Information Sharing with Technical Audiences: Findings from After Action Reports and Case Reports

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1 Executive Summary

The National Academies of Sciences, Engineering, and Medicine, Committee on Evidence-Based Practices for Public Health Emergency Preparedness and Response commissioned this report to synthesize findings from After Action Reports (AARs) and case reports related to communication of public health alerts and guidance with technical audiences. More specifically, the report seeks to understand the effectiveness of engaging technical audiences in planning processes; barriers and facilitators to effective communication; and the benefits and harms associated with specific channels. The report is intended to support findings from research studies, provide a different perspective from research studies, or provide the only available perspective concerning a specific phenomenon of interest.

The Committee identified AARs and case reports directly or indirectly related to information sharing with technical audiences by conducting a broad literature search and call for reports. These reports were then further prioritized through the development and application of a "Sorting Tool." Reports were categorized as either "high priority" or "low priority" using the criterion of relevance, adapted from the AACODS checklist (Authority, Accuracy, Coverage, Objectivity, Date, Significance). Tabletop exercises were deprioritized unless they elicited new themes. Data were then extracted and coded in Excel.

A total of 29 AARs and 12 case reports were categorized as high priority and included in the thematic analysis. The most common technical audiences and channels mentioned were healthcare partners and providers, and the Health Alert Network (HAN), respectively. An appreciation of webcasts and a direct line of communication (phone or in person) to experts was expressed in multiple reports. Few reports discussed the effectiveness of messaging when technical audiences are engaged in the planning process, however, lessons learned point to a growing recognition of the need to strengthen engagement and evaluate communication mechanisms. Barriers and facilitators to effective communication include consistency of messaging in the dynamic public health emergency environment, message amplification, maintenance of distribution lists and redundant means of communication, transparent vetting processes, accessibility, and adequate resources. Benefits and harms of specific modes or frequencies of messaging were also not directly addressed in the reports. Inferences can be made that specific communication mechanisms (e.g., hotlines and bi-directional alert systems) serve to improve timeliness. Whereas, hotlines may also unintentionally cause fatigue or stress for staff answering calls. Additionally, fatigue may result from alerts or guidance that are not targeted or tailored to specific target audiences.

The ability to effectively communicate public health guidance and alerts with technical audiences during an emergency is essential to a successful response. Findings indicate that engaging target audiences in planning processes and tailoring communication channels to better suit their needs may facilitate more effective information sharing during an emergency. However, the fast-paced nature of emergent public health threats and the corresponding changes in guidance is likely to remain as a challenging contextual factor. Ensuring transparent and timely vetting processes, and clear roles and responsibilities among partners in advance of an emergency may help alleviate some of the confusion and frustration that occurs during emergencies. Furthermore, consistency of messaging across federal, regional, state, and local levels, and amongst partners is critical as it can serve to augment or impede the credibility of the message. Therefore, finding ways to simplify, streamline, and crosscheck messaging is recommended, as well as further research into the effectiveness of specific communication mechanisms.

2 Introduction

Information sharing with technical audiences is an important component of successful public health emergency response. Emergencies often involve exchanging large amounts of information at a rapid pace with multiple agencies and groups, using multiple modes of communication. However, the effectiveness of these mechanisms for communicating public health guidance and alerts with technical audiences during a public health emergency remains unclear. This report was commissioned by the National Academies of Sciences, Engineering, and Medicine, Committee on Evidence-Based Practices for Public Health Emergency Preparedness and Response to better understand the gray literature around this research question. More specifically, this report seeks to examine the effectiveness of engaging technical audiences in planning processes; the barriers and facilitators to effective communication; and the benefits or unintended consequences of specific channels. The channels and target audiences currently engaged in information sharing are also summarized to provide additional context.

Additionally, evidence-to-decision considerations for information sharing during public health emergencies (values/preferences, resources and net benefit, equity issues, acceptability and feasibility) are discussed. Findings from this review will be used to add weight to findings from research studies examined in the commissioned paper entitled *Communicating Public Health Alerts and Guidance with Technical Audiences: Qualitative Research Evidence Synthesis*; provide a different perspective from research studies; or to provide the only perspective concerning specific phenomena of interest.

3 Method

Literature search

The Committee identified gray literature published by relevant domestic and international organizations and agencies. This included Association of Public Health Laboratories (APHL), Assistant Secretary for Preparedness and Response (ASPR), the Association of State and Territorial Health Officials (ASTHO), Centers for Disease Control and Prevention (CDC), Center for Health Security, Council of State and Territorial Epidemiologists (CSTE), European Centre Disease Prevention and Control (ECDC), Disaster Information Management Research Center at the National Library of Medicine at the National Institutes of Health (NLM/NIH), Department of Homeland Security (DHS), Federal Emergency Management Agency (FEMA), US Government Accountability Office (GAO), National Association of County and City Health Officials (NACCHO), National Center for Disaster Medicine and Public Health (NCDMPH), Preparedness and Emergency Response Centers (PERRC), Public Health Canada, Public Health England, RAND Corporation, and the World Health Organization (WHO). Additionally, the committee obtained 370 after-action reports published from 2009 to 2019 from the Homeland Security Digital Library (HSDL).

In addition to the online search, the Committee proactively solicited reports, both published and unpublished, through a request for documents. The reports were solicited through internal list servs at the National Academies, as well as through external mechanisms. An online request was published on the committee's study webpage, and the Board on Health Sciences Policy distributed the call for reports through the Forum on Medical and Public Health Preparedness for Disasters and Emergencies and the Disaster Science Action Collaborative. Staff contacted CDC, the study sponsor, for document suggestions, and also had them disseminate the announcement

to their networks, and particularly the former PERRCs and PERLCs networks. Additionally, staff sent targeted emails PHEPR practitioner associations (e.g., NACCHO and ASTHO) and disaster science organizations (e.g., DR2, NCDMPH, and ASPPH). Submissions were accepted through March 8, 2019. This proved to be an effective way to collect after action reports (AARs), theses, and white papers. Reports that did not fall into the AAR category (white papers, peer-reviewed publications, etc.) will be called "case reports" for the purposes of this report. The scope of this report is AARs and case reports that did not report a research study. The commissioned paper entitled *Communicating Public Health Alerts and Guidance with Technical Audiences: Qualitative Research Evidence Synthesis* provides a synthesis of qualitative studies that reported qualitative methods.

Prioritization of after action reports and case reports

The literature search resulted in a total of 52 after action reports and case reports directly or indirectly related to information sharing with technical audiences during public health emergencies. To further prioritize which reports to review, a Sorting Tool was developed with input from the Committee. Reports were categorized into "High" priority or "Low" priority based on relevance to the research question of interest. The definition of "relevance" was adapted from the AACODS checklist (Authority, Accuracy, Coverage, Objectivity, Date, Significance). Rigor was not used as a sorting criterion because the primary purpose of this AAR/case report review was to synthesize experiential data to add weight to findings from research studies, provide a different perspective from research studies, or to provide the only available perspective concerning specific phenomena of interest. Please see Appendix A for the tool and reviewer guidance.

AARs covering tabletop exercises were categorized as low priority given that findings from tabletops are not based on real experience or simulations. However, if a tabletop AAR was relevant to the research question, the AAR was to included in the analysis if the specific area of relevance did not otherwise emerge from analysis of high priority reports.

Time-permitting, reports categorized as low priority would be randomly sampled. If the initial random sample yielded new themes, additional reports would be randomly sampled until saturation was reached. However, because application of the sorting tool resulted in >80% of the reports being considered high priority, random sampling of low priority reports was not conducted. Tabletops were also not analyzed as the themes they covered emerged from the analysis of high priority reports.

Coding and synthesis of data from selected AARs and case reports

Matrices were created in an Excel spreadsheet to structure report characteristics (type of event, type of report, location, etc.) and data were extracted directly into Excel. A codebook was developed based on the key areas of interest and used to code data in Excel. Excel was used for ease of comparing data based on report characteristics. Once coding was completed, key word searches of the high priority reports were conducted in Mendeley to ensure reports with details relevant to the key findings were not overlooked in the analysis phase. Although AARs and case reports were jointly analyzed, findings were considered by report type to assess for any differences. There were no notable differences between themes emerging from AARs or case reports, therefore, findings are presented jointly below.

4 Findings

4.1 After Action Report/ Case Report Characteristics

The AAR/case report sorting tool was applied to 52 total reports (36 AARs and 16 case reports). Of these, 79% were categorized as high priority (29 AARs and 12 case reports). **Figure 1** provides a detailed breakdown of the sorting and prioritization.

Figure 1: Prioritization of After Action Reports and Case Reports

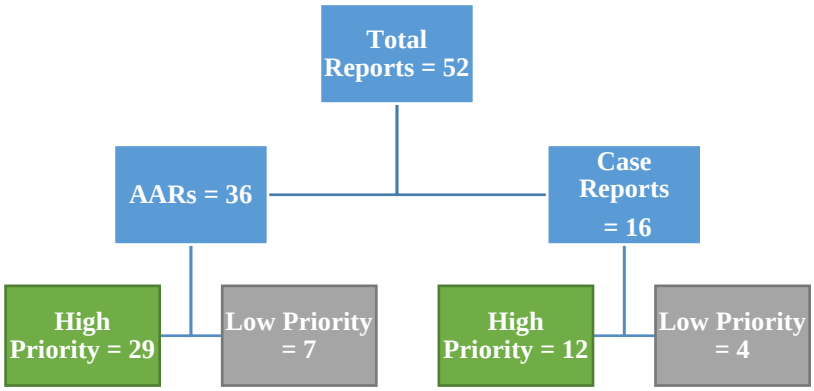

Table 1 provides a summary of AAR/ case report characteristics. Approximately three-quarters (76%) of the AAR/case reports were based on real events. Full scale exercises and functional exercises accounted for 12% of the reports each. Hazards and threats ranged from infectious diseases (H1N1, Ebola, Hepatitis A, etc.), Cyclospora, natural disasters, and man-made disasters (oil spill, explosion, etc.). Incident years ranged from 2001 to 2010 in 23 states in the United States and Canada.

Table 1: After Action Report/ Case Report Characteristics

Characteristics of AARs and Case Reports (N = 41)		
Type of Report	After Action Report 71% (n=29) Case Report 29% (n=12)	
Type of Event	Real Event 76% (n=31) Exercise 24% (n=10) • Full Scale 12% (n=5) • Functional 12% (n=5)	
Hazard/ Threats	Public health threat	Anthrax, Cyclospora, Ebola, H1N1, Hepatitis A, Influenza, Novel respiratory disease, TB
	Natural disasters	Earthquake, Flood, Hurricane
	Other	Explosion, Loss of potable water, Oil spill, White powder
Incident Years	2001 - 2010	
Location	USA: CA, CO, CT, DC, DE, FL, IA, IL, KY, MA, ME, MN, MS, MT, NH, NJ, NY, OH, OK, OR, TX, WA, WI; Canada	

4.2 Synthesis of Findings

Information gleaned from AARs and case reports was equally useful in informing this review. Case reports generally provided more detailed information about a specific type of communication channel, whereas AARs typically provided practical information about the functionality and areas for improvement related to specific processes and channels. AARs were also particularly helpful in identifying barriers and facilitators to effective communication given their focus on improvement planning efforts.

This section describes the technical audiences that receive public health guidance and alerts during a public health emergency, and channels currently used to share this information. Next, findings related to the effectiveness of engaging technical audiences in planning processes are presented, followed by a discussion of barriers and facilitators to effective information sharing. Overall, AARs and case reports did not focus on benefits and undesirable effects, therefore, findings related to this research area are limited. A summary of findings is provided in **Table 3**.

Technical audiences and Communication channels

A list of technical audiences and communication channels discussed in the AARs and case reports is provided in **Table 2**. It is possible that there were additional audiences and channels that were not mentioned in the reports. Therefore, the table is intended to serve as a general snapshot of the various communication channels and target audiences, rather than provide an exhaustive list.

The most common technical audiences and channels mentioned were healthcare partners and providers, and the Health Alert Network (HAN), respectively. While the HAN was noted as an important direct communication link to technical audiences, several reports also point to the need to further expand its reach as not all technical audiences (e.g. first responders, individual providers, emergency medical departments, medical practices, local boards of health, etc.) are enrolled in it (276, 311, 313, 664, 647, 652, 653, 665). While reach varies by jurisdiction, insufficient enrollment may leave important stakeholders out of the loop (647). An appreciation of webcasts and a direct line of communication (phone or in person) to experts was expressed in multiple AARs (669, 670, 651, 665, 648). Additionally, the need to better engage individual or private providers was mentioned in the context of H1N1 (670, 265). A handful of innovations (technological and non-technological) were also mentioned in case reports, such as the OKAlert-ILI System and the use of Family Health Team managers during H1N1 (302, 316). These along with others are referenced later in this report.

Table 2: Technical audiences and communication channels used to share public health alerts and guidance

Technical Audience	Communication Channel	
• Healthcare partners* (hospitals, clinics, long-term care facilities, emergency departments, providers, coalitions, health and hospital associations, college health services, vaccine providers, FQHCs, Regional Health Coordinators, etc.) • Response agencies (Emergency Medical Services, law enforcement, emergency management) • Health departments (state, local, tribal)* • Other: syndromic surveillance partners, pharmacies, diagnostic laboratories, child care providers, shelter staff	• Health Alert Network • EPI Update Alert • Electronic health record alert • State-run notification systems ○ *Alert Mechanisms: Email, Text, Phone call, Pager, Radio, Fax* • WebEOC, teleconferences, in person meetings, briefings • Bidirectional surveillance and messaging system • Hotline/ Call center • Website, SharePoint, document libraries (e.g., Google drive), discussion threads	• Webinar/ webcast • Social media • Medical societies and associations* • Individuals – Liaison Officer, Public Information Officer, Infection Control Coordinator, Family Health Team managers, onsite experts

*Entities mentioned as both technical audiences and communication channels are indicated with an asterisk

Engaging technical audiences in the development of communication plans, protocols, and channels

Growing recognition of the need to better engage stakeholders

Although few of the AARs or case reports examined in this review addressed if technical audiences were engaged in the development of communication plans, protocols, or channels, several AARs pointed out the need to better engage stakeholders in the future (657, 658, 669, 664, 672, 673, 665, 674). Based on lessons learned from exercises or real events, insufficient engagement of partners in planning processes may impede effective communication during responses due to planning gaps, and unclear communication channels and vetting processes.

For example, following the 2015 declaration of a public health emergency in the State of Connecticut in response to potential Ebola Virus Disease, an overwhelming amount of information was being shared by multiple sources to various partners without clear guidance, leading to a sense of "paralysis by analysis (658)." Efforts to develop recommendations within the Region through Regional ESF-8 was questioned by state partners at times and led to confusion about roles and responsibilities related to information sharing. A key recommendation resulting from the after action process was that partners should work together to develop more streamlined processes for information sharing. Local public health jurisdictions were also receptive to bringing new partners to the table and strengthening existing relationships to enhance information flow across levels and jurisdictions.

In some cases, circumstances beyond the jurisdiction's control impeded effective stakeholder engagement in the planning process. Due to staffing gaps resulting from a hiring freeze during Delaware's 2009 response to H1N1, hospitals and the medical community were not engaged earlier in the planning process (664). Following the response, the Division of Public Health recognized the need to further engage partners in the planning and decision making

process due to confusion around the vaccine ordering process. Blast faxes did not reach physicians, decisions made during meetings sometimes changed based on vaccine allocations, and changes were not well-communicated to all parties. The Division subsequently proposed establishing a hotline for medical providers to address this concern, using a stakeholder engaged process.

Wisconsin experienced similar challenges during their 2009 H1N1 response (669). Given how quickly information changed, it was difficult for physicians and employees to keep up with the information, and some questioned the credibility of the guidelines due to the frequent changes. The health department recommended engaging the Wisconsin Medical Society for them to issue a mandate or advisory and establish a point of contact at each hospital to whom emails and communications should be directed. Therefore, engaging appropriate partners during the planning process in anticipation of a dynamic environment may serve to enhance the credibility and effectiveness of messaging.

Moving towards an inclusive planning approach

Evidence suggests that public health is moving towards a more inclusive planning approach, however, the effectiveness of communication channels warrants further study (652, 653, 315, 12, 313, 275). Some jurisdictions have developed new channels based on direct feedback from stakeholders. For instance, Mississippi developed and tested an infectious disease hotline with surveillance and education capabilities in the aftermath of Hurricane Katrina in response to requests made by shelter staff for "both a reporting system and infectious disease education (12)." The hotline enabled direct verbal communication between shelter staff and hotline managers to allow for immediate feedback and education for staff unfamiliar with diseases and reporting processes. A satisfaction survey confirmed immediate positive feedback from the users of the system. While no significant infectious diseases were reported, 17 out of 43 participating shelters made 29 calls, which led to 35 patients being referred to local physicians or hospitals for further diagnosis and disease management. This example exemplifies a truly stakeholder-driven approach based on an identified need.

Gamache et al. (2010) also describe the importance of evaluating end-user acceptance of a new data sharing mechanism that delivers public health alerts to Iowa providers by leveraging an existing electronic clinical messaging system within the context of a health information exchange. Although findings from their evaluation were not presented, they emphasize the value of engaging both clinical and public health stakeholders as a means to build trust and establish infrastructure for a more complex public health decision support process (313).

The Health Emergency Response Data System (HERDS), which was developed in 2001 by the New York State Department of Health in partnership with healthcare and public health agencies, serves as the infrastructure for linking and exchanging health preparedness and response information in the state (275). A key lesson learned in developing the system was the need for a bottom-up approach to system requirements that cross-cut jurisdictions and knowledge domains. The system has proven effective in real time information exchange during emergencies. Gotham et al. (2007) point out that "cross-cutting partnerships and ongoing involvement by public health, healthcare, and emergency management are a fundamental requirement for success (275)."

It is also worth noting lessons learned from the successful response to the 2014 Boston Marathon bombing. Response success was attributed to "years of planning, training, exercising, and overall collaboration from hundreds of stakeholders (652)." Information sharing among

public health and medical professionals was identified as a key strength, and phone calls, face-to-face meetings, WebEOC, and the health alert network were effectively used by public health and healthcare stakeholders to share information (653). This example serves to show how investment in not only collaborative planning processes, but also trainings and exercises can lead to effective information sharing during a real emergency.

Although this review is focused on the United States, Wynn et al. (2012) provide a helpful example from Canada that may be applicable in the US context (302). During the 2009 H1N1 response, a local public health unit, "worked directly with [Family Health Team] (FHT) management and lead physicians, meeting monthly for six months to develop specific strategies to minimize the second wave's effect on its citizens (302)." All FHTs participated, therefore patients were well represented. This inclusive process and structure enabled FHT managers to act as primary contacts for communication between public health and primary care providers, disseminating relevant information to providers that are part of their respective teams. This strategy resulted in timely communication of relevant information to physicians responsible for over 113,000 patients (55% of the patients in the region), demonstrating the effectiveness of a stakeholder engaged planning process.

Barriers and facilitators to effective communication with technical audiences during emergencies

Consistent messaging in the dynamic public health emergency environment

Given the often dynamic nature of public health emergencies, the ability to maintain consistent messaging remains a significant challenge (643, 265, 647, 656, 661, 669, 668). Several AARs mention how lack of coordination between partners can lead to conflicting or inconsistent messaging, resulting in confusion and frustration among technical audiences. During H1N1, guidance sometimes changed several times a day with multiple guidance documents, forms, and instructions distributed with some documentation remaining valid while others were superseded by new documents (647). Some providers had clinics in border states and often received conflicting messages (669). Regions that established Joint Information Centers struggled to avoid conflicting recommendations with states (661). More coordinated messaging can help prevent information overload, duplication of efforts, or conflicting recommendations (265).

Message amplification

Amplification of public health guidance through media (including social media) has been shown to help facilitate technical guidance. During H1N1, updated information was posted to the Maine CDC website with RSS subscription option and were posted to social media sites (677). These updates were the most utilized communications tool based on findings from an after action survey.

During a 2013 Cyclospora outbreak in Iowa, a combination of media coverage and electronic messaging during the early stages of the outbreak investigation provided public health agencies an opportunity to increase testing for a disease that might not otherwise have been considered by healthcare providers or their patients (269). For instance, "one patient with severe vomiting and diarrhea was discharged without a diagnosis after a 5-day hospital stay and extensive laboratory testing, only to relapse days later. After reading the EPI Update Alert, the

patient's health-care provider ordered Cyclospora testing on the patient, and the result was positive (269)."

Engaging medical societies can also help facilitate effective communication (664, 670, 651). Delaware's 2009 H1N1 response included joint health department and Medical Society of Delaware communication to Delaware physicians and was considered an effective mode for crisis management as "physicians were more likely to use professional channels for getting technical information during a crisis (664)."

Maintenance of distribution lists and redundancies

A commonly cited barrier to effective communication with technical audiences is the lack of pre-existing distribution lists or up-to-date distribution lists (265, 667, 654). For instance many hospitals' points of contact participating in a 2011 pediatric full scale mass casualty incident exercise did not report receiving the HAN or State of Illinois Rapid Electronic Notification (SIREN) alert (643). Additionally, it is often unclear who is on alert distribution lists, especially when there are multiple channels with various permission rights to each platform (e.g., WebEOC, agency email, Everbridge, etc.) (652). Lack of accurate and well-defined distribution lists can hinder access, reach, and timeliness of public health guidance. A lesson learned from Hurricane Harvey was the need to develop and maintain standard distribution lists for healthcare providers, local health departments, executive leadership, and response managers; predetermine routine communications to be sent to each based on recipient need; and to develop an automated system (e.g., RedSky) to ensure all necessary recipients receive the appropriate information (667). Maintaining these lists and systems as routine preparedness activities can save valuable time during responses.

There are also instances in which communication systems fail either due to technical issues or power outages (643, 315, 276, 644, 675). Therefore, redundant individual contact information (e.g., cell phone, email, pager), and redundant systems are critical to ensure technical audiences receive alerts and guidance in a timely manner. For instance, recognizing that reporting systems can malfunction at individual or multiple sites, or system wide, the Boston Public Health Commission moved address books containing key partner contact lists from their internal server to an internet-based email system. Initially, the information was accessible via internal networks only and would have become inaccessible if the server went down (315).

Transparent vetting processes

Unclear vetting processes, roles and responsibilities, and communication channels can also hinder effectiveness of communication (660). During San Franscisco's 2009 response to H1N1, lack of protocols led to confusion over how reports should be reviewed, who should review them prior to release, and the appropriate target audiences for the information (650). Similarly, during the previously mentioned example of the potential Ebola threat in Connecticut, it was unclear what Regional ESF-8's role was in the development and vetting process (658). In the absence of guidance from the health department, ESF-8 developed recommendations based on information available. This concerned the health department because the guidance had not been vetted by the health department prior to dissemination. Vetting processes should, therefore, be formally documented and shared to minimize confusion over roles (652). Furthermore, processes should not be so complex that they hinder timeliness of alerts and guidance. Findings suggest that simplified review protocols and easily customizable alerting frameworks are essential for providing timely decision support to technical audiences (325).

Accessibility

Another barrier mentioned in AARs is the lack of access to platforms such as WebEOC across local, state, and regional levels (657, 656). Establishing this linkage across levels would enhance information sharing between levels. Additionally, even when WebEOC use is limited to a specific locality, ensuring passwords are routinely updated is an important aspect of accessibility. For instance, during the Boston Marathon bombing, "it was discovered that only one Boston community health center had access to WebEOC during the response, as other health center accounts had been suspended due to lack of use (652)."

Adequate resources

Sustaining effective information sharing with technical audiences requires adequate resources. Beyond the necessary technological systems, findings suggest that successful information sharing relies on the availability of critical staff such as Liaison Officers and subject matter experts (646, 662). Mathur et al. (2010) discuss the frequent need to adjust communication strategies during Canada's H1N1 response (288). Additional management support was brought in, teleconference frequency was increased, target audiences were expanded, and on-site expert support was provided. This ability to adapt based on need was contingent on a strong, adequately resourced and supported team with vaccine expertise. Conversely, reliance on a handful of Liaison Officers during a full-scale exercise testing information sharing in the context of a novel respiratory illness was demonstrated to be ineffective (666). Staff were overwhelmed by the sheer volume of calls and unable to meet the demand for information. Many partners were unable to get in touch, further highlighting the need for sufficient human resources to support effective information sharing.

Benefits and undesirable effects of communication mechanisms

Timeliness

AARs and case reports reviewed in this report did not specifically assess the benefits or unintended consequences of specific modes of communication. However, a few attributed improved timeliness to specific communication mechanisms. For instance, Carvey et al. (2009) assert that the use of telephone reporting through the previously mentioned shelter hotline improved timeliness, reporting compliance, accuracy, and staff satisfaction and knowledge (12). Gamache et al. (2010) also identified timeliness as a benefit of sending public health alerts through Health Information Exchange platforms (313). Similarly, Nagykaldi et al.'s (2006) findings from an evaluation of the OKAlert system (a bidirectional, dual-use influenza-like illness (ILI) surveillance and messaging system) indicate more timely and accurate responses to ILI cases (316). Reports suggest that in-person meetings, teleconferences, and webcasts also improve timeliness by providing real-time feedback (664, 670).

Fatigue

Although hotlines were considered effective means of bi-directional information sharing, hotline staff may experience excess fatigue as a result of stress associated with response efforts (652). The after action process following the Boston Marathon bombing recommended training in psychological first aid and triage counseling prior to being assigned to work with traumatized callers. While it is unclear if hotlines specifically for technical audiences lead to the same level

of stress and fatigue, it is possible that working long hours on an incident with high public health impact could lead to similar unintended consequences.

Additionally, Lurio et al. (2010) discuss the potential for alert fatigue if alerts are not targeted and tailored to specific provider types (325). As mentioned earlier, "paralysis by analysis" can also result from an overwhelming amount of information being shared in a short time (658). Furthermore, Delaware reported experiencing a loss of "credibility of the public health community" due to frequent and delayed CDC modifications to recommendations on vaccine distribution resulting from a temporary vaccine shortage (664).

Table 3: Summary of Findings

Key Question	*Synthesized Theme*	*Citations*
Is messaging more effective when technical audiences are engaged in the development of communication plans, protocols, and channels?	There is a growing recognition of the need to better engage stakeholders based on lessons learned; however, few reports examined the effectiveness of such engagement.	657, 658, 669, 664, 672, 673, 665, 674
	Although few reports examined effectiveness, some reports recognized the value of engaging technical audiences during the planning process and evaluating channels of communication	652, 653, 315, 12, 313, 275, 302
What are the barriers and facilitators to effective communication with technical audiences?	Consistent messaging in the dynamic public health emergency environment	643, 265, 647, 656, 661, 669, 668
	Message amplification	664, 670, 651, 269, 677
	Maintenance of distribution lists and redundancies	265, 667, 654, 643, 652, 315, 276, 644, 675
	Transparent vetting processes	650, 658, 652, 325, 660
	Accessibility	652
	Adequate resources	646, 662, 288, 633
When communicating with technical audiences, are some modes or frequencies of messaging associated with benefits or undesirable effects?	Timeliness	12, 313, 316, 664, 670
	Fatigue	652, 325, 658, 664

4.3 Evidence to Decision Discussion

Constructs from the evidence-to-decision framework were also applied when reviewing the AARs and case reports. This section describes considerations related to the values and preferences of technical audiences receiving information; the resources necessary to implement information exchange strategies and the expected net benefit; equity issues associated with different communication channels; and the acceptability and feasibility of communication channels. Some findings are limited by the lack of detail provided in many of the reports and are noted accordingly.

Values and Preferences

The vast majority of AARs and case reports reviewed in this report did not address the values or preferences of technical audiences with regard to information sharing. However, it is evident that technical audiences prefer timely, accurate, consistent information that is easy to navigate and bi-directional (ability to both send and receive information). Alerts and guidance tailored to specific audiences is also preferred to enable ease of translation of information into appropriate action. Additionally, some audiences may want greater flexibility in their application of guidance. For instance in the 2009 H1N1 response in Delaware, it was thought that while physicians look to public health to determine appropriate priority groups for treatment and prophylaxis, they also want flexibility to reevaluate priority groups based on the data available from the state during the progression of the crisis (664). The AAR suggests that doctors prefer direct communication from a credible source and that the majority would look to the department of health or medical society for leadership.

Resources and Net Benefit

As mentioned in the barriers and facilitators section of this report, adequate resources are critical for successful information sharing with technical audiences. This includes everything from phones, radios, computers, servers, software platforms, notification systems, etc., to human resources for hotline management, message development, message delivery, bi-directional communication, and many other functions. Gamache et al. (2010) report that providing public health alerts through community health information exchanges provides a cost savings to public health over the traditional mail-based alert (313). The total cost savings was estimated to be $3,638 for each set of alerts, based on sending 3,085 alerts to providers. However, it may be more relevant to learn about cost savings relative to other electronic mechanisms given advancements in technology. The OKAlert-ILI System was funded by a $50,000 health department contract, and has been made available to participating clinicians at no cost (316). The previously described New York State HERDS system reduced costs by implementing the application within an existing infrastructure used by response partner communities (275). Costs included development ($130,000), annual recurring cost ($200,000) of HERDS, and leveraging of existing multi-million dollar investments into the existing system.

Given how important information sharing is to the success of any public health emergency response, it is evident that resources are worth the net benefit. However, the field would benefit from additional studies focused on the cost effectiveness of specific channels to ensure well-informed investments.

Equity Issues

Overall, equity issues associated with different channels for communicating public health guidance and alerts with technical audiences were not addressed in the AARs or case reports included in this review, highlighting an important evaluation gap. Washington King County's AAR from the 2009 H1N1 response identified an opportunity for "improved relationships with smaller and ethnic pharmacies to expand outreach to ethnic and vulnerable populations (672)". Although this is not directly related to information sharing with pharmacies, improving relationships with technical audiences serving underserved populations may lead to more targeted and tailored information sharing during a public health emergency.

Wynn et al. (2012) are the only authors to explicitly mention equity, stating, "especially during a public health emergency, the health care system must show sensitivity to socioeconomic

circumstance and use an understanding of the determinants of health when developing emergency mitigation strategies (302).” The authors then go on to describe the previously mentioned bidirectional role of Family Health Teams during the 2009 H1N1 response in Ontario. Family Health Teams were able to relay patient needs to public health through communication with primary care providers. The US may be able to apply similar approaches when developing communication channels with technical audiences to promote greater equity.

Acceptability and Feasibility

Further research on the acceptability and feasibility of specific communication channels is needed to determine whether existing innovations (e.g., OKAlert-ILI, Mississippi shelter hotline) are replicable, and how best to improve more traditional communication channels. Some AARs point to simple solutions for making existing channels more acceptable such as posting of webinar highlights on relevant websites, sharing of meeting notes after conference calls, and color-coding of new information in frequently changing guidance documents (677, 667). While these are certainly feasible with minimal resources, additional research is warranted on the acceptability of new more resource-intensive systems during the design and planning phases.

5 Limitations

Findings in this report are limited by the lack of availability of AARs and case reports focused on the specific research questions of interest. AARs and case reports that were indirectly related to public health were helpful in informing findings, however, more directly related reports may have enabled a more nuanced understanding of information sharing specifically in the context of public health. Further research is recommended to address this important research gap.

An additional limitation is the varying level of rigor of the reports. Although some reports mentioned evaluation or research methods, many did not provide sufficient detail or any methods at all. Therefore, there is a potential for bias based on unknown methods. Guidance aimed at improving after action methods and the level of detail included in after action report methods sections is recommended for both transparency and quality purposes. For a quality assessment of after action reports reviewed in this paper, please refer to the commissioned paper entitled *Quality Assessment of After Action Reports: Findings and Recommendations*.

Findings may also be limited by selection bias as only AARs and case reports publically available or volunteered by jurisdictions were included in this review. It is possible that AARs considered too sensitive to post publically could have provided additional or conflicting views. Additionally, there is potential for reporting bias as political considerations may impact what gets included or excluded from AARs. Some AARs may be weighted towards actionable issues as AARs typically focus on identifying corrective actions based on lessons learned. Therefore, it is possible that some challenges were left out on the basis of the ability to act on them.

6 Conclusion

The ability to effectively communicate public health guidance and alerts with technical audiences during an emergency is essential to a successful response. Findings indicate that engaging target audiences in planning processes and tailoring communication channels to better

suit their needs may facilitate more effective information sharing during an emergency. However, the fast-paced nature of emergent public health threats and the corresponding changes in guidance is likely to remain a challenging contextual factor. Ensuring transparent and timely vetting processes, and clear roles and responsibilities among partners in advance of an emergency may help alleviate some of the confusion and frustration that occurs during emergencies. Review findings also strongly suggest that consistency of messaging across federal, regional, state, and local levels, and amongst partners is critical as it can serve to augment or impede the credibility of the message. Therefore, recommendations include finding ways to simplify, streamline, and crosscheck messaging. Additionally, maintenance of up-to-date distribution lists and log in information for communication platforms (e.g. WebEOC); development of redundant communication systems; and enhanced integration of WebEOC among various agencies were also identified as important facilitators for timely and effective communication. Consequently, prioritizing these issues during the preparedness phase is recommended, as well as further research into the effectiveness of specific communication mechanisms.

7 References

Report ID/ Reference

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646 New Hampshire Department of Safety and Department of Health and Human Services. (2009). *Cities Ready Initiative Operation Rapid RX Full-Scale Exercise After Action Report.*

647 New Hampshire Department of Safety and Department of Health and Human Services. (2009). *New Hampshire Spring 2009 H1N1 Response After Action Report/ Improvement Plan.*

648 Minnesota Department of Health. (2013). *Operation Loon Call 2013 After Action Report/ Improvement Plan.*

650 San Francisco Department of Public Health (2010). *Fall/Winter 2009-2010 H1N1 Swine Flu Response After Action Report/ Improvement Plan.*

651 County of San Diego. (2018). *San Diego Hepatitis A Outbreak After Action Report.*

652 Boston Public Health Commission (2013). *2013 Boston Marathon ESF-8 Health & Medical Planning, Response, & Recovery Operations After-Action Report/Improvement Plan.*

653 Massachusetts Emergency Management Agency, Massachusetts Department of Public Health, City of Boston, City of Cambridge, Town of Watertown, Massachusetts Bay Transportation Authority Transit Police Department, Massachusetts National Guard, & Massachusetts State Police (2014). *After Action Report for the Response to the 2013 Boston Marathon Bombings.*

654 Buffalo Hospital & Wright County Public Health. (2013). *Buffalo Hospital Closed POD After Action Report/ Improvement Plan.*

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657 Capitol Region Council of Governments (2016). *Ebola Virus Disease Functional Exercise After Action Report.*

658 Metropolitan Medical Response System Capitol Region Connecticut (2016). *CT Region 3 ESF-8 Ebola Preparedness & Response After Action Report/ Improvement Plan.*

660 Florida Department of Health (2010). *2010 Deepwater Horizon Oil Spill After Action Report/ Improvement Plan.*

661 Multnomah County Health Department. (2010). *H1N1 Fall 2009 MultCo After Action Report/ Improvement Plan.*
662 Minnesota Department of Heath Department. (2014) *DOC FE Flash Floods 2014 After Action Report/ Improvement Plan.*
663 New Hampshire Department of Health and Human Services and Department of Safety (2010). *New Hampshire H1N1 Response After Action Report/ Improvement Plan*.
664 Delaware Division of Public Health (2010). *Novel H1N1 Influenza Delaware Response After Action Report/ Improvement Plan.*
665 Ohio Department of Health. (2010). *Fall 2009 H1N1 Response After Action Report – Improvement Plan.*
666 Tri-County Health Department. (2017). *Public Health Emergency Dispensing Exercise (PHEDEX) After Action Report and Improvement Plan.*
667 Texas Department of State Health Services. (2018). *Hurricane Harvey Response After-Action Report.*
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670 Wisconsin Division of Public Health. (2010). *2009 H1N1 Influenza Response After Action Report/ Improvement Plan.*
672 Public Health – Seattle & King County. (2009) *H1N1 Influenza (Swine Flu) 2009 King County ESF-8 After Action Report.*
673 Blue Earth County Public Health. (2014). *Information Sharing for TB Contact Investigation After Action Report/ Improvement Plan.*
674 Minnesota Department of Health. (2013). *White Powder Incident November 2013 After Action Report/ Improvement Plan.*
675 Ramsey County Public Health. (2014). *Operation Communication Woes After Action Report/ Improvement Plan.*
677 Maine Center for Disease Control and Prevention. (2010). *Maine CDC 2009 H1N1 Influenza Pandemic After Action Summary.*

Appendix A: After Action Report/ Case Report Sorting Tool

Sorting Criteria: Significance	Prioritization	Comments	Reviewer guidance	*Notes*
1. Does the report include information relevant to **information sharing** with technical audiences during a public health emergency?	**High/ Low** ***Yes = High*** ***No = Low***	[Reviewer to provide brief explanation for prioritization]	*Yes = High Priority*: The report provides sufficient relevant information to inform a thematic analysis. It adds context, is meaningful, useful, and may be used to inform decision making *No = Low Priority*: The report either briefly mentions, or does not mention the key areas of interest. Insufficient information to inform a thematic analysis.	*Adapted from AACODS checklist - "This is a value judgment of the item, in the context of the relevant research area"* *Reports categorized as "High" priority will be analyzed by report type (AAR vs Case Report) and key area of interest (IS)* *Reports categorized as "Low" priority will be randomly sampled. The number sampled will be dependent on # of low priority reports and time available. If initial random sample yields new themes, additional reports will be randomly sampled until saturation is reached.* *AARs covering tabletop exercises will be categorized as low priority given that findings from tabletops are not based on real experience or simulations. However, if a tabletop AAR is relevant to the research question, the AAR will be included in the analysis if the specific area of relevance did not otherwise emerge from analysis of the high priority report.* *Some reports may have little to no information related to IS to warrant inclusion into the analysis. These reports will not be included in the analysis.* *Note: Rigor is not used as a sorting criterion because the primary purpose of this AAR/case report review is to synthesize experiential data to add weight to findings from research studies, provide a different perspective from research studies, or to provide the only available perspective concerning specific phenomena of interest. Additionally, reports eligible for the AAR/Case Report thematic analysis are those that have been excluded from the analysis of research studies. Therefore, they already do not meet a certain threshold for rigor.*

Appendix B: Sorted After Action Reports/ Case Reports

ID	AAR Reference	IS Prioritization
641	Multnomah County Health Department. (2009). *'Swine Flu Multco' Spring 2009 H1N1 Response After Action Report/ Improvement Plan.*	Low
642	Becker County Community Health. (2013). *People and Stuff HSEM Region 3 Logistics Exercise After Action Report/ Improvement Plan.*	Low
643	Chicago Department of Public Health, Illinois Department of Public Health, & Metropolitan Chicago Healthcare Council. (2011). *Illinois Hospitals Pediatric Full-Scale Exercise After Action Report.*	High
644	Montana Department of Public Health and Human Services (2014). *Big Sky Push II Full Scale Exercise After Action Report/ Improvement Plan.*	High
645	United States Environmental Protection Agency. (2012). *Nevada 2012 Bio-Hazard Response and Recovery After Action Report*	Low
646	New Hampshire Department of Safety and Department of Health and Human Services. (2009). *Cities Ready Initiative Operation Rapid RX Full-Scale Exercise After Action Report.*	High
647	New Hampshire Department of Safety and Department of Health and Human Services. (2009). *New Hampshire Spring 2009 H1N1 Response After Action Report/ Improvement Plan.*	High
648	Minnesota Department of Health. (2013). *Operation Loon Call 2013 After Action Report/ Improvement Plan.*	High
649	Scott County Public Health. (2014). *Operation Water Woes Tabletop Exercise EOC Operations/PIO After Action Report/ Improvement Plan.*	Low
650	San Francisco Department of Public Health (2010). *Fall/Winter 2009-2010 H1N1 Swine Flu Response After Action Report/ Improvement Plan.*	High
651	County of San Diego. (2018). *San Diego Hepatitis A Outbreak After Action Report.*	High
652	Boston Public Health Commission (2013). *2013 Boston Marathon ESF-8 Health & Medical Planning, Response, & Recovery Operations After-Action Report/Improvement Plan.*	High
653	Massachusetts Emergency Management Agency, Massachusetts Department of Public Health, City of Boston, City of Cambridge, Town of Watertown, Massachusetts Bay Transportation Authority Transit Police Department, Massachusetts National Guard, & Massachusetts State Police (2014). *After Action Report for the Response to the 2013 Boston Marathon Bombings.*	High
654	Buffalo Hospital & Wright County Public Health. (2013). *Buffalo Hospital Closed POD After Action Report/ Improvement Plan.*	High
655	Tri-County Health Department. (2017). *Community Inclusion Point of Dispensing (POD) Public Health Emergency Distribution Exercise.*	Low
656	Capitol Region Council of Governments (2017). *Ebola Virus Disease Full Scale Exercise After Action Report.*	High
657	Capitol Region Council of Governments (2016). *Ebola Virus Disease Functional Exercise After Action Report.*	High
658	Metropolitan Medical Response System Capitol Region Connecticut (2016). *CT Region 3 ESF-8 Ebola Preparedness & Response After Action Report/ Improvement Plan.*	High
660	Florida Department of Health (2010). *2010 Deepwater Horizon Oil Spill After Action Report/ Improvement Plan.*	High
661	Multnomah County Health Department. (2010). *H1N1 Fall 2009 MultCo After Action Report/ Improvement Plan.*	High
662	Minnesota Department of Heath Department. (2014) *DOC FE Flash Floods 2014 After Action Report/ Improvement Plan.*	High
663	New Hampshire Department of Health and Human Services and Department of Safety (2010). *New Hampshire H1N1 Response After Action Report/ Improvement Plan.*	High
664	Delaware Division of Public Health (2010). *Novel H1N1 Influenza Delaware Response After Action Report/ Improvement Plan.*	High
665	Ohio Department of Health. (2010). *Fall 2009 H1N1 Response After Action Report – Improvement Plan.*	High

666	Tri-County Health Department. (2017). *Public Health Emergency Dispensing Exercise (PHEDEX) After Action Report and Improvement Plan.*	High
667	Texas Department of State Health Services. (2018). *Hurricane Harvey Response After-Action Report.*	High
668	Texas Department of State Health Services (2010). *Texas Department of State Health Services Response to the Novel H1N1 Pandemic Influenza After Action Report.*	High
669	Wisconsin Hospital Emergency Preparedness Program. (2010). *After Action Report (AAR) for H1N1 Influenza.*	High
670	Wisconsin Division of Public Health. (2010). *2009 H1N1 Influenza Response After Action Report/ Improvement Plan.*	High
671	Anoka County. (2014). *Anoka County Operation Water Woes After Action Report/ Improvement Plan.*	Low
672	Public Health – Seattle & King County. (2009) *H1N1 Influenza (Swine Flu) 2009 King County ESF-8 After Action Report.*	High
673	Blue Earth County Public Health. (2014). *Information Sharing for TB Contact Investigation After Action Report/ Improvement Plan.*	High
674	Minnesota Department of Health. (2013). *White Powder Incident November 2013 After Action Report/ Improvement Plan.*	High
675	Ramsey County Public Health. (2014). *Operation Communication Woes After Action Report/ Improvement Plan.*	High
676	Bloomington Public Health. (2014). *Operation Water Woes After Action Report/ Improvement Plan.*	Low
677	Maine Center for Disease Control and Prevention. (2010). *Maine CDC 2009 H1N1 Influenza Pandemic After Action Summary.*	High

ID	Case Report Reference	IS Prioritization
12	Cavey, A. M. J., Spector, J. M., Ehrhardt, D., Kittle, T., Mcneill, M., Greenough, P. G., & Kirsch, T. D. (2009). Mississippi's Infectious Disease Hotline: A Surveillance and Education Model for Future Disasters. *Prehospital and Disaster Medicine*, *24*(1), 11–17.	High
265	Association of State and Territorial Health Officials. (n.d.) *Addressing Communication Challenges During an Infectious Disease Emergency Response: State Experiences from the H1N1 Pandemic*. Arlington, VA.	High
269	Kalas, N., & Quinlisk, P. (2013). Notes from the Field. *MMWR*, *62*(30), 613–614.	High
275	Gotham, I. J., Sottolano, D. L., Hennessy, M. E., Napoli, J. P., Dobkins, G., Le, L. H., … Fage, B. I. (2007). An Integrated Information System for All-Hazards Health Preparedness and Response: New York State Health Emergency Response Data System. *Journal of Public Health Management and Practice*, *13*(5), 486–496.	High
276	Gursky, E., Inglesby, T. V, & O'Toole, T. (2003). Antrax 2001: Observations on the Medical and Public Health Response. *Biosecurity and Bioterrorism: Biodefence, Strategy, Practice, and Science*, *1*(2), 97–110.	High
288	Mathur, A., & Beckerman, K. (2010). Moving up, moving down, communications flow to and from mass immunization clinics. *Canadian Journal of Infectious Diseases & Medical Microbiology*, *21*(4), 209.	High
296	Ringel, J. S., Trentacost, E., & Lurie, N. (2009). How well did health departments communicate about risk at the start of the swine flu epidemic in 2009? *Health Affairs*, *28*(4), 743–750.	Low
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302	Wynn, A., & Moore, K. M. (2012). Integration of Primary Health Care and Public Health During a Public Health Emergency. *American Journal of Public Health*, *102*(11), 9–12.	High
311	Daniel, J. B., Gadam, P., Yih, W., Mandl, K., Demaria, A., & Platt, R. (2005). Connecting Health Departments and Providers : Syndromic Surveillance's Last Mile. *MMWR*, *54*, 147–150.	High
312	Doniger, A. S., Labowitz, D., Mershon, S., & Gotham, I. J. (2001) Design and Implementation of a Local Health Alert Network. *Journal of Public Health Management and Practice, 7*(5), 64-74.	Low
313	Gamache, R., Stevens, K. C., Merriwether, R., Dixon, B. E., & Grannis, S. (2010). Development and Assessment of a Public Health Alert Delivered through a Community Health Information Exchange. *Public Health Informatics*, *2*(2), 1–13.	High
315	Mckenna, V. B., Gunn, J. E., Auerbach, J., Brinsfield, K. H., Dyer, K. S., & Barry, M. A. (2003). Local Collaborations : Development and Implementation of Boston's Bioterrorism Surveillance System. *Journal of Public Health Management and Practice*, *9*(5), 384–393.	High
316	Nagykaldi, Z., Mold, J. W., Bradley, K. K., & Bos, J. E. (2006). Bridging the Gap Between Public and Private Healthcare: Influenza-like Illness Surveillance in a Practice-based Research Network. *Journal of Public Health Management and Practice*, *12*(4), 356–364.	High
322	Jacobs, L. M., & Burns K. J. (2006). Terrorism Preparedness: Web-based Resource Management and the TOPOFF 3 Exercise. *Journal of Trauma, Injury, Infection, and Critical Care, 60*, 566-572.	Low
325	Lurio, J., Morrison, F. P., Pichardo, M., Berg, R., Buck, M. D., Wu, W., … Calman, N. (2010). Using electronic health record alerts to provide public health situational awareness to clinicians. *Journal of the American Medical Informatics Association, 17*, 217–219.	High