishing strong intra- and extramural partnerships
- ensure that research priorities translate into executable research (e.g., require multidisciplinary partnerships to fund research priorities that will likely require collaboration for successful execution)
- monitor agenda implementation to determine the outcomes and impact of the research investment and revisit the agenda regularly (e.g., every two to four years) to update and revise the priority areas
- promote sustainability of the research outcomes or interventions (e.g., through research that emphasizes the integration of PHEP into more routine public health capabilities, agency accreditation, or sustainability of outcomes as part of performance measures or funding criteria).

The goal of these recommendations is to help DHHS take a leadership role in realizing an agenda. However, it is clear from the breadth and depth of research needed that many stakeholders will need to be involved (e.g., foundations, community organizations, businesses). By encouraging interest in an agenda among diverse groups of partners, DHHS can help to build a strong evidence base to improve the preparedness and response of the public health system, as well as the recovery of the nation’s public.

Although an agenda is intended to play a key role in guiding future research, even when “finalized,” the agenda should not be considered final. That is, knowledge is not static, and future research will have to be adjusted as understanding of the public health system and public health threats and vulnerabilities continues to evolve.
Appendix A

Expert Panel

RAND, in collaboration with ASPR, convened a panel of 13 experts representing a diverse range of organizations and perspectives to guide the development of the research priorities discussed in this report. Through facilitated discussion and consideration of a pre-circulated review paper, the panelists identified 20 research priorities and illustrative research questions in areas related to planning, response, resources and infrastructure, and accountability and improvement.

Panelists

- Carol Chang, senior program director, American Red Cross of Central New Jersey
- Lawrence “Bopper” Deyton, chief of public health and environmental hazards officer, Veterans Health Administration
- Peggy Hamburg, former vice president for biological programs and senior scientist, Nuclear Threat Initiative, and former Assistant Secretary for Planning and Evaluation, U.S. Department of Health and Human Services
- Jack Herrmann, senior advisor, public health preparedness, National Association of County and City Health Officials
- Paul Jarris, executive director, Association of State and Territorial Health Officials
- Ana-Marie Jones, executive director, Collaborating Agencies Responding to Disasters
- Mark Keim, medical officer, National Center for Environmental Health, Centers for Disease Control and Prevention
- David Marcozzi, director, Emergency Care Coordination Center, Office of the Assistant Secretary for Preparedness and Response
- Glen Mays, professor and chair, Department of Health Policy and Management, University of Arkansas for Medical Sciences
- Sally Phillips, director, Public Health Emergency Preparedness Research Program, Agency for Healthcare Research and Quality
- Jeffrey Runge, former chief medical officer, U.S. Department of Homeland Security
- Karen Smith, health officer, Napa County Health and Human Services
- Stephanie Zaza, strategy and innovation officer, Coordinating Office for Terrorism Preparedness and Emergency Response, Centers for Disease Control and Prevention
- Observer: Barbara Ellis, Coordinating Office for Terrorism Preparedness and Emergency Response, Centers for Disease Control and Prevention
APPENDIX B

Developing the Research Agenda

Background and Introduction

Knowledge Gaps
Improving public health emergency preparedness is at the top of the national agenda. PHEP is defined here as the capability of the public health and health care systems, communities, and individuals to prevent, protect against, quickly respond to, and recover from health emergencies, particularly those whose scale, timing, or unpredictability threatens to overwhelm routine capabilities (Nelson et al., 2007). Although a considerable financial investment at multiple levels (e.g., federal, state, local, private sector) has been made in PHEP, to date, there has been a lack of sufficient and reliable evidence from which to readily draw inferences about best practices, identify and develop measures of effectiveness, and predict which capabilities are most critical to ensuring positive health outcomes related to the prevention of, preparedness for, response to, and recovery from public health emergencies.

These limitations in PHEP research are the result of several factors. For example, large-scale public health emergencies are relatively rare, but this good fortune has created few opportunities to observe, measure, and study the myriad elements involved in PHEP outcomes. This, in turn, has slowed progress in identifying evidence-based practices, developing performance measures and standards, and otherwise improving the nation’s preparedness for incidents of national significance with health consequences. A review of public health disaster research (Abramson et al., 2007) identified additional limitations of existing research, including a lack of previous studies that investigate PHEP from a multilevel, or ecological, perspective (e.g., individual, organizational, societal, and political levels), as well as research on the outcomes of PHEP interventions (e.g., training, the provision of PHEP “tool kits” to the public) and processes related to long-term disaster recovery.

To address the gap in evidence, the PAHPA (Pub. L. 109–417, § 101 et seq.) (1) directed university-based (and federally funded) PERRCs to begin conducting public health systems research related to PHEP and (2) directed DHHS to derive a broader agenda to solicit involvement from a wider range of representatives beyond the PERRCs. A report by the IOM commissioned by CDC recommended a set of near-term, systems-focused research priorities for the PERRCs, including training, improving communication in preparedness and response, creating and maintaining preparedness and response systems, and developing metrics (Altevogt et al., 2008). The broader, national agenda being developed by HHS will also emphasize a public health systems approach, for which public health systems research has been defined as “a field of study that examines the organization, financing, and delivery of public health services within communities, and the impact of these services on public health” (Mays, Halverson, and
Scutchfield, 2003, p. 180) and the public health system, as “a complex network of individuals and organizations that have the potential to play critical roles in creating the conditions for health” (IOM, 2002, p. 28). Both of these definitions underscore the multifaceted nature of the public health system and imply that both individual system components as well as their interactions are important to consider in systems-level investigations of PHEP.

**A Systems Approach to PHEP Research**

It should be noted that, to date, there is no widely agreed-upon definition of the public health system, and a systems approach to PHEP research has been the exception more often than the rule (thus the need for a systems-focused PHEP research agenda). Therefore, limiting a literature review to only those PHEP investigations that took a systems approach would potentially eliminate the incorporation of citations that could usefully inform a systems-focused PHEP agenda. In this review, we did not restrict ourselves to including only systems-focused PHEP research; rather, we began the review by highlighting some exemplary systems-focused investigations of PHEP but devoted the majority of this report to a synthesis of the larger PHEP literature, emphasizing the implications of the results for a systems-level PHEP research agenda.

Although approaches to systems research vary, at the most basic level, they seek to understand and improve the organization and management of the system by identifying system components, how those components interact, and contextual factors that may affect the overall system or its components. The review is constructed with these approaches in mind (see, in particular, “Noteworthy Findings and Limitations” in Appendix C).

**Summary of Existing Research and Relevant Knowledge Gaps**

ASPR in DHHS asked RAND to facilitate a process for developing the Secretary’s agenda for systems research on PHEP. The process featured a panel that convened on September 22 and 23, 2008. The panel’s charge was to identify gaps in existing research and to develop a prioritized set of topics that warrant further research, using, among other materials, this literature review as a background document.

We were particularly interested in deriving, if possible, practice or policy recommendations regarding drivers or predictors of successful emergency preparedness, response, or recovery. To this end, the review aimed to answer four questions:

1. What are the shared characteristics of studies that represent exemplary systems investigations of PHEP? (See “Exemplary Systems Approaches to PHEP Research” in Appendix C.)
2. In the broader body of PHEP research, what types of studies and methodological approaches have been used, what objectives has the research sought to achieve, and what types of emergencies and elements of preparedness has the research addressed? (See “Types of Studies and Methodological Approaches in PHEP Research” in Appendix C.)
3. What are some noteworthy findings from and limitations of the literature to date? (See “Noteworthy Findings and Limitations” in Appendix C.)
4. What are the financial and intellectual sources of PHEP research? (See “Intellectual and Financial Sources of Current Systems Research” in Appendix C.)
We began with a close look at a subset of citations that took a systems approach to PHEP research in an effort to determine what these citations have in common as a way to inform the continued development of systems research on PHEP (question 1). Identifying the types of studies, objectives, and stages of preparedness addressed in the literature captures the breadth of existing research (question 2), while identifying noteworthy findings and research limitations speaks to the depth of the existing literature (question 3). The discussion of financial and intellectual sources aims to describe the context in which this research has been developed (question 4).

This review was informed by and builds on Abramson and colleagues’ work (Abramson et al., 2007) by incorporating databases into the literature search that index additional fields of study (e.g., behavioral science) and research published in 2007 and 2008. Additionally, we review relevant statutes and policies to supplement and provide context for our results. A final review that incorporates panel comments will be delivered to DHHS with a final research agenda.

Identifying Gaps and Recommending Priorities
The identification of a gap in knowledge requires a determination both that there is a need for knowledge about a specific aspect of PHEP and that existing knowledge on that aspect is insufficient. In the absence of consensus on what knowledge is needed and what counts as “sufficient,” identifying gaps necessarily involves a considerable amount of judgment. During the course of the panel, we sought to facilitate building this consensus to help the panel meet its goals. However, for the purposes of this review, it is important to emphasize at the outset that literature alone cannot objectively point to gaps in research. Instead, the review was intended to inform the panel’s efforts to identify gaps by (1) describing the range of topics addressed by existing PHEP research, (2) assessing the methodological quality of the research, and (3) reporting gaps identified by authors of existing studies.

Methods Used to Conduct the Review

Empirical Studies of PHEP
Our review included peer-reviewed citations published in English between January 1, 2004, and June 15, 2008. We limited the review to studies published between these dates in order to concentrate our efforts on a cross-section of the empirical PHEP literature at a time of stimulated growth. (Figure C.1 in Appendix C shows the date distribution of the peer-reviewed studies included in our literature review.) To produce a review that focused specifically on empirical research on emergency preparedness, we excluded literature reviews, discussion papers and commentaries, letters to the editor, and conference abstracts. We also did not include citations that addressed emergency medicine or public health systems without substantively addressing emergency preparedness. From the larger literature on emergency preparedness, we reviewed the portion \((n = 192, \text{ or } 28 \text{ percent})\) that specifically included empirical research on emergency preparedness. For a detailed description of our inclusion criteria, please see Appendix D.

Of the 192 citations selected for review, 12 percent were excluded, deemed to be inappropriate for inclusion (e.g., the citation was revealed to be a commentary or discussion piece, could not be located, was outside the date range, or was otherwise not congruent with review
criteria). Thus, our results are based on a review of the 169 peer-reviewed manuscripts listed in Appendix D.

**Key Policy Documents**

In addition to peer-reviewed literature, we also reviewed selected statutes, policies, and other related government or organizational reports. These documents provide one benchmark against which to judge the adequacy of the existing literature. In Appendix C, we describe the degree to which the literature appears to address the priorities identified in the key policy documents.

Because statutes and policies are primarily intended as guidance documents for states and localities, they are traditionally not found in the online databases of published, peer-reviewed literature; it is therefore difficult to conduct a systematic search of these documents. To identify relevant statutes, policies, and other reports for review, we relied on input from experts in the field and a targeted Web search (of federal government sites). The documents in Table B.1 were included in our review. Brief summaries of the 25 statutes and policies reviewed can be found in Appendix E.

**Systematic Abstraction Tool**

We used a data abstraction form (DAF) to facilitate a systematic evaluation of each document reviewed. Specifically, the DAF was used to record information from the citations included in the review (peer-reviewed literature and statutes/regulations). The DAF was developed by the research team to capture standard elements regarding quality and content (e.g., type of special needs population addressed) and included an item for which team members indicated whether the citation was an excellent example of a systems approach to PHEP research. The creation of the DAF, including that of some specific data elements (e.g., type of study, primary research objective), was usefully informed by the approach used by Abramson et al. (2007) in their review of public health disaster research. For a detailed description of the development of the DAF, a complete copy of the form, and our analytic strategy, see Appendix F.

For most DAF items, more than one category could be selected to characterize the literature (e.g., one citation could address more than one element of preparedness or have more than one objective). Therefore, the number of studies rather than the percentage is presented throughout Appendix C. This strategy made it possible to have more counts across categories than citations reviewed. That is, because one citation could address more than one element of preparedness (e.g., both countermeasures and mitigation strategies and mass health care), the count of elements of preparedness addressed could be greater than the total number of citations reviewed. Once the research team conducted a pilot test of the DAF to ensure inter-rater reliability in the consistency of data abstraction and to determine whether the categories adequately captured data from the literature, the remaining citations were divided among the team for a full review. The DAF enabled quantitative analyses (frequencies and crosstabs) to characterize the literature as well as qualitative analyses of the content of each citation included in the review.
### Table B.1
Statutes, Policies, and Other Government or Organizational Reports Included in the Review

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<th>Number</th>
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<tr>
<td>8.</td>
<td>HSPD-9, <em>Defense of United States Agriculture and Food</em>, January 30, 2004</td>
</tr>
<tr>
<td>13.</td>
<td>National Science and Technology Council, Subcommittee on Disaster Reduction, <em>Grand Challenges for Disaster Reduction</em>, June 2005</td>
</tr>
<tr>
<td>20.</td>
<td>Federal Emergency Management Agency, Emergency Support Function No. 8: Health and Medical Services</td>
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</table>
Limitations of the Review

We aimed to be comprehensive in our review; however, some limitations to our approach are worth noting. First, although we utilized both medical (PubMed) and social sciences (PsycINFO) databases in our literature search, we did not include other databases that may have better represented literature from relevant disciplines (e.g., engineering, systems research, business). This strategy may have decreased the representation of systems-level literature in the citations captured by our search strategy, thereby limiting our ability to draw systems-level conclusions. We discuss the relevance of other disciplines that were beyond the scope of this review in the concluding section of Appendix C. Further, we chose to focus our review on empirical research and therefore excluded some types of publications (e.g., commentaries, discussion papers). While these types of publications do not directly inform the preparedness evidence base with data, they can provide valuable perspectives on and recommendations for the state of research that did not inform our results here. Additionally, it is possible that the evidence base for public health is broader than what is represented in the academic literature. Lessons learned from after-action reports, innovations that are included in emergency plans, and legislative changes at the local level represent untapped sources of data. Finding an appropriate and more centralized dissemination venue for high-quality public health research that reaches outside the traditional academic structures could also help improve the robustness of this evidence base. Finally, by focusing on literature published since 2004, studies addressing the September 11 attacks, the 2004 tsunami, and Hurricane Katrina may have been overrepresented in the 169 citations included in the review, compared with the larger public health literature on emergency preparedness.
Figure C.1 shows how the number of peer-reviewed articles on preparedness has grown steadily over time: Twenty-six of the 169 citations we reviewed were published in 2004, compared with 57 published in 2007. A few (n = 16) published in 2008 were available for review.

Our results are divided into four sections: First, we review the small number of citations (n = 15) that were determined by the team to represent exemplary systems approaches to PHEP research. Second, we provide some broad descriptions and conclusions regarding the quality and content of the peer-reviewed literature, emphasizing the limitations of the existing evidence base. Next, we describe in greater detail some of the findings from and implications of
the peer-reviewed literature. Together, the latter two sections offer some insight into knowledge gaps in the research, identifying areas of inquiry on which little work has been done to date, noting the recommendations for further research that are identified in the peer-reviewed literature and the statutes and policies reviewed, and exposing the limitations of the existing evidence base. Finally, we describe the intellectual and financial sources of the research reviewed by tabulating the funding sources for the studies and where they were published.

Exemplary Systems Approaches to PHEP Research

The review team indicated whether a citation was an excellent example of a systems approach to PHEP research using the definition of the public health system described by the IOM (2002) as guidance: The “public health system” is a “complex network of individuals and organizations that have the potential to play critical roles in creating the conditions for health” (p. 28). This step in the review process allowed us to characterize the shared features of citations that took a systems approach to PHEP research within the broader PHEP literature that was reviewed. We acknowledge that this procedure was necessarily subjective. Nonetheless, in the absence of clear guidance on how to define research with a “systems” focus, the process allowed us to address in detail examples of PHEP research that may best represent the types of investigations that the Secretary’s research agenda aims to stimulate.

Fifteen citations (Beitsch et al., 2006; Eastman et al., 2007; Harris and Clements, 2007; Jackson et al., 2006; Macario et al., 2007; Moore et al., 2008; Nuno, Chowell, and Gumel, 2007; Prezant et al., 2005; Roorda, van Stiphout, and Huijsman-Rubingh, 2004; Tan et al., 2007; Van der Velden et al., 2007; Vlahov et al., 2004; Waring et al., 2005; Wray et al., 2008; and T. S. Wu et al., 2008) were identified as excellent examples of systems approaches to PHEP research. Within these, we identified four shared characteristics: They (1) considered the influence of multiple system components, (2) leveraged multiple sources of data, (3) looked deeply at one component of the system and considered its relevance to other parts of the system, and (4) discussed implications for multiple system components. Next, we discuss these characteristics and provide brief summaries of relevant findings.

Systems Research on PHEP Considered the Influence of Multiple System Components

Exemplary systems citations often considered the influence of multiple components of the public health system and how those components interact to affect outcomes. For example, in their study of alternate-site medical surge capacity in the wake of Hurricane Katrina, Eastman et al. (2007) describe how the Dallas Convention Center was transformed into an alternative site for medical surge capacity, with 10,326 persons seeking urgent and emergent care after Hurricane Katrina, and how this alternative site protected the integrity of Dallas’s existing trauma centers and emergency department infrastructure and ongoing operations. The authors highlight how collaboration and coordination among several components of the public health system (e.g., city emergency management officials, health care providers, state and local health departments) were necessary to establish this alternative site, which increased access to care among affected individuals.

Multiple components of the public health system were also addressed in Moore et al.’s (2008) development of a decision tool for pandemic influenza preparedness. This statistical decisionmaking tool was developed to improve the probability and timeliness of detecting
early human influenza cases or clusters; it aids decisionmaking by providing an estimated relative effect of potential interventions and surveillance strategies, allowing public health staff to choose strategies that are appropriate for their population and resources. The authors based their tool on a process map they developed to incorporate the influence of multiple system components between the time an individual is infected with influenza and the time the case is confirmed, including the effect of the infected individual’s behavior, media coverage of the event, the actions of health care providers, other surveillance mechanisms (e.g., community monitoring systems), and laboratory testing procedures.

In acknowledging the role of multiple system components and the effects of their interactions on health outcomes, these citations—more so than citations that did not take this approach—offered deeper insights into the ways in which the public health system components collectively influence preparedness, response, and recovery.

**Systems Research on PHEP Leveraged Multiple Sources of Data**
The public health system represents several entities, each of which has associated data sources that, when drawn on together, can provide a more comprehensive account of the system’s role in PHEP. After the 2003 blackout in New York City, Prezant et al. (2005) used 911 emergency services call data from the city as well as emergency department and hospital admissions data to determine the effect of the event on the city’s health care system. In examining these two data sources together, the authors determined that the main surge had to do with increases in respiratory issues due to the loss of power for respiratory-support devices, highlighting these devices as particularly important to consider in planning for future events.

Similarly, Roorda, van Stiphout, and Huijsman-Rubingh (2004) leveraged data from individuals affected by a disaster, as well as health care providers’ reports, to offer a more comprehensive investigation of postdisaster physical and mental health recovery. In using these sources together, and in following them over time, the authors were able to provide recommendations to both the public and health providers that resulted in policy changes toward increasing provision of mental and physical health services for affected individuals.

**Systems Research on PHEP Looked Deeply at One Component of the System and Considered Its Relevance to Other Parts**
Investigating multiple components of the public health system is one way to take a systems approach to PHEP research; another is to focus closely on one system component but to consider study results in the context of the broader system. Beitsch et al. (2006) took this approach in their state-based analysis of preparedness programs. The authors surveyed preparedness programs in 45 states (including the District of Columbia) on multiple issues, including organizational structure, administration, workforce, and exercises. Results not only offered an in-depth examination of state-based preparedness efforts but also provided insights into how respondents’ efforts fit within the larger system (e.g., prevalence of partnerships with other system components, such as emergency services; prevalence of collaboration with other system components, such as law enforcement and the private sector, on exercises). The variability in cross-component system collaboration that the survey results revealed suggested several targets for improvement.

Harris and Clements (2007) used social network analysis to examine the degree to which county-level emergency planners interfaced with other system components in Missouri. This sort of analysis, directed at the county level but allowing for the incorporation of a wide vari-
Systems Research on PHEP Discussed Implications for Multiple System Components
A systems approach to PHEP research acknowledges the implications of a disaster for multiple components of the public health system. In their report on a multiagency exercise based on the intentional release of H5N1 virus, Jackson et al. (2006) describe lessons learned related to expectations about management, roles and responsibilities, and communication for multiple system components. The authors emphasize the utility of the multiagency exercise approach in deriving systems-level implications and highlight that the presence of multiple agencies at an exercise is not as powerful as multiagency participation in exercise development, design, and execution.

Finally, T. S. Wu et al. (2008) describe the process of developing a nationwide syndromic surveillance system in Taiwan, including the type of data collected, the data sources used, and the procedures for data analysis. The authors not only discuss the implications of their results for the system components that came together to achieve real-time surveillance, but also offer their in-depth description of surveillance development as a way to encourage other countries to do the same, suggesting that a global perspective on the public health system is necessary to ensure that potential infectious-disease pandemics can be quickly identified and contained.

Summary
The citations identified by the review team as exemplary systems approaches to PHEP research investigated a variety of topical areas using a number of different methods, but they shared several characteristics related to how they achieved a systems perspective on PHEP. These characteristics may inform the development of the Secretary’s research agenda and are highlighted in the section “Noteworthy Findings and Limitations,” later in this appendix.

Types of Studies and Methodological Approaches in PHEP Research
In the broader PHEP literature included in this review, we used several criteria to represent general indicators of quality and content, including type of study conducted, type of public health emergency and stage of emergency addressed, and research objectives. These criteria were informed by Abramson et al.’s (2007) review. Note that, in general, when evaluating research, evaluators consider some types of studies or research objectives to be indicators of higher quality than others (e.g., randomized controlled trials are the gold standard for generating data from which causal inference can be derived; studies with a hypothesis-driven objective are often considered superior to descriptive studies because of their reliance on past evidence to derive research questions that aim to advance knowledge). In the absence of other standards, we generally followed these guidelines in our review of the literature. However, given that emergency preparedness research is a relatively new area of inquiry, these quality standards may not apply as readily to this field of research as to other, more established areas of investigation.
Overall, the Literature to Date Constitutes an Extremely Limited Empirical Evidence Base

The literature is particularly limited as a source from which to derive practice or policy recommendations or strong conclusions regarding the drivers or predictors of successful emergency preparedness, response, or recovery. These limitations are largely due to the types of studies conducted and the objectives of much of the research. Most studies have focused on documenting the status quo rather than trying to assess or estimate causality between a given factor and a measure of preparedness. Nearly half (47 percent) of the 169 peer-reviewed citations reported data that resulted from a survey study; qualitative studies (e.g., focus group, interviews) were also prevalent (17 percent). Few studies were based on pre-test/post-test comparisons of training outcomes (11 percent), observations during drills or exercises (8 percent), meta-analysis (7 percent), or randomized controlled trials (3 percent). Several studies (17 percent) fell into a different category, including modeling or simulation studies, social network analysis, basic laboratory science, or registry or administrative data review.

Thus, on the whole, very few studies have attempted to leverage the existing evidence base to identify associations observed across multiple studies or to provide strong empirical evidence on factors or interventions that caused or reliably influenced changes in outcomes related to preparedness, response, or recovery. More than 60 percent of the citations presented results based on a cross-sectional survey or qualitative investigations. Even when studies of these types are well executed, they do not generate data from which strong causal implications can be derived, and results are often of limited generalizability (for qualitative studies in particular). Further, many are compromised by small sample sizes or low response rates.

Most of the Research Has Been Observational and Descriptive

The majority of studies tend to describe the knowledge level regarding elements of preparedness among different samples, including the general public, health care providers, and first responders, or they report on the lessons learned from a drill or exercise. These points are reinforced by our observation that the objective of most of our reviewed citations (59 percent) was descriptive (e.g., the study aimed to describe an outcome among a population or sample), rather than an attempt to develop or evaluate a program or policy (e.g., training program), or they presented a hypothesis (e.g., aiming to answer a stated research question or test a specific theory about the effect of a variable or intervention) or focused on a needs assessment (e.g., focused on the needs of a sample or population and strategies to meet those needs). The objective of the one study that fell into the “other” category was to develop a new measure. (See Figure C.2.)

The Literature Has Tended to Focus Primarily on All-Hazards or an Unspecified Threat and Secondarily on a Terrorist Incident

In both the peer-reviewed literature (see Figure C.3) and the statutes and policies (data not shown), the type of emergency most often addressed was an all-hazards or unspecified type, followed by terrorist threats or incidents. (These citations most often addressed the attacks in New York City and Washington, D.C., on September 11 and the anthrax attacks in 2001.) Natural disasters (most often Hurricane Katrina and the tsunami of 2004), infectious-disease outbreaks, and infectious-disease pandemics were addressed in the peer-reviewed literature with similar frequency, and chemical, biological, radiological, nuclear, and explosive (CBRNE) incidents were least frequently addressed. Five citations (Beatty et al., 2006; Hupert et al., 2007; Prezant et al., 2005; Ransom, Bashir, and Phillips, 2007; and Shimabukuro et al., 2007) addressed a different
type of public health emergency (e.g., the 2003 blackout in New York City, vaccine shortage). More than one-quarter (27 percent) of the studies had been conducted in the context of a real public health emergency (e.g., Abatemarco et al., 2007; Adams, Ford, and Dailey, 2004; Kile et al., 2005); most of these (55 percent) were conducted during the recovery phase (e.g., Gross et al., 2006; Roorda, van Stiphout, and Huijsman-Rubingh, 2004). Fewer were conducted during the response (36 percent; e.g., Pantukosit, 2007) or preparedness (9 percent; e.g., Moore et al., 2008) phase.

**The Literature Has Tended to Focus Primarily on Emergency Preparedness and Secondarily on Response (and Rarely on Recovery)**

We coded four stages of preparedness in the peer-reviewed literature: *preparedness* (e.g., capacity-focused studies related to activities before an emergency takes place, such as education, training, or resource gathering); *response: hypothetical* (e.g., exercise or drill); *response: actual* (e.g., evacuation during a real public health emergency); and *recovery* (e.g., shelter management, safety maintenance, mental health). We also identified “other” stages of preparedness. A differentiation was made between the “response: hypothetical” and “response: actual” categories to distinguish between studies that were conducted during real-time emergency response and
studies that used an exercise or drill to study response capabilities. Of the 58 citations that addressed emergency response, nearly equal numbers did so during actual public health emergencies ($n = 30$) and staged or hypothetical emergencies ($n = 28$).

We also examined elements of preparedness that were addressed in the peer-reviewed literature and in the statutes and regulations. We coded elements of preparedness taken from our previous work developing a definition of public health preparedness (Nelson et al., 2007). These elements have been adopted for use by the IOM in its report on research priorities for the PERRCs (Altevogt et al., 2008). In addition to the 16 elements defined by Nelson et al. (2007), we added two other elements based on their recurrence in the literature: psychosocial outcomes and community resilience, and interagency communication and coordination. Brief descriptions of these elements of preparedness are shown in Table C.1.

The prevalence with which the peer-reviewed literature addressed stages of emergency and elements of preparedness is displayed in Figure C.4. Broadly, the peer-reviewed literature addressed emergency preparedness, followed by response. Relatively few citations addressed recovery (a similar pattern is observed in the statutes and policies, although the references to preparedness and response in these documents are relatively equal). Significant variability was observed in the elements of preparedness addressed: Several citations focused on operations-
Table C.1
Elements of Preparedness

<table>
<thead>
<tr>
<th>Element of Preparedness</th>
<th>Brief Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operations-ready workers and volunteers</td>
<td>Develops/maintains skilled/capable workforce</td>
</tr>
<tr>
<td>Countermeasures and mitigation strategies</td>
<td>Develops/tests/improves community mitigation and countermeasure distribution strategies</td>
</tr>
<tr>
<td>Health risk assessment</td>
<td>Identifies individual, community, and structural hazards/vulnerabilities to inform plans</td>
</tr>
<tr>
<td>Psychosocial outcomes and community resilience</td>
<td>Develops/tests/improves capability to respond to individual and community psychological consequences of a public health emergency</td>
</tr>
<tr>
<td>Mass health care</td>
<td>Develops/tests/improves capability to provide mass health care</td>
</tr>
<tr>
<td>Public information and communication</td>
<td>Develops/improves rapid provision of credible and culturally appropriate public communication</td>
</tr>
<tr>
<td>Testing operational capabilities</td>
<td>Practices/reviews/reports on/improves preparedness by using real events and/or drills and exercises</td>
</tr>
<tr>
<td>Interagency communication and coordination</td>
<td>Develops/improves communication and/or coordination between relevant agencies and responding entities</td>
</tr>
<tr>
<td>Epidemiology functions</td>
<td>Maintains/improves systems to monitor, detect, and investigate emergency events</td>
</tr>
<tr>
<td>Roles and responsibilities</td>
<td>Defines/assigns/tests responsibilities across sectors</td>
</tr>
<tr>
<td>Robust supply chain</td>
<td>Identifies critical resources for public health response/practice and improves delivery of resources through supply chain</td>
</tr>
<tr>
<td>Incident Command System (ICS)</td>
<td>Develops/tests/improves ICS capabilities</td>
</tr>
<tr>
<td>Public engagement</td>
<td>Educates/engages/mobilizes the public to be active preparedness participants</td>
</tr>
<tr>
<td>Laboratory functions</td>
<td>Maintains/improves systems to test for hazards, especially CBRNE events</td>
</tr>
<tr>
<td>Legal climate</td>
<td>Identifies/addresses legal and liability barriers to effectively respond to public health emergencies</td>
</tr>
<tr>
<td>Performance management</td>
<td>Implements a performance management and accountability system</td>
</tr>
<tr>
<td>Leadership</td>
<td>Trains/recruits public health leaders</td>
</tr>
<tr>
<td>Financial tracking</td>
<td>Develops/tests/improves financial systems and resources</td>
</tr>
</tbody>
</table>

ready workers and volunteers (representing a large portion of the literature devoted to training), countermeasures and mitigation strategies, health risk assessment, psychosocial outcomes and community resilience, and mass health care. A moderate number addressed testing operational capabilities, epidemiology functions, interagency communication and coordination, and roles and responsibilities. The remaining eight elements were observed at relatively low frequencies.
Figure C.4
Elements of Preparedness Addressed, by Stage of Preparedness

<table>
<thead>
<tr>
<th>STAGE OF PREPAREDNESS</th>
<th>Recovery</th>
<th>28</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>Preparedness</td>
<td>101</td>
<td></td>
</tr>
</tbody>
</table>

NOTE: Totals listed for elements of preparedness and stage of preparedness do not necessarily sum to the cell counts in the matrix because citations could address more than one element or stage of preparedness.
Research Has Concentrated More on Some Elements for Particular Stages of Preparedness

Figure C.4 crosses the stage of preparedness with the elements of preparedness addressed; in this way, it estimates areas in which research has been concentrated to date. For example, countermeasures and mitigation strategies have been relatively well studied in preparedness and response, whereas psychosocial outcomes and community resilience have been most often studied in the context of recovery. In contrast, no citations we reviewed investigated testing operational capabilities or interagency communication and coordination during recovery, and little has been done at any stage of preparedness on performance management, leadership, or financial tracking. Note, however, that while our review found relatively little research on laboratory functions, it may be that research on this element of preparedness is more often found in the basic science literature, which was not generously captured by our search strategy.

Frequently Studied Areas Have Not Necessarily Been the Focus of High-Quality Studies

Some elements of preparedness have been more frequently studied than others; however, this does not necessarily mean that the quality of the work that has been done is sufficient to suggest that further research is not necessary. Therefore, we evaluated the quality of the research for the ten most prevalent elements addressed in the literature. (For the remaining elements, each of which was addressed fewer than ten times in the literature, continued study may be warranted regardless of the quality of the research to date.) Four indicators of quality were considered: the type of study conducted (randomized controlled trial, meta-analysis, qualitative, survey, observational, pre-test/post-test, other); the analytic strategy used (qualitative synthesis, descriptive/bivariate statistics, multivariate statistics, other); the objective of the research (descriptive, program or policy development/evaluation, hypothesis-driven, needs assessment); and whether the research on the element contained any of the citations identified by the review team as exemplary studies of public health systems research on emergency preparedness (i.e., the study was coded by the reviewer as being an excellent example of public health systems research on emergency preparedness).

Across all 169 citations reviewed, the majority of the literature represented survey or qualitative studies that used qualitative, descriptive, or bivariate analytic approaches to achieve the objective of describing a sample or population. Thus, we investigated the degree to which the research to date on each of the ten most prevalent elements of preparedness went beyond what the larger literature has achieved. Elements coded in green are those for which more than half of the research involved methodologies other than survey or qualitative research, used analytic strategies other than qualitative synthesis or descriptive/bivariate statistics, aimed to achieve an objective other than describing outcomes for the sample or population, and included several (i.e., more than 15 percent) of the studies identified as exemplary. Elements coded in yellow are those for which between 25 and 50 percent of the research involved methodologies other than survey or qualitative research, used analytic strategies other than qualitative synthesis or descriptive/bivariate statistics, for which at least 15 percent aimed to achieve an objective other than describing outcomes for the sample or population under study, and included some (i.e., more than 10 percent) of the studies identified as exemplary. Finally, elements coded in red are those for which less than 25 percent of the research involved methodologies other than survey or qualitative research, used analytic strategies other than qualitative synthesis or descriptive/bivariate statistics, for which less than 15 percent aimed to achieve an objective other than describing outcomes for the sample or population under study, and included few or none (i.e., less than 10 percent) of the studies identified as exemplary.
Figure C.4 should be interpreted with care and caution. First, it is important to keep in mind that, although there is variability in the prevalence and quality of the research, on the whole, the literature to date is significantly limited by the types of studies that have been conducted and their objectives. Thus, for every stage or element of preparedness, more rigorous research is needed to strengthen the existing evidence base. Second, we used four broad indicators of quality to characterize the 169 reviewed citations. However, there are other indicators of quality that we did not include (e.g., sample size), and our conclusions regarding quality within elements of preparedness are tentative at best.

Nonetheless, Figure C.4 does display the stages and elements of preparedness most frequently addressed in the literature and offers some rough indicators of the quality of research in different areas of preparedness. In doing so, it provides a summary that may be used with the other results contained in the review to help inform both a short- and long-term research agenda for public health systems research on emergency preparedness.

Summary
Our broad review of the literature reached the following conclusions:

- The literature to date has been primarily descriptive in nature, and very few studies have been designed and conducted either to use the existing evidence base to draw strength from associations observed across multiple studies or to provide strong empirical evidence on factors or interventions that caused or reliably influenced changes in outcomes related to preparedness, response, or recovery.
- Most of the peer-reviewed literature has taken an all-hazards approach to the type of emergency addressed. However, a substantial portion of the peer-reviewed literature is devoted to research on terrorist threats or incidents, with a sizable minority focused on natural disasters and infectious-disease outbreaks/pandemics.
- Additionally, most of the peer-reviewed literature (69 percent) addressed one of the four research priorities identified by the IOM (Altevogt et al., 2008) (training, improving communication in preparedness and response, creating and maintaining preparedness and response systems, and developing metrics). These priorities were addressed in 48 percent of the statutes and policies reviewed.

Given the significant limitations of the research to date, the literature is unable to provide conclusive or definitive recommendations regarding ways to improve the public health system’s emergency preparedness, response, or recovery. In the absence of ample practice or policy recommendations regarding drivers or predictors of successful emergency preparedness, response, or recovery, we highlight some preliminary consensus achieved across studies (when available) and offer recommendations for areas of future research to improve the public health preparedness evidence base.

Noteworthy Findings and Limitations

A summary of the results and implications of individual studies was recorded for each citation reviewed, using free-text entry. This text was cut and sorted to identify common topics or areas that emerged in the literature. Across the 169 reviewed citations, ten research areas emerged.
While many of these research areas match closely with the 18 elements listed in Table C.1, some do not. It should also be noted that these research areas are by no means mutually exclusive, and the conclusions—and, more often, limitations—of research in one area frequently apply to another. Summaries of results in these research areas are presented in the following sections (along with highlights for a systems-focused research agenda), ordered roughly by the prevalence of the research area in the peer-reviewed literature.

**Research Area 1: Interagency Communication and Coordination**

Interagency communication and coordination are critical to successfully executing several emergency capabilities, including countermeasure distribution, isolation and quarantine, risk communication, and surveillance.

**Several articles suggested that more needs to be done to strengthen interagency communication and coordination.** This includes communication and coordination across multiple components of the public health system, both within levels of public health (e.g., state and local health departments; Taylor et al., 2005) and between public health and other stakeholder groups (e.g., with emergency services; Maguire et al., 2007; Markenson, Reilly, and DiMaggio, 2005); the media (including meteorologists) and the press (Barnes et al., 2008; Cretikos et al., 2007; Lowrey et al., 2007); private-sector/retail organizations (Harris and Clements, 2007; Lien et al., 2006), military and civilian leadership, including first responders (Braun et al., 2004; DiGiovanni et al., 2005); community-based organizations (CBOs) and NGOs (Baezconde-Garbanati et al., 2005; Braun et al., 2006); health care practitioners (including mental health practitioners); and state health associations (Beitsch et al., 2006; Clements-Nolle et al., 2005; Hogg et al., 2006).

**There is limited evidence concerning the potential facilitators of successful communication and coordination.** Limited consensus across the results of several descriptive or small-scale studies offered preliminary suggestions about potential facilitators of successful interagency communication and coordination. For example, the results of evaluations of smallpox vaccination clinics in New Jersey (Taylor et al., 2005) suggested that significant coordination between local health agencies, health care providers, law enforcement, and the state hospital association was key in achieving success. Partners were surveyed, and respondents indicated that training offered before implementation, support from hospital management and administration, and consistent, reliable communication facilitated the effort. Areas in need of improvement included information about vaccine safety and benefits, more clearly defined roles and responsibilities for team members and system components, and technological issues (e.g., slow Internet connection).

Regionalization of clinics was also noted in the New Jersey study as a successful strategy for improved resource sharing and coordination. Regionalization has been highlighted as a successful way to support intra- and interagency communication and coordination in other studies as well (e.g., Lurie et al., 2004; Maldin et al., 2007; Wetta-Hall et al., 2007). Case studies in California (Lurie et al., 2004) have revealed that, in the absence of regionalization, local health departments often duplicate efforts (e.g., training development), leading to an inefficient use of limited resources—an inefficiency that could be avoided through regionalization and increased interagency communication and coordination. Lerner et al. (2007) identified seven features of communities with strong interagency communication and coordination between public health and emergency services (e.g., regularly scheduled face-to-face meetings, strong leadership, resource sharing) based on case studies of seven “model communities.”
Limitations of the literature on interagency communication and coordination point to ways in which the research may be improved. For example, previous work has often been limited by a reliance on respondents’ self-reports of linkages (e.g., Braun et al., 2006), although research using social network analyses holds promise for new methods to assess interagency communication and coordination (Harris and Clements, 2007). While some factors associated with success have been identified, to date, the field lacks both a well-tested set of best practices for establishing linkages between emergency preparedness stakeholders and a set of evidence-based measures to assess whether critical collaboration across the system is occurring (Braun et al., 2006). There appears to be a strong need to generate empirical evidence that identifies, strengthens, and predicts the organizational factors, practices, and policies that support interagency communication and collaboration, as well as continued investigation on improved approaches for how to measure success.

Research Area 2: Countermeasures and Mass Health Care
Research on countermeasure distribution and the provision of mass health care includes investigations that are specific (e.g., distributing prophylaxis to individuals with superficial skin exposure to infectious agents [Subbarao et al., 2007], preventing and effectively mitigating countermeasure-related adverse events [Hupert et al., 2007]) and general (e.g., how to establish sufficient and equitable pharmaceutical preparedness; Hsu et al., 2007). Existing studies suggest some preliminary findings.

Research highlights the importance of knowledge and suggests that more needs to be done to ensure that the public, first responders, and hospital staff have adequate knowledge of countermeasures and mass health care. For example, one study examined knowledge about potassium iodide among residents and first responders living and working in an area near a nuclear power plant. Few reported being adequately informed about potassium iodide prophylaxis in the event of exposure to radiation (Blando, Robertson, and Bresnitz, 2008). In a case study of lessons learned from an alternate-site hospital surge capacity facility in the aftermath of Hurricane Katrina (Eastman et al., 2007), the authors note that it took nearly one week to procure necessary equipment (e.g., bandaging supplies, prescription medications, fax machines)—equipment that is now known to be needed and ready for deployment to prevent a similar delay in future disasters. Regarding receipt of supplies from the Strategic National Stockpile, 22 acute care hospitals were surveyed to examine levels of pharmaceutical response preparedness. Most hospital staff expected that requests for supplies would be fulfilled within 48 hours, but a more likely scenario is that the hospital would have to independently meet countermeasure distribution needs for up to 72 hours (Hsu et al., 2006b). Taken together, these results suggest that both public and professional audiences may not be adequately informed about countermeasure distribution and mass health care procedures and/or that these audiences may need additional information to ensure adequate public expectations of the system (and may need to be kept updated as the system improves). Thus, these studies indicate that more research is needed to test methods of dissemination for educating and informing the public and practitioners about issues related to countermeasure distribution and mass health care.

Facilitators of countermeasure distribution include well-trained staff and the use of “express lanes”; barriers include low English proficiency among countermeasure recipients. In a complex and well-executed aerosolized anthrax exposure exercise (Agocs et al., 2007), the Philadelphia Department of Public Health found that a relatively small number of quickly
trained staff could successfully execute ciprofloxacin distribution using a head-of-household distribution model. The study identified factors that both improved and impaired the speed at which countermeasures were distributed. Heads of households who were eligible to receive medications through express lines (i.e., lines for heads of households who reported no contraindications on a brief intake questionnaire) were found to pass through the distribution process significantly faster than those who were screened. The authors concluded that the inclusion of express lines improves the speed of distribution without sacrificing accuracy or consumer safety. When exercise participants were scripted to have difficulty understanding English or to act anxious or distressed, transit times increased significantly. That study—the first of its kind when published in 2006—is a good example of research that aimed to specifically test the drivers of successful execution of countermeasure distribution and may guide future research on similar topics.

**Social distancing may help reduce transmission rates for influenza almost as effectively as countermeasure distribution.** Finally, simulation studies and mathematical models have also been used to identify rate-limiting or critical steps in countermeasure distribution and mass health care. In a study that modeled influenza transmission (J. T. Wu et al., 2006), voluntary household quarantine was found to significantly reduce transmission rates, with an additional marginal benefit detected when voluntary household quarantine was combined with voluntary individual isolation. These social-distancing strategies were estimated to be about as effective as countermeasure (antiviral) distribution, leading the authors to suggest that the strategy chosen by an affected area could be guided by the relative feasibility of social distancing or countermeasure distribution.

**Limitations of the literature include a lack of real-time data collection and a lack of studies in key areas, including vaccine shortages, equipment maximization, and use of information technology.** There are several limitations to the research that has been conducted on countermeasure distribution and mass health care. For example, during actual emergency events, real-time data have not been collected to adequately inform simulation and model specifications—a current limitation in refining and improving the utility of simulation and modeling studies (Baccam and Boechler, 2007; Bell and Dallas, 2007). Additionally, researchers in the field have stated a need for continued research in several areas, including addressing naturally occurring influenza epidemic shortages (Shimabukuro et al., 2007), maximizing the performance of specific equipment (e.g., ventilators; Paladino et al., 2008), improving the efficiency of point-of-dispensing stations (Agocs et al., 2007), using information technology to provide decision support to health care providers (Bravata et al., 2004), and investigating countermeasure procurement and distribution by institutions that care for special needs populations (e.g., long-term care facilities; Roddy, Tracy, and Ehresmann, 2006).

Overall, the literature to date does not provide a strong set of empirically supported recommendations for how to leverage multiple components of the public health system to successfully execute countermeasure distribution or mass health care; thus, future research aimed at testing different approaches under varying circumstances at several levels of investigation (e.g., supply chain, distribution, and provision of care to large numbers of people) will help strengthen the public health system’s evidence base on countermeasure distribution and mass health care.
Research Area 3: Training

Established in 1999, the existing PERRCs have devoted a substantial portion of their work to training. Given this investment, it is not surprising that approximately 25 percent of the literature reviewed addressed training in some regard. Studies varied from those assessing worker competence and evaluating the effect of training, to reporting on innovative training methods that show promise.

The research points to the value of active learning. The research suggests that active learning, in which training is accompanied by or culminates in an exercise or other experiential activity (Livet et al., 2005; Macario et al., 2007; Pryor et al., 2006; Sarpy et al., 2005; Silenas et al., 2008), has a positive effect on trainees’ self-reported knowledge and capabilities. For example, the University of South Carolina Center for Public Health Preparedness, in partnership with the South Carolina Department of Health and Environmental Control, developed the Academy for Public Health Emergency Preparedness to facilitate collaboration between public health professionals and community first responders and to increase preparedness competencies (Livet et al., 2005). Evaluation results suggested that engaging participants in developing and implementing a tabletop exercise strengthened learning and enhanced communication, collaboration, and coordination among disciplines. Sarpy et al. (2005) also noted that tabletop exercises are a valuable method of competency-based training and suggested that participants be surveyed three to six months after the exercise to measure the application of knowledge gleaned to changes in behavior in work activities.

Most studies have focused only on short-term self-reported gains in knowledge, and very few have focused on training outcomes. Although numerous studies have demonstrated a positive effect of training (Ablah et al., 2005, 2007; Mack et al., 2006; Reischl and Buss, 2005; Wang et al., 2008), few have gone beyond examining short-term self-reported knowledge gains (Fowkes et al., 2007; Gebbie et al., 2006; Kerby et al., 2005a, 2005b; Mack et al., 2006; Qureshi et al., 2004; Williams, 2008), and few examined the relationship of training to outcomes. For example, some studies focused on assessing worker competence through the use of workforce surveys, but as pointed out by Kerby and colleagues (Kerby et al., 2005a, 2005b), workforce surveys have two limitations. First, surveys tend to be phrased in terms of generic goals rather than specific actions in a local plan. Generic goals are subject to interpretation differences and, therefore, are not a good assessment of worker competence. Second, workforce surveys rely on self-assessment—specifically, asking public health workers to share their perceptions of what they know and what they can do. Research has yet to show that self-assessment is a good predictor of objective knowledge (Kerby et al., 2005b), and evidence suggests that workers are poor judges of what they know. For example, Kerby et al. found that self-assessment correlates poorly with objective knowledge, and workers are only weakly able to distinguish what they know from what they do not know (Kerby et al., 2005a). Kerby and colleagues suggest that a better approach for assessing worker competence might be to use generic goals to develop the local response plan, assess knowledge of the plan, and then measure performance in drills and exercises (Kerby et al., 2005b).

Some innovative training models are available. Several citations described innovative training models, including Internet-based training (Macario et al., 2007; Shield et al., 2005), distance learning combined with local exercises (Macario et al., 2007), and train-the-trainer approaches (Becker, 2007; Orfaly et al., 2005). Internet-based training has become popular because it allows for broad distribution of training materials, minimizes time away from work, and offers convenience and cost-effectiveness (Horney et al., 2005; Macario et al., 2007). How-
ever, more research is needed on ideal audience size and composition, as well as methods to measure the effect of the training (Shield et al., 2005). Overall, these relatively new training models are in need of continued research to assess effectiveness.

**Research Area 4: Health Care Providers and the Public Health Workforce**

Several authors examined the role of health care providers (e.g., physicians, nurses, dentists) in public health emergency preparedness. These professionals will be on the “front lines” in the event of a disaster and are a critical component of the public health system, providing medical care and counseling (Alexander, Larkin, and Wynia, 2006; Beaumont et al., 2007; Colvard et al., 2007; Cowan et al., 2005; Hsu et al., 2006a; O’Boyle, Robertson, and Secor-Turner, 2006; Tsao et al., 2006). Administrative health care workers can also expect to play a role in responding to wide-scale emergencies, including performing triage and patient logistics, and communicating with other agencies and the media (Pryor et al., 2006).

Although health care providers believe that preparedness is important, they tend to feel inadequately prepared. The findings of the survey studies suggest that health care providers perceive public health preparedness as important and acknowledge their responsibility in emergency response, but they do not feel adequately prepared to execute their duties when needed (Alexander, Larkin, and Wynia, 2006; Beaumont et al., 2007; Colvard et al., 2007; Cowan et al., 2005; Hawley et al., 2007b; Hsu et al., 2006a; O’Boyle, Robertson, and Secor-Turner, 2006; Tsao et al., 2006). For example, physicians report that they lack confidence in their or their organization’s ability to accommodate a pandemic influenza surge (Beaumont et al., 2007), respond to a bioterrorism attack (Alexander, Larkin, and Wynia, 2006), recognize post-traumatic stress disorder (PTSD) (Colvard et al., 2007), vaccinate against smallpox (Cowan et al., 2005), or treat CBRNE cases (Hsu et al., 2006a). Nurses fear that safety and security issues during an emergency will hamper their ability to address patient needs (O’Boyle, Robertson, and Secor-Turner, 2006).

Factors that appear to promote a competent and capable workforce include the physical condition of workers and their concerns about the safety of their own families during an emergency. The emergency preparedness literature provides some preliminary insight into how to ensure a competent and capable workforce. For instance, in one study (Abatemarco et al., 2007), researchers found health care providers to be unfit to perform respirator assistance because of limitations related to their own physical fitness. Another research team (Blessman et al., 2007) found that public health workers were so distracted by concerns for their own family’s safety during a crisis that they could not adequately respond to an emergency. Nurses have emphasized the need for a strong infrastructure to provide workforce safety and security, as well as adequate information and supplies (Alexander, Larkin, and Wynia, 2006; Blessman et al., 2007).

Research is needed on ways to improve the health, fitness, and preparedness of the workforce. The themes just described underscore the importance of strengthening the public health organizational capacity to support workers in performing their duties, and they suggest that research should identify ways to foster personal health, fitness, and preparedness in the workforce at both the individual and organizational levels. More research is also needed on how to improve the preparedness of health care providers at early stages in their training (e.g., medical students exhibit significant knowledge deficits regarding pandemic influenza; Herman et al., 2007). Furthermore, in keeping with other calls for increased research on interagency communication and coordination, research has suggested a need to investigate ways
to better integrate health care providers into public health preparedness efforts (Cowan et al., 2005; Shaw et al., 2006). This research should include the valuable perspectives of the workers themselves and could make use of exercises and drills to improve capabilities (e.g., Ablah et al., 2007; Pryor et al., 2006).

**Limitations of workforce studies include small sample sizes and an emphasis on self-reporting.** There are additional limitations to note regarding the health care provider workforce research to date. Most of the studies we examined consisted of a small sample size and took place in isolated settings (Abatemarco et al., 2007; Ablah et al., 2007; Blessman et al., 2007; Brodie et al., 2006; O’Boyle, Robertson, and Secor-Turner, 2006; Pryor et al., 2006; Tsao et al., 2006), thus tempering the generalizability of the findings. Furthermore, the articles relied heavily on workers’ self-reported capabilities rather than direct observation of competencies through real events, simulations, or exercises (Ablah et al., 2007; Alexander, Larkin, and Wynia, 2006; Beaumont et al., 2007; Blessman et al., 2007; Colvard et al., 2007; Pryor et al., 2006). Some studies documented changes in provider preparedness knowledge through pre- and post-testing; however, these investigations did not examine the application of this knowledge during an exercise or real event (Abatemarco et al., 2007; Tsao et al., 2006). To provide relevant, actionable strategies for preparing the workforce for public health emergencies, future research should be designed to reliably and objectively test competency rather than subjectively rate capacity. As with the other areas of public health emergency preparedness research, studies on health care personnel are too few and focused to provide a strong evidence base. Nonetheless, the articles we reviewed represent a starting point for understanding the responsibilities of the public health workforce in emergency response and provide context for future investigation.

**Research Area 5: The Community and Special Needs Populations**

Much research has been conducted on methods of informing the public about a public health emergency, but less is known about how effective these methods are at reaching intended audiences and affecting behavior (Chesser et al., 2006). This is especially true of special needs populations. As stated in PAHPA, special needs populations are defined to include children, pregnant women, the elderly, and any other individual who would have special needs related to preparing for, responding to, or recovering from a public health emergency.

**Current preparedness information sometimes misses special needs populations.** Several of the articles reviewed focused on identifying trusted sources of information in the community and among special needs populations (Chesser et al., 2006; Eisenman et al., 2006; Eisenman et al., 2004; Leung et al., 2008; Rosenkoetter et al., 2007). Chesser et al. (2006) surveyed both rural and urban areas and found that preparedness information offered by existing sources does not always reach the intended audience. For example, in rural areas, where resources are more dispersed, populations are more likely to access or interact with close resources and may not have the advantage of accessing multiple resources conveniently clustered in one central location (e.g., local health department, locations within city infrastructure). Studies often used interviews and surveys to identify unique challenges facing special needs populations, such as homeless people, rural populations, and minorities, and to outline strategies for emergency planning (Chesser et al., 2006; Eisenman et al., 2004; Leung et al., 2008). For example, through interviews with homeless service providers and public health officials, Leung et al. (2008) identified challenges for homeless populations related to communication, infection control, isolation and quarantine, and resource allocation and recommended
strategies to overcome these challenges. Such strategies (e.g., developing efficient and effective communication systems between public health officials and homeless service providers) may involve multiple components of the public health system.

**Participatory involvement in research is key.** The public represents a key component of the public health system. Participatory involvement in research by the public, including special needs populations, has been noted as one strategy to enhance the study of preparedness, response, and recovery (Bailey et al., 2006). Strategies identified by the literature to increase public engagement in preparedness activities include establishing trusting relationships between public health agencies and community organizations, particularly those that serve diverse or special needs populations (Eisenman et al., 2004). For example, 27 organizations from 12 states in the National Alliance for Hispanic Health (which comprises more than 50 CBOs/NGOs that serve Hispanic populations in the United States) participated in a survey to describe barriers to integrating the services of CBOs/NGOs into local preparedness efforts (Baezconde-Garbanati et al., 2005). These organizations reported a strong willingness to participate in preparedness activities, but they indicated that a lack of culturally appropriate resources, materials, and funding, as well as training needs, were barriers to fully engaging with local partners in supporting their community’s level of preparedness. The survey also identified the potential benefits of leveraging CBOs/NGOs that serve community subgroups or special needs populations in preparedness efforts. Specifically, these organizations have several assets that would benefit emergency preparedness, response, and recovery, such as the variety of services that CBOs/NGOs commonly offer (e.g., health education, mental health), thus positioning these organizations to seamlessly integrate emergency preparedness into the services they provide; their regular use of communication channels that may fall outside those routinely used to reach the general public (e.g., Spanish-language television and radio, educational materials in multiple languages, expanded social networks); and the cultural proficiency of their staff, including bilingual and bicultural staff, who, in the event of a public health emergency, are uniquely positioned to reach the populations that these organizations serve.

The literature does not clearly identify the predictors of successful communication and engagement with special needs populations. As noted earlier, the literature to date does not offer conclusive evidence on predictors of the successful interagency communication and coordination that is required to achieve linkages between the public health system and the communities and special needs populations that the system serves. Additionally, some have suggested that more research needs to be done on how to tailor individual-level preparedness interventions to specific populations, because different subgroups require different public health messages, programs, and communication channels (Eisenman et al., 2006). Continued research that identifies and strengthens organizational factors, practices, and policies that support strong partnerships between public health and community organizations (e.g., CBOs/NGOs, faith-based and neighborhood associations) would advance what is currently known about the role of communities and special needs populations in emergency preparedness, response, and recovery.

**Research Area 6: Psychological Impact**

Several citations addressed the psychological effects of emergency events, and much of this literature was focused on the recovery phase of preparedness. Citations that addressed the psychological effects of disasters often focused on the aftermath of the terrorist attacks on Septem-
PTSD can be common after a disaster, but it is often untreated. A survey of Pentagon employees, conducted within months of 9/11 (Jordan et al., 2004), found that 40 percent of respondents reported significant psychological symptoms related to PTSD: depression, anxiety (panic attacks and generalized anxiety), or substance abuse. In addition, more than one-fifth reported that their psychological symptoms negatively affected their functioning. Yet, only 31 percent of respondents who reported significant psychological symptoms sought professional help, suggesting that the majority of individuals affected did not receive the psychological care they needed. Psychological symptoms were also prevalent among tsunami survivors, and Becker (2007) found that in the weeks following the tsunami, community members were able to learn basic psychosocial care procedures (e.g., active and empathic listening, relaxation techniques) during a three-day training session, greatly expanding the availability of psychological care for survivors.

Predictors of psychological problems after a disaster include exposure to “high-intensity” events, history of other trauma, and smoking. Other studies have identified correlates or predictors of psychological problems in the aftermath of a disaster. For example, not surprisingly, among preschool children affected by 9/11 (Chemtob, Nomura, and Abramovitz, 2008), those who were exposed to more high-intensity events (e.g., saw dead bodies, saw the towers collapse) were more likely to have symptoms of anxiety or depression and sleep problems than children not exposed to such events. However, the authors also uncovered that children who had been exposed to high-intensity events on 9/11 and who had a history of other trauma (e.g., car accident, death of a close relative) were at significantly elevated risk for emotional and behavioral problems than were children with no trauma history or children who had experienced high-intensity events or other trauma alone. Mills, Edmondson, and Park (2007) found that in the weeks following Hurricane Katrina, more than half of study participants interviewed met criteria for acute stress disorder and that this diagnosis was more than twice as likely among women, individuals who had sustained an injury, and people with a history of psychological problems. Symptoms were more severe among African-Americans than whites. Finally, two articles found that substance abuse can negatively affect psychological risk and recovery. Individuals affected by disaster continue to use substances at higher rates post-event, even after symptoms of PTSD and depression dissipate, underscoring the need for public health to address psychological consequences during the recovery phase (Vlahov et al., 2004). Substance use, specifically smoking, was also shown to increase the likelihood that an individual will develop postdisaster emotional problems, including anxiety, hostility, or PTSD (Van der Velden et al., 2007).

The study of preschool students affected by 9/11 was one of the few hypothesis-driven investigations \( (n = 5) \) that addressed the psychological consequences of disasters; additional studies such as these, which specifically investigate risk factors for poor psychological outcomes, would strengthen the evidence base regarding what characteristics put individuals and communities at risk for poor psychological outcomes postdisaster.

Much about psychological reactions to public emergencies remains unknown. The research to date suggests that there is still much to be learned regarding the range of psychological reactions to public health emergencies, the trajectories across which these reactions occur, and what interventions can best address the psychological consequences of disasters (Becker, 2007; Mills, Edmondson, and Park, 2007; Roorda, van Stiphout, and Huijsman-Rubingh,
2004; van Griensven et al., 2006). Additionally, studies are needed to better document the short-term (versus long-term) psychological consequences of emergency events (Brackbill et al., 2006), and there is a need to improve engagement with mental health services for those who need treatment (den Ouden et al., 2007; Jordan et al., 2004; Vlahov et al., 2004) as well as to enhance the capability of first and secondary responders to recognize and address psychological consequences (Hawley et al., 2007a). Absent sufficient research that follows representative samples through longitudinal designs or randomized trials to investigate long-term outcomes or the effect of psychological interventions, the literature to date does not offer strong evidence regarding how to best prepare for and respond to the psychological consequences of disasters or mitigate their psychological effects. Future research that examines the long-term psychological consequences of disasters, as well as whether and how mental health interventions improve psychological outcomes, will strengthen and advance this area of research, as will continued research that identifies predictors of community- and individual-level postdisaster psychological outcomes (Ranasinghe and Levy, 2007).

Research Area 7: Surveillance

Several areas for continued research on surveillance were identified in the peer-reviewed literature, ranging from general (e.g., how best to support active surveillance for emergency events and the effect of surveillance on outcomes; Daniel et al., 2005; Drociuk, Gibson, and Hodge, 2004; Gilmore, Schwan, and McLaughlin, 2007; Kile et al., 2005) to more specific, such as improving syndromic surveillance and identification of acute illness clusters (e.g., Barthell et al., 2004) and developing better early-warning systems for bioterrorism incidents and natural disasters (Foldy et al., 2004; Olowokure et al., 2005).

Several innovative approaches to surveillance have been developed. Some innovative approaches were examined in the peer-reviewed literature, including electronic data mining (Moore et al., 2008), electronic health records and other Internet-based surveillance tools (den Ouden et al., 2007; Foldy et al., 2004), and use of geographic information system (GIS) data in the context of surveillance. GIS data have particular promise in communicating and coordinating surveillance data across representatives in the public health system, because geographic data displays are fairly interoperable and interpretable across stakeholder groups (Hsu et al., 2006a; Jackson et al., 2006; Waring et al., 2005).

New approaches are being developed for early detection of emergencies. One noteworthy area of surveillance research includes studies that focus on early detection of emergency events (e.g., disease outbreaks or bioterrorist events). For example, the Frontlines of Medicine Project (Barthell et al., 2004) aims to standardize emergency reporting across several stakeholders (e.g., emergency medicine, public health, first responders) for improved speed and accuracy of surveillance. Although the Frontlines Work Group has made progress in defining standardized data elements, to date, the system has not been empirically tested. Syndromic surveillance was addressed in several studies (Daniel et al., 2005; Foldy et al., 2004; Moore et al., 2008; T. S. Wu et al., 2008). For example, the Milwaukee Health Department reported on a month-long pilot testing of a dashboard surveillance model (Foldy et al., 2004) that used a secure Internet platform to integrate syndromic surveillance data from several sources (emergency departments, clinical lab reports, health care provider offices, emergency services, poison control, nursing hotline calls, and over-the-counter medication sales). The costs of establishing and running the dashboard model were not excessively high, and users of the system reported positive experiences. However, the results of the study were limited by the fact that no outbreaks
of any kind occurred during the pilot period, making it unclear whether the system would be effective during a small- or large-scale emergency. Finally, a statistical decisionmaking tool was developed by Moore et al. (2008) to improve the probability and timeliness of detecting early human influenza cases or clusters. The authors identified 13 strategies for improving influenza surveillance related to coverage (e.g., developing community-based alert and response systems), quality (e.g., improving epidemiologic capacity), and timeliness (e.g., use of data-mining methods for early detection). Based on a systems-level process map that lays out the series of events between the time when an individual becomes symptomatic and when a novel influenza strain is confirmed, the tool is used to estimate time to detection based on baseline probability values for each of the steps in the process map (e.g., case is detected by community monitoring system, doctor is contacted by active surveillance, hospital authorities conduct epidemiological investigation). The tool aids decisionmaking by providing an estimated relative effect of potential interventions and surveillance strategies, allowing public health staff to choose strategies that are appropriate for their population and resources.

Another promising approach is the establishment of a postdisaster registry. The creation or leveraging of registries for individuals affected by disasters during emergency preparedness or recovery can provide extremely valuable data on vulnerabilities and late- and long-term consequences (Brackbill et al., 2006; Brennan and Rimba, 2005; Chemtob et al., 2007; Ford et al., 2006), leading some to recommend that this sort of systematic surveillance be routine after any public health emergency (Brennan and Rimba, 2005) as part of government policy (Chemtob et al., 2007). Brackbill et al. (2006) describe preliminary findings from the World Trade Center Health Registry, which is being used to track physical and psychological health consequences of the terrorist attacks among more than 70,000 enrollees. Short-term results (two to three years post–9/11) found that individuals who were located in severely damaged or collapsed buildings on 9/11 continued to report significant physical (e.g., respiratory problems) and psychological (e.g., emotional distress) health problems. The authors describe the strengths of the registry approach, since this surveillance mechanism will enable long-term tracking of health outcomes for survivors and can be used to inform future planning around disaster recovery. Other studies (Ford et al., 2006) have used existing surveillance data (e.g., from the Behavioral Risk Factors Surveillance Survey) to investigate vulnerabilities that may affect a community’s preparedness or response capabilities. The 2004 survey results estimated that more than one-quarter of individuals in the New Orleans area were living with a chronic disease (e.g., diabetes, cardiovascular disease, asthma), providing baseline data that help explain the challenges related to chronic disease management that were encountered during recovery.

The impact of these innovative approaches is unclear. Surveillance research is making use of innovative approaches and is rapidly evolving; however, to date, there are limited data on whether and how these innovative approaches affect preparedness, response, and/or recovery. More research that examines the utility of new surveillance systems or that leverages existing systems (either through secondary data analysis or via the addition of items that are relevant to emergency planning) and that extends current work by tracking the influence of registries and population surveillance on emergency preparedness, response, and recovery would help strengthen the evidence base related to the role of population surveillance in a systems approach to emergency preparedness.
Research Area 8: Measurement

The quality of public health emergency preparedness research is strongly tied to the quality of the measures used to assess preparedness, response, and recovery. Individuals and agencies cannot be held accountable or track improvement without performance measures (Dausey, Lurie, and Diamond, 2005). However, as a somewhat new area of inquiry, the public health emergency preparedness field is relatively bereft of evidence-based measures, and it lacks widespread standards and models for evaluation (Bissell et al., 2004; Braun et al., 2006; Dausey, Buehler, and Lurie, 2007; Dausey, Lurie, and Diamond, 2005). Furthermore, precise data collection is challenging in emergency events because the priority is to save lives rather than conduct research (Bissell et al., 2004).

There is a need for measures that rely on observed capability rather than self-reported data. Although the area of measurement research in emergency preparedness is in its nascent stages, initial research provides some guidance about suggested directions for the field. The emergency capabilities required may differ with the type of disaster; therefore, some researchers (e.g., Lovelace et al., 2007) have suggested that measurement instruments should be disaster-specific (although this approach does not represent a point of consensus across studies). Furthermore, there is a need to develop measures that rely less on self-reported capacity or capability and more on observed capability, because self-assessment is not a reliable predictor of actual performance (Kerby et al., 2005a; Kerby et al., 2005b; Lovelace et al., 2007). For example, in a study of public health workers in Oklahoma, the correlation between self-assessed knowledge of various preparedness factors (e.g., “I know the chain of command in an emergency response”) and actual performance on objective knowledge items (e.g., “Who activates the EOC?”) was quite low, suggesting that workers were not particularly good judges of their own knowledge or response capabilities. While tabletop exercises go beyond self-reported measures and offer greater insight into capabilities, they must be supplemented with follow-up observations to determine whether the exercise has a measurable effect on preparedness, response, or recovery (Dausey, Buehler, and Lurie, 2007).

Rapid assessment tools are needed, as are measures that capture predictors of health outcomes in disasters. There is also a need for some specific types of measures; for example, increasing the availability of postdisaster rapid assessment tools would enhance the ability to collect valuable information during response and recovery (Jordan et al., 2004). Health care workers would benefit from culturally appropriate measures of psychological consequences of disasters (Kile et al., 2005; van Griensven et al., 2006). Evaluators called for better measurement of predictors of health outcomes in disasters (Bissell et al., 2004) and improved surveillance to observe changes in morbidity and mortality related to emergencies (Kile et al., 2005). There is also a need for measures of coordination and collaboration at the systems level, both within public health (e.g., measures of coordination and collaboration between the state and local levels) and between public health and other key stakeholders (e.g., emergency services, law enforcement, health care providers, community organizations, the general public) (Braun et al., 2006; Dausey, Lurie, and Diamond, 2005). The research suggests that social network analysis is a promising strategy for measuring coordination and collaboration (Harris and Clements, 2007), but continued research is needed to determine the reliability and utility of this method.

Evidence-based, outcome-focused measures are needed. Overall, evidence-based PHEP measures are critical in focusing scarce resources, identifying and closing performance gaps, and ensuring accountability for the considerable expenditure of public resources. Continued
research that develops evidence-based measures of coordination and collaboration and that moves beyond self-reported measures of capability will improve the ability to measure critical outcomes, thereby strengthening efforts to improve the public health system’s preparedness, response, and recovery.

Research Area 9: Risk Communication
A large body of research (built on the larger psychological literature on risk communication and decisionmaking) has addressed risk communication in the context of public health emergencies (e.g., Glik, 2007).

Honesty and consistency are among the most important components needed to build trust. Several studies have focused on fostering trust related to public health emergency risk communication and on identifying subgroups in need of targeted communication campaigns. For example, Meredith et al. (2007) used focus groups to identify components that promote trust in risk communication during a bioterrorism event. The authors identified five components of trust (honesty, consistency, fiduciary responsibility, competency, and faith) and found that the importance of these components differed depending on the stage of the emergency. Honesty and consistency were the most important components overall; however, perceived honesty of the risk communication was particularly important during the early stages of a bioterrorist attack, whereas fiduciary responsibility and consistency were more important during response.

Individual preparedness might be increased through tailored risk communication. Eisenman et al. (2006) used survey data to identify sociodemographic characteristics associated with better levels of individual preparedness among people living in Los Angeles County and recommended that results be used to tailor associated interventions, such as risk communication. Their study found that individuals who reported African-American or Latino race/ethnicity, had young children, were born outside the United States, achieved higher levels of education, and perceived a greater likelihood of terrorist attacks were significantly more likely to have emergency supplies. African-American respondents, those with young children, and individuals with disabilities were more likely to have an emergency plan. These findings suggest that risk communication might be tailored to certain subgroups (e.g., individuals without children, individuals with lower levels of education) to increase individual preparedness among those least likely to be prepared.

Current literature provides insufficient evidence about the potential effectiveness of risk communication strategies. Several limitations must be noted in the area of risk communication research. Although some messaging sources and strategies show potential for success (e.g., use of the Internet to disseminate risk information from health care providers; Kittler et al., 2004), there is insufficient evidence to determine the degree to which pre-scripted messages are effective during emergency response (Kile et al., 2005), how best to craft messages to increase trust and facilitate decisionmaking (Meredith et al., 2007), and how to best tailor risk communication to diverse and special needs populations (Eisenman et al., 2006; McGough et al., 2005). For example, Meredith et al. (2007) offer suggestions on how to promote trust in risk communication; however, their study results do not offer the level of evidence that could be derived from an experimental study that examined trust in or behavioral response to risk communications that vary with respect to the five components. Eisenman et al.’s (2006) results are limited in their generalizability because their sample was made up entirely of individuals living in or around Los Angeles. Although their results have implications for how risk com-
munication might be tailored to improve individual preparedness among some groups, they do not provide any evidence regarding the actual effect of such tailored communications. There is a need for continued research to refine and improve emergency risk communication strategies (McGough et al., 2005), and this research may be most effective when conducted in a participatory manner with those from the public who represent the intended audience (Blanchard et al., 2005). Some tentative recommendations for how to construct and disseminate risk communication messages about a public health emergency can be drawn from the literature. Nevertheless, more large-scale studies that employ experimental or longitudinal designs to measure the effect of risk communication on actual behavior are necessary to strengthen the evidence base in this area of research. Since communication is a key capability in both small- and large-scale public health emergencies, there will be ample opportunities to strengthen the evidence base.

Research Area 10: Legal Climate
Only a small number of citations addressed the legal climate as it relates to preparedness, and this small collection of work does not enable us to draw any conclusions or recommendations at this time. However, the importance of legal issues within the public health system and across several elements of emergency preparedness warrants a brief description of the research to date.

Legal issues are perceived as being critical to preparedness, response, and recovery. The peer-reviewed literature recognized that legal issues are critical to preparedness, response, and recovery, particularly for some emergency capabilities (e.g., isolation and quarantine, evacuation, mandatory vaccination; Taylor et al., 2005; Weiss, McKie, and Goodman, 2007). There is also evidence that the public may be unlikely to fully comply with emergency mandates, highlighting potential legal complications. For example, in a survey of residents from the United States, Hong Kong, Singapore, and Taiwan (Blendon et al., 2006), the majority of respondents supported mandates to wear masks, submit to having one’s temperature taken, and quarantining individuals suspected of having an infectious disease. However, reported support for these measures dropped if arrest was indicated as a consequence of noncompliance, and respondents generally viewed strict compliance monitoring methods (e.g., video monitoring) unfavorably.

Improving awareness of and compliance with the legal climate relevant to public health emergencies is critical. Misinterpretations of public health’s legal authority during real events can significantly and negatively affect response (Drociuk, Gibson, and Hodge, 2004). Given that little research has been done on the topic to date, the legal climate associated with emergency preparedness and the roles and responsibilities of legal entities in the public health system represent areas in need of further research.

There was congruence between the research areas identified in the peer-reviewed literature and the recommendations and mandates in the statutes and policies reviewed. We coded the content of the statutes and policies we reviewed to determine whether these documents identified current gaps in preparedness and examined them against identified areas of research in the peer-reviewed literature. Nine of the reviewed statutes and policies noted gaps in emergency preparedness in research areas identified in the peer-reviewed literature. Table C.2 displays the statutes and policies that noted gaps relevant to the research areas identified earlier. (A complete list of statutes and policies reviewed and complete titles can be found in Table B.1 in Appendix B.)
Table C.2
Statutes and Policies Reviewed That Noted a Gap Relevant to the Research Themes in the Peer-Reviewed Literature

<table>
<thead>
<tr>
<th>Research Area from Literature</th>
<th>Statutes or Policies Noting a Related Gap</th>
</tr>
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<tbody>
<tr>
<td>Interagency communication and coordination</td>
<td>IOM letter report (Altevogt et al., 2008); PAHPA; HSPD-10; Advancing the Nation’s Health (CDC, 2006)</td>
</tr>
<tr>
<td>Countermeasures and mass health care</td>
<td>HSPD-21; PAHPA; Grand Challenges for Disaster Reduction (National Science and Technology Council, Subcommittee on Disaster Reduction, 2005); Advancing the Nation’s Health</td>
</tr>
<tr>
<td>Workforce and performance management</td>
<td>IOM letter report; PAHPA; Grand Challenges for Disaster Reduction; Advancing the Nation’s Health</td>
</tr>
<tr>
<td>Community resilience and public engagement</td>
<td>HSPD-21; National Response Framework (DHHS, 2008); Grand Challenges for Disaster Reduction; Advancing the Nation’s Health</td>
</tr>
<tr>
<td>Surveillance (epidemiology and lab functions)</td>
<td>HSPD-21; PAHPA; Target Capabilities List (DHHS, 2007b); Grand Challenges for Disaster Reduction; Reducing Loss of Life and Property from Disasters (Helz and Gaynor, 2007); Advancing the Nation’s Health</td>
</tr>
<tr>
<td>Measurement</td>
<td>Grand Challenges for Disaster Reduction</td>
</tr>
<tr>
<td>Risk communication</td>
<td>Grand Challenges for Disaster Reduction; Advancing the Nation’s Health</td>
</tr>
<tr>
<td>Legal climate</td>
<td>HSPD-21; PAHPA</td>
</tr>
</tbody>
</table>

Table C.2 suggests that a fair amount of congruence exists between the statutes and policies and the peer-reviewed literature. Specifically, several existing statutes, policies, and other governmental or organizational reports noted a gap in preparedness research in an area addressed by the peer-reviewed literature, suggesting some potential influence of statutes and policies on the direction and content of public health research on emergency preparedness.

**Summary**

Our review of citations reached the following conclusions:

- Across the peer-reviewed citations and the statutes and policies reviewed, calls for continued or new research were identified in ten research areas, each of which would benefit from continued research that addresses current limitations.
- Several of these areas (interagency communication and coordination, training, community and special needs populations, measurement, risk communication) represent an overlap with the research priorities outlined by the IOM report (Altevogt et al., 2008) for the next generation of PERRCs.
- However, other research areas (countermeasures and mass health care, health care providers and public health workforce, surveillance, legal climate) are more distinct from the priorities identified by the IOM and may be best addressed within a broader national agenda.
Intellectual and Financial Sources of Current Systems Research

In this final section of the review, we identify the financial and intellectual sources for the literature reviewed and report funders of the sources in which the peer-reviewed literature was published.

Multiple funding sources were included in the review. We examined the funding sources for the citations we reviewed, when available (not all citations reported a funding source). More than 100 funders supported the reviewed research. HHS was the largest funder of PHEP research; within HHS, the CDC funded more of the reviewed literature than any other single institution. Beyond CDC, the funding was scattered across multiple sources. After U.S. government agencies, universities were the most prevalent funders of preparedness research, followed by state- or city-level agencies (e.g., Kansas Association of Local Health Departments, Minnesota Department of Health, New York City Department of Health and Mental Hygiene), foundations (e.g., Robert Wood Johnson Foundation, California Endowment), and international governmental agencies (e.g., Norway’s Royal Ministry of Foreign Affairs, China’s Ministry of Health). Additional sources (e.g., Nuclear Threat Initiative, National Alliance for Hispanic Health) fell outside these categories. Table C.3 offers more detail on these funding sources. From our review, we can say that substantial investment in public health emergency preparedness research has been led by funds from DHHS, followed by a variety of funders supporting preparedness research.

The literature spanned more than 80 peer-reviewed journals. To examine the distribution of journals across which the peer-reviewed literature has been published, we tabulated the sources of the 192 citations that were originally considered for review based on our literature search. The three most common sources for the literature we reviewed were Biosecurity and Bioterrorism, Journal of Public Health Management and Practice, and Prehospital Disaster Medicine. The journals in which at least two citations were published are displayed in Figure C.5; the “other” category includes journals represented by only one citation. Sixty-two journals were represented by only one citation. Examples of these journals include BMC Emergency Medicine, Journal of Medical Internet Research, Medical Decision Making, Journal of the American Medical Association, and Journal of Public Health Policy.

Table C.3
Funding Sources for the Literature Reviewed

<table>
<thead>
<tr>
<th>Funder</th>
<th>Number of Studies</th>
</tr>
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<tbody>
<tr>
<td>U.S. Department of Health and Human Services</td>
<td>57</td>
</tr>
<tr>
<td>Centers for Disease Control and Prevention</td>
<td>40</td>
</tr>
<tr>
<td>Other operating divisions of the U.S. Department of Health and Human Services</td>
<td>12^a</td>
</tr>
<tr>
<td>Agency for Healthcare Research and Quality</td>
<td>5</td>
</tr>
<tr>
<td>Universities or other nonprofit research institutions</td>
<td>30</td>
</tr>
<tr>
<td>State- or city-level agencies</td>
<td>24</td>
</tr>
<tr>
<td>Foundations</td>
<td>19</td>
</tr>
<tr>
<td>International governmental agencies</td>
<td>18</td>
</tr>
</tbody>
</table>

^a These 12 citations specified DHHS as the funding source.
Figure C.5
Source Journals for the Peer-Reviewed Literature
Research Areas, Their Limitations, and Additional Fields of Study

PHEP research represents a relatively new area of empirical inquiry, but studies of emergency preparedness, response, and recovery have grown steadily over time. At this point, the PHEP literature is large enough to allow us to characterize some distinct but related areas of research, to identify the limitations of the work that has been done to date, and to derive recommendations for future PHEP research.

The literature is mostly descriptive; it does not provide strong guidance for improving practice. The literature to date has been primarily descriptive; few studies have provided empirical evidence about how specific strategies or practices relate to outcomes. Moreover, very few studies have sought to develop cumulative knowledge, either by developing and testing clear hypotheses based on the existing evidence base or by looking (in the manner of systematic research syntheses) at associations observed across multiple studies. Given these limitations, the existing literature cannot support conclusive or definitive recommendations about how to improve the public health system’s emergency preparedness, response, or recovery.

With these limitations in mind, we characterized the results of ten areas of research. The focus of several such areas is congruent with the PHEP research priorities identified by the IOM (Altevogt et al., 2008) (interagency communication and coordination, training, community and special needs populations, measurement, and risk communication), whereas the focus of other areas (countermeasures and mass health care, health care providers and the public health workforce, surveillance, and legal climate) is distinct from the priorities identified by the IOM and may be best addressed within a broader national research agenda.

There is variability across the 169 peer-reviewed citations included in this review in the degree to which they address different stages of emergencies and elements of emergency preparedness. For example, emergency preparedness has been studied more often than emergency response or recovery, whereas “operations-ready workers and volunteers” has been the element of preparedness most often studied, reflecting the heavy investment in PHEP training. Further, the peer-reviewed literature’s content parallels, to some degree, the issues in emergency preparedness, response, and recovery addressed by the 25 statutes and policies we included. The emergency preparedness research that has been conducted between 2003 and 2008 has appeared in a wide variety of peer-reviewed publications and has been funded by a number of governmental, university, foundation, and international sources, most often by HHS.

More multidisciplinary research using a wider variety of methods may be required to strengthen the evidence base. Given that PHEP requires a variety of stakeholders and professional disciplines, we might expect similar variety and transdisciplinarity in research on PHEP. To date, there is no strong evidence that this parallel has been achieved. The citations we reviewed addressed multiple stages of emergencies, types of disasters, and areas of research; however, these studies relied heavily on a narrow set of approaches to PHEP research (i.e., cross-sectional surveys or qualitative investigations), and most aimed to be descriptive, rather than to test or evaluate specific research questions or programs/policies.

PHEP research will need to diversify its approaches and objectives if the evidence base is to grow and strengthen in a way that reflects the complex and transdisciplinary nature of this field of study, particularly to achieve a systems-focused research portfolio. Specifically, there is a need for PHEP research to reflect a greater variety of types of studies (e.g., survey studies; qualitative studies; longitudinal studies; observational studies based on real events, drills, or exercises; experimental studies) and to aim at testing hypotheses that draw on previous
research. Such an approach would be more likely to support purposeful and efficient development of the PHEP evidence base and lead to more value for the research dollar.

This is not to say that any specific methodological or analytic approach or research objective should be discouraged. On the contrary, all types of studies, ranging from small-scale qualitative investigations to large-scale longitudinal or experimental designs, will be needed to foster the continued development of the PHEP evidence base. However, funders will need to be strategic in supporting portfolios of projects that, taken together, address key knowledge needs in an efficient manner.

**Incorporation of other disciplines into PHEP research can enhance a systems approach.** Whereas this review attempts to be exhaustive within its search parameters, other disciplines that were beyond the scope of our examination may further inform a systems approach to PHEP research. To further help this review inform the development of a systems-focused PHEP research agenda, we introduce and briefly review some key findings from these “peripheral” areas of research.

The following section briefly highlights several fields that fell beyond the scope of the current review, including the science of team science, decision sciences, systems engineering, information science, the broader literature on syndromic surveillance, and the study of learning. We also explain their relevance to a systems approach to PHEP and cite sample studies for each.

**The Science of Team Science**

The results of our literature review suggested that interagency communication and coordination are necessary to successfully execute many of the capabilities involved in emergency preparedness, response, and recovery. Further, a systems approach to research on PHEP necessitates a high level of communication and coordination across the professional disciplines and approaches that are relevant to PHEP. The science of team science (STS) is a relatively new area of inquiry that may usefully inform the development and execution of a systems-level PHEP research agenda.

STS is the study of the antecedent contexts, collaborative processes, and outcomes associated with team science approaches to research, including the nature of scientific discoveries made through team science and the effect of a team approach on the translation of research into practice and policy (Stokols et al., 2008). Overall, STS aims to elucidate best practices for convening and carrying out the sort of complex, cross-disciplinary collaborations required to successfully study multifaceted problems such as PHEP. As applied to PHEP, an STS approach may improve the outcomes of systems-level research as well as the success of collaborations aimed at strengthening the PHEP evidence base (Stokols et al., 2008). Two relevant examples of team science applied to PHEP are the areas of weather forecasting and pandemic influenza preparedness (Leischow et al., 2008). Both of these areas of inquiry rely on four common elements: (1) rapid accrual of large amounts of data from multiple sources, (2) communication and coordination among multiple agents, (3) a transdisciplinary approach to data analysis and interpretation, and (4) use of modeling to understand the dynamics of complex systems (Leischow et al., 2008). STS can be leveraged within a systems approach to PHEP research to both improve the study of well-established areas of inquiry (such as weather forecasting and pandemic preparedness) and achieve progress in newer areas of inquiry that make use of innovative collaborations to strengthen the PHEP evidence base (Syme, 2008), including the
advances in information systems, information technology, and cyberinfrastructure that will be required to support these collaborations (Hesse, 2008).

**Decision Sciences**

Decision sciences include *behavioral decision research*, which draws on psychology, economics, and management science to study and improve decisionmaking under conditions of risk and uncertainty, and *risk analysis*, which draws on social, natural, and mathematical sciences to predict and improve the performance of complex systems. Decision sciences have been used to inform many aspects of PHEP, including optimization, risk prioritization, and risk communication, but they may be leveraged further in these and other areas, such as measuring decision quality and crisis decisionmaking by groups.

One specific application of decision sciences is in risk communication, which integrates behavioral decision research and risk analysis. In PHEP applications, risk communication research (1) identifies the facts that are critical to effective decisionmaking, (2) designs and evaluates effective communications, and (3) predicts responses in terms that are relevant to PHEP (e.g., expected compliance rates, needed data collection). Important aspects of risk communication research are that it addresses (1) the uncertainty associated with many emergencies, (2) the establishment of trust in authorities, and (3) the situations in which individuals must be allowed to make their own decisions. Fischhoff et al. (2006) describe its application to preparing for a pandemic. Dombroski, Fischhoff, and Fischbeck (2006) show how it can be incorporated in formal models, predicting the consequences of alternative public health emergency plans, with a case study of evacuation following the explosion of a radioactive dispersion device. Risk communication was identified as one of the focal research areas of the literature review, including the need for a more substantial evidence base.

A type of systems-level application of decision sciences to PHEP is in the study of crisis decisionmaking by groups of individuals. One example is provided by emergency and department operations centers (EOCs and DOCs, respectively), where complex teams coordinate the efforts of ICS sections and their functional roles. Parker et al. (2009) present an approach to measuring crisis decisionmaking, using lessons learned from behavioral decision research to inform an observational assessment of the group's collection and use of information (situational awareness), how actions are decided upon and implemented (action planning), and how the decisionmaking process is managed (process control). Interagency communication and coordination, the first research area highlighted in the literature review, often occurs through just such cross-agency groups as EOCs and DOCs.

**Systems Engineering**

Systems engineering is an approach to engineering in complex environments that attempts to take into consideration the entirety of a problem, often considering the interplay of multiple subsystems and drawing on multiple fields of expertise. With a systems-level PHEP research agenda, systems engineering has the potential to provide insight into understanding the coordination issues inherent in emergency response through the complex public health system environment.

One application of this approach is demonstrated in Wein, Craft, and Kaplan’s (2003) systems-level analysis of emergency responses to an anthrax attack. They use multisystem simulations that integrate models of atmospheric dispersion, dose-response, disease progression, and intervention. The results highlight the relative importance of key parameters, such as the
timning and use of oral antibiotics (including preattack dispensing strategies) while showing that other parameters, such as the use of more rapid and sensitive biosensors, are less critical. A similar analysis regarding smallpox (Kaplan, Craft, and Wein, 2002) found that mass vaccination is generally superior to vaccination strategies that trace contact with known infected individuals across a range of possible scenarios.

Information Science
Research in information science examines how an organization organizes and uses information, including through the use of computer-based information systems. These systems are increasingly relevant to the preparedness efforts of multiple components of the public health system. Zins (2007) engaged 57 leading scholars in a Critical Delphi study to define information science. This study highlights the roles of cognitive, social, and technological mediators in the dissemination of human knowledge from originator to user. It, in turn, points out the potential individual, community, and technology applications to PHEP, including two-way information flow between community and public health agencies (arguably, the basis for risk communication), computerized surveillance and notification systems, the use of GIS data to visualize geographic dispersal, and coordination of command and control.

In an example that cuts across the individual-community-technology distinction, Troy et al. (2007) describe a pilot study examining an information-technology approach to improving community-based disaster preparedness. This approach takes advantage of information and knowledge that resides at the local level to bolster local-level capacity and capability building. The study used a database of locally available resources (maintained by local Red Cross chapters) that is accessible via the Internet by resident on laptops or personal digital assistants. Critical to understanding such efforts are systematic evaluations of their effectiveness. Bravata et al. (2004) suggest a conceptual framework for evaluating a specific set of informational interventions—information technologies and decision support systems used by medical and public health decisionmakers in cases of bioterrorism. Analyzing reports of real outbreaks and relevant exercises, they produced influence diagrams to pinpoint informational needs and therefore necessary characteristics of relevant technologies and decision support systems. In all, they identified eight critical decision domains, common across many problems, and used subtasks within each domain to develop evaluation criteria.

Syndromic Surveillance
While syndromic surveillance is a well-established area of inquiry and clearly a valuable tool to speed the process of detecting infectious-disease outbreaks and cases of bioterrorism, some of the literature on this topic falls outside the scope of PHEP. Given its relevance to an agenda on PHEP systems research, we briefly review syndromic surveillance from a broader perspective here.

A working definition of syndromic surveillance, coined by Sosin (2003, p. 247), is “the ongoing, systematic collection, analysis, interpretation, and application of real-time indicators for disease outbreaks that allow for their detection before public health authorities would otherwise note them.” Information targeted by syndromic surveillance comes from multiple components of the public health system, including emergency room visits, pharmacy sales, school or work absenteeism, and calls to 911 or other medical telephone helplines, such as poison control centers. Abnormal spikes in conditions, such as fever, rash, and hemorrhage, as well as certain respiratory, gastrointestinal, and neurological symptoms, can serve as a warning
to public health departments that an outbreak or pandemic is under way or that a biological attack has occurred.

For example, Lemay et al. (2008) analyzed syndromic surveillance in a retrospective study of five influenza seasons in Canada. They found that pediatric admissions to emergency rooms for fever and respiratory symptoms were a particularly reliable harbinger of subsequent influenza outbreaks. Yet the authors caution that there is a delay between the chief complaint and official discharge diagnosis and there is a compromise between early availability and accuracy of data. A study by Sloane et al. (2006) suggests that primary care physicians may see victims of an outbreak and record diagnoses even earlier than emergency rooms do. However doctors would need to be able to transfer information to a central processing system in order for data to be analyzed for abnormal patterns in illness. Eysenbach (2006) even found a positive correlation between a spike in Google searches for “flu” or “flu symptoms” and laboratory-confirmed influenza cases in Canada.

Study of Learning

One of the four research priority areas for the PERRCs is enhancing the usefulness of training. As previously discussed in this literature review, most studies on PHEP training evaluation to date have focused on short-term, self-reported gains in knowledge, and few have looked at the relationship of training to outcomes. Research tends to demonstrate positive outcomes from training and learning training material, but it often fails to find significant training effects on behavior or performance (Ostroff, 1991). While not included in the original search criteria, the broader study of learning—specifically, looking at how people learn what they learn—may be relevant to improving the evidence base for preparedness training from a systems perspective.

In general, learning refers to “a change in the state of the human being that is remembered and that makes possible a corresponding change in the individual’s behavior in a given type of situation” (Gagné, 1984). However, there has been insufficient research on what constitutes learning and how learning outcomes should be measured (Kraiger, Ford, and Salas, 1993). The most popular evaluation model, proposed by Kirkpatrick (1987), identifies four levels of evaluation: trainee reactions, learning, behavior, and organizational results. According to the model, learning is measured by traditional multiple-choice tests, which assess the extent to which trainees have acquired principles, facts, or skills. However, critics of this and other evaluation models claim that they define learning in a simplistic and one-dimensional way (Kraiger, Ford, and Salas, 1993).

To strengthen the evidence base for preparedness training, the PHEP field may want to consider implementing a more multidimensional approach to measuring learning outcomes. One such approach, derived by Kraiger, Ford, and Salas (1993), proposes three categories of learning outcomes: cognitive, skill-based, and affective. Cognitive outcomes include the learning constructs of verbal knowledge, knowledge organization, and cognitive strategies. Skill-based outcomes include compilation and automaticity. Affective outcomes include attitudinal and motivational outcomes, such as disposition, self-efficacy, and goal setting. For each category, Kraiger, Ford, and Salas provided learning constructs, measurement foci, and measurement techniques.
Conclusions

This literature review was conducted to summarize the relevant research to date and to highlight current knowledge gaps in emergency preparedness that impede progress in improving and bringing about a systems approach to research on PHEP. Identifying these knowledge gaps will facilitate the identification, prioritization, and organization of research priorities for a national research agenda.

The recommendations made by the IOM letter report (Altevogt et al., 2008) provide a good starting point; nonetheless, the findings suggest that there are additional areas of research that are critical to the development of effective and efficient public health systems for emergency preparedness. The results of this review provided a foundation for discussion among members of our expert panel as they developed suggestions for a broad national agenda to guide public health systems research on emergency preparedness.
Detailed Peer-Reviewed Literature Search Methods

Our literature review included peer-reviewed citations published in English between January 1, 2004, and June 15, 2008. Within these limits, the search strategy shown in Table D.1 was used to identify citations for possible review in two databases: PubMed (including MEDLINE) and PsycINFO. The research team examined titles and abstracts to filter out duplicate retrievals and to determine whether citations met additional inclusion criteria.

The 697 citations identified by our search strategy underwent a thorough abstract review to identify which specifically addressed empirical research on public health systems on emergency preparedness. From these, 192 (28 percent) met our additional criteria and represented the final literature sample for full review.

Table D.1
Literature Review Search Strategy and Inclusion Criteria

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<tr>
<th>Search Terms</th>
<th>Citations Identified (n)</th>
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<tr>
<td>[&quot;public health&quot; OR &quot;public health systems&quot;] AND [&quot;emergency preparedness&quot; OR &quot;preparedness&quot; OR &quot;emergency response&quot; OR &quot;emergency recovery&quot; OR &quot;public health emergency&quot; OR &quot;disaster&quot;]</td>
<td>697</td>
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</tbody>
</table>

Additional Criteria:
- Cannot include literature reviews, legal reviews, discussion papers/commentary pieces, editorials, letters to the editor, case studies, or conference abstracts
- Cannot focus solely on an emergency medicine or pre-hospital issue that was not disaster-related
- Cannot focus exclusively on public health systems research that is not disaster related
- Cannot focus on development of a training, curriculum, or measure without providing associated outcome or pilot data
- Health AND emergency/disaster are specifically and substantially referenced in the title and/or abstract
- An analytic method (qualitative or quantitative) is specifically referenced in the title and/or abstract

Peer-Reviewed Citations Included in the Review

This section lists the articles included in our literature review.


For the 25 statutes, policies, and other relevant governmental or organizational reports reviewed, we used a free-text entry system to record the overall implications of the document and any recommendations made. These results are summarized in Table E.1.

**Table E.1**
Implications and Recommendations of Statutes, Policies, and Other Governmental or Organizational Reports

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<tr>
<th>Statute/Policy/Report</th>
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<tr>
<td>Research Priorities in Emergency Preparedness and Response for Public Health Systems: A Letter Report, Institute of Medicine (Altevogt et al., 2008)</td>
<td>This report is specifically focused on a short-term research agenda (3 to 5 years) for a new generation of PERRCs. It makes four recommendations for primary research priorities (public health preparedness training, preparedness and response communication, creation and maintenance of sustainable preparedness and response systems, and metrics to measure effectiveness and efficiency) and secondary research priorities (special needs populations, workforce, behavioral health, integration of new technologies). It also states that research in these areas should emphasize depth rather than breadth, suggests an all-hazards approach, and prioritizes translational and multidisciplinary approaches to research.</td>
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<tr>
<td>Pub. L. 109-417, Pandemic and All-Hazards Preparedness Act (PAHPA, 2006)</td>
<td>PAHPA gives authority to the Secretary of Health and Human Services to lead public health and medical responses, establishes the ASPR, and broadly lays out the authorities and responsibilities of this office. PAHPA also requires the development and application of evidence-based benchmarks and objective standards. These standards should address the National Preparedness Goals and be tested annually. PAHPA requires pandemic influenza plans and provides for technical assistance in planning and exercising. PAHPA provides for grants for real-time disease detection improvement, gives DHHS authority over the Commissioned Corps (professional), and addresses the Medical Reserve Corp (volunteer). Further, PAHPA transfers the National Disaster Medical System to DHHS from the U.S. Department of Homeland Security and establishes the authority to acquire and operate mobile medical assets. It dictates the development of centralized core training curricula and allocates funds for the PERRCs. Finally, PAHPA establishes the National Biodefense Science Board to “provide expert advance and guidance to the Secretary on scientific, technical, and other matters of interest to [DHHS].”</td>
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Table E.1—Continued

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<tr>
<th>Statute/Policy/Report</th>
<th>Overall Implications and Recommendations Made</th>
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<tr>
<td>Pub. L. 100-707, Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended, and Related Authorities, (with FEMA guidance, 2007)</td>
<td>The Stafford Act codifies federal agency roles during a disaster, including the role of the President during a disaster. The intent of this act is to revise and broaden the scope of disaster relief programs. Encourage the development of comprehensive disaster preparedness programs by states and locals. Achieve greater coordination among preparedness programs. Encourage greater use of insurance. Encourage hazard mitigation strategies. Provide federal assistance programs. The Stafford Act defines emergency preparedness as “all those activities and measures designed or undertaken to prepare for or minimize the effects of a hazard upon the civilian population, to deal with the immediate emergency conditions which would be created by the hazard, and to effectuate emergency repairs to, or the emergency restoration of, vital utilities and facilities destroyed or damaged by the hazard.” Based on this definition, research is considered a part of preparedness.</td>
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<tr>
<td>HSPD-1, Organization and Operation of the Homeland Security Council (2001)</td>
<td>HSPD-1 provides organizational/operational details for the Homeland Security Council, which was formed by Executive Order 13228 in response to the events of September 11, 2001. The purpose of the HSPD is to promote greater federal coordination regarding homeland security. The document also indicates that the Homeland Security Council has a Research and Development Policy Coordination Committee.</td>
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<tr>
<td>HSPD-5, Management of Domestic Incidents (2003)</td>
<td>HSPD-5 mandates the development of the National Incident Management System (NIMS) and the National Response Plan to encourage a comprehensive and consistent approach to domestic incident management.</td>
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<tr>
<td>HSPD-7, Critical Infrastructure Identification, Prioritization, and Protection (2003)</td>
<td>HSPD-7 outlines general guidelines for identifying, prioritizing, and coordinating the protection of critical infrastructure and key resources. It is largely terrorism-focused but does mention health effects and mass casualties. HSPD-7 calls for the creation of (1) a national plan for critical infrastructure and key resources protection and (2) an annual federal research and development plan.</td>
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<tr>
<td>HSPD-8, National Preparedness (2003)</td>
<td>HSPD-8 dictates the creation of a domestic and all-hazards national preparedness goal. It also requires the creation of a single point of access to federal preparedness assistance and a comprehensive training program to collect, analyze, and disseminate research and other information relevant to preparedness.</td>
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<tr>
<td>HSPD-9, Defense of United States Agriculture and Food (2004)</td>
<td>HSPD-9 focuses on protection of the food supply and builds on the critical infrastructure protections outlined in HSPD-7. Explicitly mandated is epidemiologic, laboratory, and countermeasures research regarding the food supply. University-based centers of excellence are called for, as is integration of these efforts into agency budgets.</td>
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<tr>
<td>HSPD-10, Biodefense for the 21st Century (2004)</td>
<td>HSPD-10 is a broad, cross-cutting policy statement about defense against biological weapons. It defines a set of pillars of the biodefense program: Threat awareness, focused on biological warfare related intelligence, assessments, and anticipation of future threats. Prevention and protection, including proactive prevention and critical infrastructure protection. Surveillance and detection, including response planning, mass-casualty care, risk communication, medical countermeasure development, and decontamination. A classified version of this directive provides specific directions to departments and agencies.</td>
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HSPD-18, Medical Countermeasures Against Weapons of Mass Destruction (2007)

HSPD-18 outlines a comprehensive, interdepartmental vision of medical countermeasure research, development, and procurement. It emphasizes the need to focus on the most likely threats, countermeasures that have the greatest potential to help, and countermeasures that are supportable by present and foreseeable operational and logical capabilities. HSPD-18 proposes the near- to midterm development of agent-specific medical countermeasures to target the immediate need to address the most catastrophic threats. Research is needed to develop a flexible capability for new medical countermeasures, including approaches with broad applicability. This HSPD also calls for consideration of streamlined regulatory approval processes, when needed.

Authority is given to the Secretary of Health and Human Services to lead and coordinate the research, development, and procurement outlined in HSPD-18. An interagency committee is to be formed, a dedicated strategic planning activity established, an advanced and broad development portfolio established, and the private sector engaged.

HSPD-20, National Continuity Policy (2007)

HSPD-20 establishes a national policy for ensuring continuity of the federal government. It establishes a national continuity coordinator to assist the Assistant to the President for Homeland Security and Counterterrorism. This HSPD also establishes “national essential functions,” two of which are relevant to public health emergency preparedness:

“Providing rapid and effective response to and recovery from the domestic consequences of an attack or other incident.”

“Providing for critical Federal Government services that address the national health, safety, and welfare needs of the United States.”

HSPD-21, Public Health and Medical Preparedness (2007)

HSPD-21 “focuses on human public health and medical systems” and identifies four critical components of public health and medical preparedness: biosurveillance, countermeasure distribution, mass-casualty care, and community resilience—capabilities that “currently hold the greatest potential for mitigating illness and death.”

HSPD-21 mandates the establishment of the Public Health and Medical Preparedness Task Force, which is required to develop an implementation plan that can be incorporated into the National Health Security Strategy required by PAHFA.

This policy directive draws the following key principles from the National Strategy for Homeland Security (2007), the National Strategy to Combat Weapons of Mass Destruction (2002), and Biodefense for the 21st Century (2004):

- Preparedness for all potential catastrophic health events
- Vertical and horizontal coordination across levels of government, jurisdictions, and disciplines
- Regional approach to health preparedness
- Engagement of the private sector, academia, and other nongovernmental entities in preparedness and response efforts
- The important roles of individuals, families, and communities.

Notably, it does not address basic and applied research in threat diseases and countermeasures. It is largely based on the framework provided by HSPD-10.

Grand Challenges for Disaster Reduction (National Science and Technology Council, Subcommittee on Disaster Reduction, 2005)

This document presents six “grand challenges” for disaster reduction and recommendations for specific research to address each of the challenges:

- Provide hazard and disaster information when and where it is needed.
- Understand the natural processes that produce hazards.
- Develop hazard mitigation strategies and technologies.
- Recognize and reduce the vulnerability of interdependent critical infrastructure.
- Assess disaster resilience using standard methods.
- Promote risk-wise behavior.

It also provides a framework for prioritizing investments in science and technology.
Table E.1—Continued

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<td><strong>Reducing Loss of Life and Property from Disasters: A Societal Benefit Area of the Strategic Plan for U.S. Integrated Earth Observation System (IEOS) (Helz and Gaynor, in cooperation with the National Science and Technology Council, Subcommittee on Disaster Reduction 2007)</strong></td>
<td>This report documents the efforts of the Earth Observation Task Group of the Subcommittee on Disaster Reduction in “identifying U.S. capabilities and needs in the area of observing and predicting hazards and disasters.” Most of the report is dedicated to the specification of which hazards to cover and what observations are critical to respond to those hazards. In this sense, the report is more focused on surveillance than on research. It does, however, recognize research scientists as a secondary audience. Most of the observational needs, resources, and gaps discussed in this document are not specifically public health–related (e.g., need for better high-resolution digital topography), but it does specify recommendations to improve epidemiological and laboratory functions during emergency preparedness and response.</td>
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<td><strong>Guidelines for Defining Public Health Research and Public Health Non-Research (CDC, 1999)</strong></td>
<td>While this document is not specifically about emergency preparedness, it “sets forth CDC guidelines on the definition of public health research conducted by CDC staff irrespective of the funding source (i.e., provided by CDC or by another entity).” It provides guidance on what constitutes research and is therefore subject to institutional review board approval. This is particularly crucial, since many public health activities are not unambiguously research or nonresearch. It is particularly challenging to distinguish research from nonresearch for surveillance, emergency responses, and evaluation. A key distinction between research and nonresearch is intent. Research intends to create generalizable knowledge, whereas the intent of nonresearch is to prevent disease or injury.</td>
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<td><strong>Advancing the Nation’s Health: A Guide to Public Health Research Needs, 2006–2015 (CDC, 2006)</strong></td>
<td>This guide outlines research in key areas to develop the policies, practices, and programs to improve all people’s health. Overall, it emphasizes interdisciplinary and cross-cutting research that extends into nontraditional areas of public health. Specifically, it suggests a need for research that will enable the identification of strategies and interventions to reduce communities’ susceptibilities across a wide range of hazards. Operational and applied research outlined in the document aims to promote and evaluate integrated systems of care and risk management, incident management, and communication among health and safety authorities and residents. Additionally, it identifies community stakeholders and academic, private, tribal, and government researchers as critical partners with whom to collaborate when conducting public health research.</td>
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<td><strong>National Response Framework (DHS, 2008)</strong></td>
<td>The National Response Framework builds on NIMS to provide a guide for how the nation conducts all-hazards response. It focuses on roles and responsibilities, key actions, response and organizational structure, and planning. It includes a core document, emergency support function annexes, support and incident annexes, and partner guides. The framework recognizes that small incidents often have the potential to grow into a larger threat and outlines a response doctrine with five key principles: engaged partnership; tiered response; scalable, flexible, and adaptable operational capabilities; unity of effort through unified command; and readiness to act. It is an outgrowth of the previous National Response Plan (2004) and Federal Response Plan (1992).</td>
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The Target Capabilities List provides a detailed overview of the target capabilities related to the four homeland security mission areas of prevent, protect, respond, and recover and also provides guidelines for assessing preparedness. The list is not focused on research priorities but does advocate for research in four areas:

- Detect CBRNE by establishing “a research and development program to address shortfalls in technologies for detecting chemical, biological, radiological, nuclear and explosive material.”
- Protect critical infrastructure through “a national [critical infrastructure protection] research and development program.”
- Enhance volunteer management through “research [on] existing liability issues and laws that affect volunteer utilization.”
- Improve environmental health by conducting “research and establish[ing] health-risk based tolerance thresholds for key contaminants; including updating existing methods and developing new ones where none exist.”

The Target Capabilities List also emphasizes that preparedness involves all levels of government, NGOs, citizens, and the private sector.

The purpose of ESF-8 is to provide a mechanism for federal assistance in response to “a public health and medical disaster, potential or actual incidents requiring a coordinated Federal response, and/or during a developing potential health and medical emergency.” ESF-8 provides supplemental assistance to state, tribal, and local governments in the following core functional areas:

- Assessment of public health/medical needs
- Health surveillance
- Medical care personnel
- Health/medical/veterinary equipment and supplies
- Patient evacuation
- Patient care
- Safety and security of drugs, biologics, and medical devices
- Blood and blood products
- Food safety and security
- Agriculture safety and security
- All-hazard public health and medical consultation, technical assistance, and support
- Behavioral health care
- Public health and medical information
- Vector control
- Potable water/wastewater and solid waste disposal
- Mass fatality management, victim identification, and decontaminating remains
- Veterinary medical support.

The National Preparedness Guidelines supersede the Interim National Preparedness Goal (2005) and define “what it means for the Nation to be prepared for all hazards.” The guidelines outline four critical elements for the nation’s preparedness:

- The national preparedness vision: “A NATION PREPARED with coordinated capabilities to prevent, protect against, respond to, and recover from all hazards in a way that balances risk with resources and need”
- The national planning scenarios
- The Universal Task List
- The Target Capabilities List
- The guidelines state that DHS shall coordinate preparedness research and development activities across agencies.
This document presents the first annual version of the National Critical Infrastructure Protection Research and Development Plan, an outgrowth of HSPD-7. Public health and health care are considered one of several critical infrastructures. The focus of this first plan is twofold: (1) provide a baseline read on research-and-development efforts in federal agencies, and (2) identify future needs and research gaps.

To protect critical infrastructure, the plan advocates the following research priorities for near term:

- Improved sensor performance
- Advance risk modeling, simulation, and analysis for decision support
- Improve cybersecurity
- Improve prevention and protection
- Better assess the insider threat
- Improve large-scale situational awareness for critical infrastructure
- Develop next-generation designs and architecture for devices and systems
- Develop a human-technology interface that allows better comprehension and decisions

NIMS is the overarching guide to organizational structure, roles, and responsibilities in incident response. It is designed to be an all-hazards approach that can be applied at all levels of government, the private sector, and NGOs, and in incidents of all sizes. NIMS contains the ICS. Key to this approach are concepts of interoperability and compatibility, which in turn rely on flexibility and standardization.

NIMS and HSPD-5 establish the National Integration Center, which provides oversight of NIMS guidance, including updates. The center, in collaboration with DHS’s Science and Technology Directorate, oversees strategic NIMS-related research and development. NIMS generally does not address specific research goals, but it does advocate for general research and development related to NIMS guidance.

These regulations were adopted by the World Health Assembly in 2005 and implemented in 2007. They focus on establishing public health response capabilities within and across national boundaries.

The purpose of this act is to “improve the ability of the United States to prevent, prepare for, and respond to bioterrorism and other public health emergencies.” It amends the Public Service Act and specifies that the Working Group on Bioterrorism and Other Public Health Emergencies shall meet periodically and make recommendations on (among other things) “research on pathogens likely to be used in a biological threat or attack on the civilian population.” It further specifies that the Secretary shall award grants, contracts, and cooperative agreements for research regarding “pathogens of potential use in a bioterrorist attack.” These include investigations in the areas of epidemiology and pathogenesis of pathogens, genomics of pathogens, countermeasure development, and other areas, with specific attention to the needs of special needs populations. The Secretary is further instructed to consider the research capabilities of the U.S. Department of Veterans Affairs in these endeavors.

The act also instructs the Secretary of Energy and the head of the National Nuclear Security Administration to ramp up research on “rapid detection and identification of pathogens likely to be used in a bioterrorism attack or other agents that may cause a public health emergency” and directs the Secretary of Health and Human Services, through the director of the National Institute for Occupational Safety and Health, to increase research on the health and safety of workers at risk of a terrorist attack in the workplace.

The Secretary, in coordination with the Secretary of Agriculture, is to provide for appropriate availability of toxins and agents for research purposes. The Secretary is also directed to provide for research on the development of tests and methodologies for ensuring food safety and protecting the food supply.

The act calls for the review (and possible funding of) “biomedical research into the short-term and long-term impact on public health of various chemical, biological and radiological contaminants that may be introduced into public water systems through terrorist or other intentional acts.”

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<td>National Plan for Research and Development in Support of Critical Infrastructure Protection (Executive Office of the President, Office of Science and Technology Policy, and U.S. Department of Homeland Security, Science and Technology Directorate, 2004)</td>
<td>This document presents the first annual version of the National Critical Infrastructure Protection Research and Development Plan, an outgrowth of HSPD-7. Public health and health care are considered one of several critical infrastructures. The focus of this first plan is twofold: (1) provide a baseline read on research-and-development efforts in federal agencies, and (2) identify future needs and research gaps. To protect critical infrastructure, the plan advocates the following research priorities for near term: Improved sensor performance Advance risk modeling, simulation, and analysis for decision support Improve cybersecurity Improve prevention and protection Better assess the insider threat Improve large-scale situational awareness for critical infrastructure Develop next-generation designs and architecture for devices and systems Develop a human-technology interface that allows better comprehension and decisions</td>
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<tr>
<td>National Incident Management System (draft, 2007)</td>
<td>NIMS is the overarching guide to organizational structure, roles, and responsibilities in incident response. It is designed to be an all-hazards approach that can be applied at all levels of government, the private sector, and NGOs, and in incidents of all sizes. NIMS contains the ICS. Key to this approach are concepts of interoperability and compatibility, which in turn rely on flexibility and standardization. NIMS and HSPD-5 establish the National Integration Center, which provides oversight of NIMS guidance, including updates. The center, in collaboration with DHS’s Science and Technology Directorate, oversees strategic NIMS-related research and development. NIMS generally does not address specific research goals, but it does advocate for general research and development related to NIMS guidance.</td>
</tr>
<tr>
<td>International Health Regulations (World Health Organization, 2005)</td>
<td>These regulations were adopted by the World Health Assembly in 2005 and implemented in 2007. They focus on establishing public health response capabilities within and across national boundaries.</td>
</tr>
<tr>
<td>Pub. L. 107-188, Public Health Security and Bioterrorism Preparedness and Response Act (2002)</td>
<td>The purpose of this act is to “improve the ability of the United States to prevent, prepare for, and respond to bioterrorism and other public health emergencies.” It amends the Public Service Act and specifies that the Working Group on Bioterrorism and Other Public Health Emergencies shall meet periodically and make recommendations on (among other things) “research on pathogens likely to be used in a biological threat or attack on the civilian population.” It further specifies that the Secretary shall award grants, contracts, and cooperative agreements for research regarding “pathogens of potential use in a bioterrorist attack.” These include investigations in the areas of epidemiology and pathogenesis of pathogens, genomics of pathogens, countermeasure development, and other areas, with specific attention to the needs of special needs populations. The Secretary is further instructed to consider the research capabilities of the U.S. Department of Veterans Affairs in these endeavors. The act also instructs the Secretary of Energy and the head of the National Nuclear Security Administration to ramp up research on “rapid detection and identification of pathogens likely to be used in a bioterrorism attack or other agents that may cause a public health emergency” and directs the Secretary of Health and Human Services, through the director of the National Institute for Occupational Safety and Health, to increase research on the health and safety of workers at risk of a terrorist attack in the workplace. The Secretary, in coordination with the Secretary of Agriculture, is to provide for appropriate availability of toxins and agents for research purposes. The Secretary is also directed to provide for research on the development of tests and methodologies for ensuring food safety and protecting the food supply. The act calls for the review (and possible funding of) “biomedical research into the short-term and long-term impact on public health of various chemical, biological and radiological contaminants that may be introduced into public water systems through terrorist or other intentional acts.”</td>
</tr>
</tbody>
</table>
The Project Bioshield Act is an amendment to the Public Health Services Act and is intended to accelerate the “research, development, purchase, and availability of effective medical countermeasures against biological, chemical, radiological, and nuclear (CBRN) agents” (HHS, undated). Project Bioshield authorizes $5.6 billion to be drawn (over ten years) from the “special reserve fund” provided by the Homeland Security Appropriations Act (2004) for advanced development and purchase of countermeasures. DHHS/ASPR/Biomedical Advanced Research and Development Authority oversees such procurements. The act mandates and provides for the Strategic National Stockpile.

The Project Bioshield Act prioritizes countermeasure development, directs National Institute of Health/National Institute of Allergy and Infectious Disease to expedite and simplify the grants process for the development of countermeasures, and establishes the Emergency Use Authorization to give access to these countermeasures during an emergency.
The DAF was used to systematically record information from the 169 citations and 25 statutes and policies included in our review. The DAF was developed by the research team to capture standard elements regarding quality and content (e.g., type of study, sample size, analytic approach). Items to capture the primary research objective of each study and the stages of emergency preparedness, response, and recovery addressed were included based on results of a literature review on disaster medicine and public health preparedness (Abramson et al., 2007). Finally, a field was included to enable a qualitative analysis wherein the review team summarized each study in a free-text entry of three to four sentences. Once a DAF was complete for each identified document, the data were entered into SPSS®, Version 16.0, for analysis. Free-text entries were added to the SPSS database, cut, and sorted into thematic categories.

**Peer-Reviewed Literature DAF**

<table>
<thead>
<tr>
<th>Citation:</th>
<th>[Does the reference address an identified research priority (IOM)?]</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>[If yes: Which ones? (check all that apply)]</td>
<td>PHEP training Research that will create best practices for design and implementation of training (e.g., simulations, drills, and exercises) and facilitate the translation of results into improvements in preparedness</td>
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<td>Communications in preparedness and response Research that will identify and develop communications in relation to preparedness and response that effectively exchange vital and accurate information in a timely manner with diverse audiences</td>
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<td>Creation and maintenance of sustainable preparedness and response systems Research that will identify the factors that affect a community's ability to successfully respond to a public health emergency and systems/infrastructure needed to foster constructive and sustainable responses</td>
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</tr>
<tr>
<td></td>
<td>Metrics to measures effectiveness and efficiency Research that will generate criteria for evaluating preparedness, response, and recovery and metrics for measuring efficiency and effectiveness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[Is this article an excellent (i.e., top 10% of those you've read) example of public health systems research on preparedness, as described below?]</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The &quot;public health system&quot; is a &quot;complex network of individuals and organizations that have the potential to play critical roles in creating the conditions for health&quot; (IOM, 2002)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Evaluation of Quality

### Type of study (check all that apply)

- Randomized controlled trial
- Meta Analysis / Systematic Review
- Qualitative data
- Survey
- Observational (e.g., observational data collected during a drill or exercise)
- Pre-test/Post-test (e.g., training evaluation)
- Other (specify):

### Sample size

### Data collection method

- Focus group
- Interview
- Phone/Paper/Web survey
- Other (specify):

### Data description

- Primary data collection
- Secondary data analysis
- Other (specify):

### Was this study conducted in the context of a public health emergency? (i.e., was the study conducted while a public health emergency was imminent, happening, or very recently over?)

- No
- Yes—If yes, during which stage? (see definition guidance below)

#### Only complete if answer above is "Yes"

<table>
<thead>
<tr>
<th>Preparedness</th>
<th>Response</th>
<th>Recovery</th>
<th>Other (specify):</th>
</tr>
</thead>
</table>

### Analytic approach

- Qualitative synthesis
- Descriptive or bivariate analysis only
- Multivariate analysis
- Other:
### Evaluation of Content

#### Stages of preparedness addressed (check all that apply)

<table>
<thead>
<tr>
<th>Preparedness (e.g., capacity focused study related to activities before an emergency takes place such as vaccine development, education, training, resource gathering)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response—Hypothetical (e.g., exercise/drill)</td>
</tr>
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<td>Response—Actual (e.g., evacuation during a real public health emergency)</td>
</tr>
<tr>
<td>Recovery (e.g., shelter management, safety maintenance, mental health)</td>
</tr>
<tr>
<td>Other (specify):</td>
</tr>
</tbody>
</table>

#### Primary research objective (check all that apply)

<table>
<thead>
<tr>
<th>Descriptive (e.g., aim of the study is to describe an outcome among a population or sample)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program/policy development or evaluation (e.g., aim of the study is to develop or evaluate a training program/policy change such as workforce development)</td>
</tr>
<tr>
<td>Hypothesis driven (e.g., the study is designed to test a specific hypothesis described in the Introduction)</td>
</tr>
<tr>
<td>Needs assessment (e.g., the needs of a sample or population are the focus of the study and possibly strategies to meet those needs)</td>
</tr>
<tr>
<td>Other (specify):</td>
</tr>
</tbody>
</table>

#### Type of emergency (check all that apply)

<table>
<thead>
<tr>
<th>Natural disaster</th>
</tr>
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<tbody>
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<td>Non-terrorist CBRNE (Chemical, Biological, Radiological, Nuclear, or Explosive)</td>
</tr>
<tr>
<td>Terrorist threat/incident</td>
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<tr>
<td>Infectious disease outbreak</td>
</tr>
<tr>
<td>Infectious disease pandemic</td>
</tr>
<tr>
<td>All hazards or unspecified type</td>
</tr>
<tr>
<td>Other emergency (specify):</td>
</tr>
</tbody>
</table>

#### Elements of preparedness substantively addressed by the research (check all that apply)

<table>
<thead>
<tr>
<th>Health risk assessment (Identifies individual, community, &amp; structural hazards/vulnerabilities to inform plans)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legal climate (Identifies/addresses legal and liability barriers to effectively respond to public health emergencies)</td>
</tr>
<tr>
<td>Roles and responsibilities (Defines/assigns/tests responsibilities across sectors)</td>
</tr>
<tr>
<td>Incident Command System (Develops/tests/improves ICS capabilities)</td>
</tr>
<tr>
<td>Public engagement (Educates/engages/mobilizes the public to be active PHEP participants)</td>
</tr>
<tr>
<td>Epidemiology functions (Maintains/improves systems to monitor, detect, and investigate PHEP events)</td>
</tr>
<tr>
<td>Laboratory functions (Maintains/improves systems to test for hazards, especially CBRNE)</td>
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<tr>
<td>Area</td>
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<tr>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Countermeasures and mitigation strategies</td>
</tr>
<tr>
<td>Mass health care</td>
</tr>
<tr>
<td>Psychosocial outcomes and community resilience</td>
</tr>
<tr>
<td>Public information and communication</td>
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<td>Robust supply chain</td>
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<td>Operations-ready workers and volunteers</td>
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<td>Leadership</td>
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<td>Testing operational capabilities</td>
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</tr>
<tr>
<td>Financial tracking</td>
</tr>
<tr>
<td>Interagency communication and coordination</td>
</tr>
</tbody>
</table>

Based on the data and results, were gaps, priorities, or recommendations made for any of the following areas? (check all that apply)

- Knowledge
- Practice
- Policy
- Resources

Describe the above gaps, priorities, and/or main recommendations identified (1-2 sentence summary)

Overall implications (2–3 sentence summary)
## Statutes and Policies DAF

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<tr>
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## Evaluation of Content

### Stages of preparedness addressed (check all that apply)

- Preparedness (e.g., vaccination, education, resource gathering)
- Response—Hypothetical (e.g., exercise/drill)
- Response—Actual (e.g., evacuation during a real public health emergency)
- Recovery (e.g., shelter management, safety maintenance, mental health)
- Other (specify; e.g., prevention):

### Type of Emergency (check all that apply)

- Natural disaster
- Non-terrorist CBRNE (chemical, biological, radiological, nuclear, or explosive)
- Terrorist threat/incident
- Infectious disease outbreak
- Infectious disease pandemic
- All hazards or unspecified type
- Other emergency (specify):
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<tr>
<th>Elements of Preparedness Addressed (check all that apply; indicate if it was an identified or implied strength or gap/weakness)</th>
<th>Define/Establish</th>
<th>Note Strength</th>
<th>Note Gap/Weakness</th>
<th>Call/Provide for Research ($ set aside?)</th>
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Reference to Specific Research or the Overall State of Research

<table>
<thead>
<tr>
<th>No</th>
<th>Yes, Specify:</th>
</tr>
</thead>
</table>

Overall implications and recommendations made (2–3 sentence summary)
Major Assumptions:
References


CDC—see Centers for Disease Control and Prevention.


DHHS—see U.S. Department of Health and Human Services.


GAO—see U.S. Government Accountability Office.


References


IOM—see Institute of Medicine.


References


