Science in Emergency Response at CDC: Structure and Functions

Recent high-profile activations of the US Centers for Disease Control and Prevention (CDC) Emergency Operations Center (EOC) include responses to the West African Ebola and Zika virus epidemics.

Within the EOC, emergency responses are organized according to the Incident Management System, which provides a standardized structure and chain of command, regardless of whether the EOC activation occurs in response to an outbreak, natural disaster, or other type of public health emergency. By embedding key scientific roles, such as the associate director for science, and functions within a Scientific Response Section, the current CDC emergency response structure ensures that both urgent and important science issues receive needed attention. Key functions during emergency responses include internal coordination of scientific work, data management, information dissemination, and scientific publication.

We describe a case example involving the ongoing Zika virus response that demonstrates how the scientific response structure can be used to rapidly produce high-quality science needed to answer urgent public health questions and guide policy. Within the context of emergency response, longer-term priorities at CDC include both streamlining administrative requirements and funding mechanisms for scientific research. (*Am J Public Health*. 2017;107:S122–S125. doi:10.2105/AJPH.2017.303951)

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Between 2003 and 2012, the US Centers for Disease Control and Prevention (CDC) Emergency Operations Center (EOC) activated 55 times in response to public health emergencies.[1] Activations of the EOC can be triggered by foreign or domestic events, or may include both foreign and domestic elements because of disease spread across national borders. Activations may be reactive or proactive in response to natural disasters, infectious disease outbreaks, events of national security importance, mass gatherings, and man-made disasters in which the public's health and safety is at risk.[1] More recently, the EOC has been activated in support of two international public health emergencies—outbreaks of Ebola virus in 2014 and Zika virus in 2016. As of January 2017, the Zika activation is ongoing, as is a December 2011 activation in support of the Global Polio Eradication Initiative.

There are three levels of EOC activation. Level 3 (lowest), requires modest surge staffing and public health emergency management support related to operations and logistics. The polio activation is currently Level 3, and entails support for field deployments as well as program coordination. Level 2 requires surge staff for multiple functional teams, additional emergency management support, or both. Level 1 (highest) typically occurs as part of a comprehensive agency-wide response and involves support for interagency coordination and large numbers of deployments for field operations. The Zika response began at Level 1 to facilitate coordination across multiple parts of CDC with diverse expertise, as well as to provide support to US territories affected by the outbreak. It is not uncommon for the EOC to support multiple activations simultaneously.

Activation of the EOC provides a clear signal to the broader public health community of CDC's view of the urgency of a response. Beyond providing a physical locus for response coordination and response coverage for clinical or public health inquiries, EOC activation allows the agency to mobilize personnel and, at times, financial resources in support of emergency response functions. Another essential function of the EOC is to enhance information sharing among internal and external emergency response partners. For example, when the emergency is a natural disaster, the Federal Emergency Management Agency plays a major role, as do police, fire, and public works departments at the state and local levels. In this commentary, which draws on a review of selected publications as well as the experience of the authors, we will describe how scientific functions and priorities are embedded within the current CDC emergency response framework, and identify possible future agency directions for emergency response research and practice.

SCIENCE IN THE EOC STRUCTURE

For a science-based agency such as CDC, ensuring that scientific functions are incorporated into the structure of emergency responses is paramount. Regardless of the public health emergency or event for which the activation has occurred, the EOC operates according to principles of the Incident Management System. Organizing all emergency responses according to principles of Incident Management System clarifies roles, responsibilities, chain of command, and accountability.[2]

The Incident Management System (Figure A, available as a supplement to this article at http://www.ajph.org) is led by an incident manager, typically a senior CDC subject matter

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expert with response-specific knowledge as well as leadership experience. For an extended EOC activation, time-limited assignments may be established so that those serving in incident manager or other response leadership roles can rotate on and off the response. The Incident Management System allows flexibility in leadership—for example, permitting unified command for responses led by multiple agencies. The Incident Management System also facilitates coordination of staff and expertise across multiple organizational components of CDC, each of which has its own specialized programs and areas of public health practice. For each emergency response, an associate director for science is also appointed to provide scientific coordination, consultation, and document approval. The reporting structure of the Zika response and the positions of the incident manager and associate director for science are shown schematically in Figure A.

The EOC associate director for science performs a number of core functions. These include oversight of scientific quality assurance, including manuscript and guidance document approval. The scope of document review includes not only scientific reports, but also key policy documents such as emergency use authorizations that enable use of new preventive, diagnostic, and treatment modalities.[3] There are also needs to coordinate scientific content review by diverse subject matter experts, provide consultations to authors and editors on timing and process considerations for proposed *Morbidity and Mortality Weekly Report* (*MMWR*) articles and other key scientific materials, and advise Incident Management System leadership on prioritization of complex scientific documents. In addition, as part of maintaining high ethical standards in the conduct of science, the associate director for science monitors compliance of scientists working on the response with scientific regulations and policies including protection of human participants, the CDC scientific misconduct policy, Office of Management and Budget regulations, and the Privacy Act.

Within the Incident Management System, the Scientific Response Section is where most primary scientific work occurs. The Scientific Response Section organizational chart for the Zika virus response is shown as an inset within Figure A. As part of the Zika Scientific Response Section, epidemiologists, laboratory scientists, entomologists, clinicians, and other health professionals with expertise in arboviral disease, pregnancy, or birth defects are organized into task forces, which are under the leadership of the incident manager and deputy incident managers. Task forces serve a crucial information-sharing role by communicating summarized information throughout the Incident Management System, through daily reports using a standard template. A chief science officer coordinates the Scientific Response Section research functions and serves as a science advisor (Figure A, inset). The chief science officer provides guidance to both the incident manager and the task forces on the strategic direction of the scientific effort as well as subject matter–specific technical content. In some responses, the chief science officer is the leader of the Scientific Response Section. Across different emergency responses and even within the same response over time, the number of members of each task force, internal organization, and reporting structure of the Scientific Response Section may differ. The Zika virus response has been notable for its complexity, with the need to integrate subject areas ranging from prevention of birth defects to vector control.[4]

The broad mission of the Scientific Response Section within the Incident Management System is to manage scientific activities, including operational requirements such as public health surveillance, laboratory testing, medical countermeasures (e.g., vaccines, prophylactic or treatment medications, ventilators, and personal protective equipment), travelers' health, and state coordination activities. In some emergency responses, international coordination with ministries of health or nongovernmental organizations may be required as well. The Scientific Response Section mission also includes initiation and justification of scientific research, coordination of extramural research and external peer reviews, and publication of scientific documents. For key scientific documents generated by the emergency response, CDC's Office of the Associate Director for Science provides final agency-level scientific review and clearance—for example, approving all content, including guidelines and recommendations, published in *MMWR*, which represents CDC policy.[5]

One of the recurring functions of the Scientific Response Section is maintaining scientific situational awareness for all who are engaged in the work of the emergency response. Both raw data and synthesized scientific information can evolve rapidly as emergency responses unfold. Situational awareness, a component section within the Incident Management System structure (Figure A), is produced in the form of reports and visual displays through integration and analysis of data from multiple sources. Data sources may include not only traditional surveillance and laboratory testing data, but also information on relevant health or public health infrastructure and facilities, population data derived from census reports or other sources, and environmental exposure data. Information can be analyzed in multiple ways, including spatially, to build the response knowledge base and inform decision-making.[6] Another aspect of situational awareness that may be led by the associate director for science is monitoring PubMed and other citation databases for publication of new findings, and sharing relevant references across the Incident Management System structure. The CDC Public Health Library and Information Center,[7] which can set up automated PubMed alerts and perform customized searches of the scientific literature, is a crucial partner in maintaining scientific situational awareness.

CASE STUDY: ZIKA VIRUS AND MICROCEPHALY

The generation and dissemination of new scientific knowledge, including research findings, is an important aspect of emergency response at CDC. During the early phase of the Zika virus EOC activation, agency publications stated only that a link between Zika virus infection and microcephaly in infants who might have been prenatally infected was suspected, rather than confirmed.[8] The medical and

public health communities urgently needed clarity on whether the observed association was more likely to represent causation or merely correlation. To answer the question of whether Zika virus was causally associated with microcephaly and other birth defects, a small working group was formed within the Scientific Response Section. The group was led by a birth defects subject matter expert, who also had both emergency response leadership and editorial experience. The working group included the response incident manager and other key scientific leaders with expertise in vector-borne diseases, maternal and child health, and birth defects epidemiology.

After the appropriate causality framework was identified by the group lead, the following activities were rapidly completed: drafting of a manuscript, internal presentation and review of findings at the incident manager weekly meeting, formal clearance by the Incident Management System associate director for science, and review and final document approval by CDC's Office of the Associate Director for Science. The manuscript was subsequently submitted to and published in a high-profile biomedical journal following expedited peer review.[9] The authors concluded that "a causal relationship exists between prenatal Zika virus infection and microcephaly and other serious brain anomalies," while also noting that a number of crucial unanswered questions about the epidemiology and pathophysiology of Zika virus infection remained. Notable aspects of this process are that it combined the organized structure of an emergency response with the rapid turnaround characteristic of CDC outbreak and field responses while maintaining scientific quality and rigor.

This case study demonstrates the beneficial impact of science conducted within the Incident Management System setting. Beyond being widely cited, the article[10] has led to a general scientific consensus that Zika virus can cause microcephaly and other serious brain abnormalities in fetuses and infants infected in utero. This has encouraged more specific research on the pathophysiology of the virus, and has helped focus other research on potential treatment and prevention modalities.[9,11]

RESEARCH IN EMERGENCY RESPONSE

Part of science leadership in the public health context is to find an appropriate balance between immediate data collection and information needs, such as that needed for situational awareness, notification of public health partners, and day-to-day Incident Management System decision-making, with the need of the broader public health and health care communities for generalizable knowledge, including the conduct of original research. One underappreciated role of the scientific enterprise in public health emergency response is to identify critical knowledge gaps, as well as to classify and prioritize research questions. In the Zika and Ebola virus responses, research was used to inform shorter-term response objectives, including development of diagnostic tests and studies of viral persistence in semen and other bodily fluids.[12]

The role of research in public health emergency response has received increasing attention in policy and senior leadership circles in recent years through a US Department of Health and Human Services initiative to enhance "science preparedness."[13] CDC initiatives to better support emergency preparedness and response include efforts to streamline administrative and regulatory processes (e.g., institutional review board and Paperwork Reduction Act submissions) while maintaining required research oversight. Operationally, this might involve revising standard operating procedures, enhancing coordination and expediting of regulatory reviews, creating new ways to design and execute research more quickly, and revising data management procedures. Other agency-wide priorities include rapid development of research agendas in a response, in coordination with the use of expedited contract or other financial mechanisms, to more rapidly fund intramural or extramural research. Other cross-cutting issues that have been identified by CDC and Department of Health and Human Services analysis include planning for the needs of vulnerable and at-risk populations, including children, in public health emergencies,[14] and appreciation of the widening role of mathematical modeling in the emergency response decision-making process.[15,16]

CONCLUSIONS

With use of the Incident Management System platform, scientific roles and functions are built into existing CDC emergency management structures. The Incident Management System provides an organizational framework that is consistent from activation to activation, as well as the flexibility to allow each EOC activation to have different Scientific Response Section composition and leadership. Science leadership in emergency response is needed to provide situational awareness, oversee quality assurance for both data and publications, and generate and synthesize new scientific knowledge. Emergency response organizational principles and structures can have important public health benefits. In public health emergencies, scientific findings needed by public health staff and clinicians can be shared through a variety of public access platforms including agency publications, especially *MMWR*. AJPH

CONTRIBUTORS

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HUMAN PARTICIPANT PROTECTION

Human participant protection was note required because the work described here does not involve research on human participants.

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