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Utilization of Syndromic Surveillance with Multiple Data Sources to Enhance Public Health Response

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As part of an International Society for Disease Surveillance (ISDS) project to support member-initiated consultations on priority unresolved questions in the field of syndromic surveillance research, development, or practice, the Duval County Health Department obtained ISDS support to address the use of syndromic surveillance data, in combination with other human health and veterinary surveillance data, environmental sampling data, and plume modeling results, in the event of an airborne bioterrorist attack. The Duval County Health Department convened several state and local Florida public health officials to address this topic in the context of a hypothetical bioterrorist attack scenario in Duval County. The objective of this consultation was to develop expert, consensus-based recommendations for use of syndromic surveillance in combination with other data sources to improve situational awareness in the event of a large-scale public health emergency.

While the practice of establishing or adapting surveillance systems to support outbreak management is well established, the discussions highlighted the absence of criteria for assessing the utility of various surveillance systems for situational awareness during a public health crisis. The breadth of data sources considered in this consultation—traditional and newer syndromic approaches to human health surveillance, environmental and atmospheric information combined into plume models, and multiple sources of animal health data—point to the potential utility of integrating widely different streams of information and to the challenges in assuring that the mix of data can be used effectively in a crisis.

Medical Subject Headings: Bioterrorism; Disease Notification; Epidemiology Surveillance; Evaluation Methodology**;** Referral and Consultation.

OBJECTIVE

The objective of this consultation was to develop expert, consensus-based recommendations for use of syndromic surveillance (SS) in combination with other human health, animal health, and environmental data sources to improve situational awareness in the event of a large-scale public health emergency. The consultation, convened by the Duval County, Florida, Health Department, involved other local and state public health officials from Florida who addressed this question in the context of a hypothetical bioterrorist (BT) attack scenario in Duval County. Insights arising from the consultation will be used to strengthen public health surveillance capacities as part of both local and state emergency preparedness efforts in Florida. The approach used by the consultation may be useful to other health departments seeking to enhance their emergency situational awareness capacity.

BACKGROUND

In the event of a large-scale public health crisis, successfully detecting and assessing health threats and monitoring population health status over a sustained period of time is likely to require integration of information from multiple sources. In addition, this information must be shared at varying levels of detail both among different agencies or organizations within an affected locality and among response participants at local, state, and federal levels of government (1).

In early 2007, the International Society for Disease Surveillance (ISDS) proposed a project to support member-initiated consultations on priority unresolved questions in the field of SS research, development, or practice. The Duval County Health Department sought and obtained ISDS support to address the use of SS data in combination with other human health and veterinary surveillance data, environmental sampling data, and plume modeling results in the event of an airborne BT attack. To date, the development of SS in Florida has mainly focused on systems that monitor information from emergency department (ED) visits. In addition, because SS development was decentralized and managed primarily by county health departments, various systems were used in Florida, including ESSENCE (2,3), STARS (4), EARS (5) and BioDefend (6,7).

Questions addressed by the participants included the following:

- What are the available data sources and their respective strengths and limitations? These include SS systems, reportable disease and sentinel systems for routine and ad hoc public health surveillance, environmental monitoring systems, laboratory testing of environmental and human or veterinary specimens, and plume modeling.
- How can these multiple information resources be used together to develop a composite situational "picture" throughout the course of a large-scale public health crisis?
- How will these data sources be accessed and maintained in the event of a large-scale public health crisis that may be sustained for a period of days or weeks, taking into account possible stresses on public health staff and public health partners?
- How will information and insights from these data be shared among local and state public health officials and with federal officials?

The discussion during the consultation raised additional questions regarding situational awareness capacity. Evaluation strategies have been developed for surveillance systems with respect to reporting of cases of disease or the early detection of disease outbreaks (8,9). To date, specific strategies are lacking for evaluating the utility of systems originally designed for public health surveillance for the somewhat different function of situational awareness. This function includes monitoring population health and informing the public health response over a sustained crisis period. While this consultation primarily focused on Duval County and Florida, the process of this consultation may be useful to other local and state health departments in adapting surveillance systems to the needs of situational awareness.

Consultation Process

The panel discussion was held in Jacksonville, Florida, on August 20–21, 2007. Jacksonville is coextensive with Duval County. According to 2006 census estimates, Jacksonville/Duval County had a population of approximately 795,000. The Jacksonville metropolitan area had a population of >1.3 million. Jacksonville is a rail, air, and highway hub and a busy port of entry, with an international airport, naval bases, ship repair yards, and extensive freight-handling facilities.

Panel members included representatives of the Florida Department of Health (FDOH) Bureau of Epidemiology, Bureau of Environmental Public Health Medicine, Bureau of Laboratories, and Office of Emergency Operations, Tallahassee, Florida; Duval County Health Department (DCHD) Epidemiology Program and Emergency Preparedness Program; Miami-Dade CHD Epidemiology Program; the University of South Florida; and DataSphere LLC, an information services vendor that developed an SS application used in Duval County. The discussions were alternatively moderated by representatives from the DCHD, FDOH, and ISDS. Panel members included epidemiologists responsible for managing surveillance systems, laboratorians, environmentalists, and emergency response managers (a complete list of panel members is provided in the Appendix). Several have roles that interact with federal agencies.

The discussion was organized around a hypothetical BT attack in Jacksonville. The scenario involved large-scale clandestine airborne dissemination of aerosols containing both *Yersinia pestis* and *Francisella tularensis*, both CDC Category A bioterrorism agents. The scenario release was initially recognized by ongoing BioWatch environmental monitoring, with cases of plague or tularemia in area residents occurring over the following days. As the scenario progressed, updates were provided to drive the discussion, such as information about the location of detecting equipment, wind direction, and specifics of initial positive laboratory results and their subsequent confirmation. This scenario was employed to represent a worst-case situation that would maximally stress environmental and laboratory monitoring and epidemiologic response procedures.

As the discussion scenario unfolded, participants gave brief presentations about several information resources. Participants considered how the information from these systems would be communicated among local, state, and federal public health officials, how the information would be used in making critical response decisions, and how the systems would be maintained at various stages during an event from initial response to eventual postevent recovery. The specific information sources considered include:

- Laboratory systems that support environmental monitoring, eg, the BioWatch system (10,11), and human and veterinary specimen testing
- Use of plume modeling tools to enhance BioWatch environmental detection of a release of pathogens into the air (10). These help users interpret the significance of a confirmed biological event detected by BioWatch and other environmental monitoring systems. They can then be used to evaluate the threat to public health, the extent of the contamination, and the choices for response decisions (12).
- SS ED data systems
- Florida Poison Information Center Network data
- Reportable disease data, including electronic laboratory reporting
- Ad hoc active surveillance for specific health outcomes of interest in a crisis
- Veterinary health data

At the time of the consultation, wildfires in South Georgia and adjacent parts of Florida had recently exposed residents of Jacksonville to relatively high levels of smoke, raising concerns about health effects and potential triggering of exacerbations of disease in people with underlying respiratory illnesses. The wildfires had led epidemiologists to try to use several of the information resources under consideration here to assess the health impact of the fires. The response management questions that were of concern were similar to those that might be prompted by a bioterrorist attack. For example, the possibility of using ED SS data to assess any health impacts of the smoke on people with asthma or other chronic pulmonary diseases. This discussion also raised questions about the flexibility and sensitivity of the ED SS system, which had been designed to detect and monitor infectious diseases, not to detect and monitor potential changes in trends in noninfectious complications of environmental exposures.

General Observations

Three general themes quickly emerged in the discussions and remained apparent throughout the two-day deliberations.

First, while many participants had previously participated in tabletop exercises that probed questions related to their specific disciplines or programs in much greater depth than considered at this meeting, none had participated in a broadly cross-cutting discussion that required simultaneous consideration of different "pieces of the puzzle" with respect to multiple information resources and their use by emergency response managers.

Second, it was apparent that prior meetings and exercises had focused largely on the initial detection and confirmation of BT events and the initial assessment and response, but not on the longer-term maintenance of surveillance and attendant needs to redirect or refocus surveillance at different stages in an event. As manifest from the discussion scenario, these stages may include intensive epidemiologic and laboratory assessment of people with initial cases of attack-related disease, collection of much more limited information about affected people during a phase when large numbers of cases of illness are occurring and surveillance resources are maximally stressed, and eventual assurance that attack-related exposures and associated illness have ceased.

Third, there is a broader need for criteria that can be used to define and evaluate public health situational awareness capacity.

The deliberations successfully identified vulnerabilities in protocols for accessing and communicating information from multiple sources among response participants in different locations, in parts of organizations (eg, laboratory, epidemiology, emergency response management), or in different levels of government (eg, local and state) over the course of an event. Ironically, in some instances procedures for direct communication to the CDC and the Department of Homeland Security, two federal agencies, were clearer than procedures for communication among local and state officials.

Specific Observations

1. **Public Health Laboratory.** Participants generally expressed confidence about their capacity to respond to an initial positive "signal" from environmental air sampling for biological agents and to initiate and complete procedures to confirm and communicate those results. Concerns were voiced about the capacity to meet anticipated surges in demand for laboratory testing for both human and environmental specimens throughout the course of the response to a large-scale BT event.

   Similarly, procedures for communicating initial positive findings to the federal government were generally clear, but procedures for assuring adequate communication of laboratory testing results among local, state, and federal participants over the longer-term course of a response were less clear. Insufficient connections among various existing electronic reporting systems for environmental and human laboratory results, notifiable diseases, and outbreak investigations could hinder communication across agencies. For example, there was no clear plan for storage, retrieval, analysis, or sharing of ongoing positive and negative BioWatch sensor results past the initial detection phase. Following the recognition of an event, both positive and negative test results may be of importance in documenting whether potential exposure risks or occurrence of disease are waning.

2. **Plume Modeling.** Atmospheric measurement and modeling tools can contribute substantially to informing emergency responses in the minutes to hours after an occurrence (13). In the event of the detection of a biological agent through environmental sampling, the plume modeler may be used to draw conclusions about where the biological agent was released, thus assisting efforts to determine where exposures may have occurred and where additional exposures may occur in the near term. If a site of release is suspected or known, additional predictions can be made about the future spread of contamination. However, key factors required to develop accurate models such as the size, elevation, and timing of the release will likely be unknown, requiring the use of assumptions about these parameters in order to develop the model (14).

   Given these uncertainties and the resulting ambiguities in any plume model, participants agreed that plume models would be useful to help frame the understanding of exposure risks in a community, but such modeling would unlikely serve as a sole or definitive determinant for decisions about evacuations or use of prophylactic agents. Instead, the main use of plume modeling may be to inform where surveillance efforts should be focused.
3. **Syndromic and Ad Hoc Surveillance.** Panelists considered how SS could be used in conjunction with other surveillance methods to enable situational awareness throughout each stage of an event, including both initial detection of an event and support for active case finding. In the early stages of an event, there is likely to be intense interest in carefully evaluating people with cases of the suspect disease. Such cases may be reported by physicians, detected through electronic laboratory reporting of positive human laboratory results, or detected through follow-back to persons detected in a SS system. Such active surveillance often casts a broad net to find cases when reporting completeness is at a premium, as in the effort to find inhalational anthrax cases in 2001 (15).

   Later, if the event proves to be large, only less detailed information about the overall size and impact of the event might be needed. Thus, SS systems may have different utilities at different stages of an event: for initial event detection and as a supplement to ad hoc active case finding efforts during initial stages, and as a broader indicator of community-wide health impacts later in the event. Regardless of the stage of an event, the flexibility of syndromic systems to adjust syndrome classification criteria to fit evolving surveillance needs may be critical.
4. **Veterinary Health Data.** Zoonotic infections are very important as emerging human pathogens and as potential BT agents. Potential agents used is BT attacks may in themselves pose a significant risk to agriculture. (16,17). Thus, participants considered several potential sources of animal health data: pets, stray or feral animals, agricultural flocks or herds, and wildlife. While data on pets may be relatively accessible from community veterinary practices, household pets may not be the population of animals most vulnerable to a BT attack. In contrast, stray or feral animals may be more vulnerable due to poorer underlying health and greater outdoor environmental exposures, but these animals are less likely to be seen at veterinary clinics. Illness in stray or feral animals may be most apparent from an increase in dead animal complaints made to animal control services.

   In the event of a BT event in a rural or semirural area, agricultural herds or flocks may be affected depending on the nature of attack and plume direction. Understanding patterns of morbidity or mortality in agricultural herds or flocks (as well as understanding the importance of detection of certain pathogens in environmental air sampling) requires prior understanding of locale-specific endemic infections among both commercially raised and wild animals. Participants agreed that despite the potential utility of veterinary information, the main limitation to their use is they are not easily assembled for quick analysis in the event of a crisis.
5. **Wildfires.** Earlier in 2007, wildfires in South Georgia and north Florida had led to intense smoke exposures in the Jacksonville area, prompting public health assessments and response activities that were analogous to some of the response activities considered during the meeting in the context of a potential BT attack. Issues included the role of public health and environmental health agencies in issuing public advisories and the role of SS in assessing human health effects of smoke exposure. During the wildfires, the primary source of information used to provide health protection guidance to the public was air quality data, not human health data.

   The ED SS systems in Duval County did not detect an increase in the respiratory syndrome category, despite claims by a prominent local ED physician who was quoted in the local media. The inability of the SS system to detect increases in ED visits due to respiratory illness triggered by smoke exposures, particularly among people with underlying respiratory diseases such as asthma, may have been the result of several factors. Perhaps the smoke exposure was not as intense as feared. The existing system was designed to report symptoms attributed to acute infectious causes rather than aggravation of underlying chronic diseases. The syndrome classification procedures were not sufficiently flexible to adapt to this situation. Public service announcements advised staying indoors, especially for those with underlying respiratory conditions, which may have reduced exposure or may have deterred some from seeking care.

DISCUSSION

Early detection of a BT event can allow for timelier implementation of control measures. Timely monitoring of population health effects throughout the course of an event, regardless of how the event is detected, may be critical for allocating health care resources and assessing the impact of mitigation efforts (18). Integration of information from various data sources may enable public health officials to draw a more complete picture of human health impacts (19).

Many participants in this consultation had participated in previous exercises or planning discussions but without representation from such a mix of disciplines. Prior discussions had emphasized the initial detection, assessment, and response to a potential BT attack. This consultation presented a broader mix of perspectives and it considered not only the initial phase of a response but also the full course of a large-scale bioterrorism-related epidemic. Much of the discussion focused on the next steps to be taken by Florida state and local officials to address potential vulnerabilities identified by the deliberations. Officials in other states may similarly benefit from broadening preparedness discussions to consider how multiple sources of data could be sustained and used throughout a public health crisis.

The CDC has developed guidelines for evaluating the utility of SS systems for early epidemic detection (8). The concept of situational awareness implies a broader use of information derived from surveillance systems throughout the course of an event. The practice of establishing or adapting surveillance systems to support outbreak management is well established, but the discussions highlighted the absence of criteria for assessing the utility of various types of surveillance data for situational awareness during a public health crisis. Likewise, while the practice of combining multiple data sources to paint a composite picture of a health problem is common, the breadth of data sources considered in this consultation—traditional and newer syndromic approaches to human health surveillance, environmental and atmospheric information combined into plume models, and multiple sources of animal health data—points to the potential utility of integrating widely different streams of information. There will also be challenges in assuring that the mix of data can be used effectively in a crisis.

These observations led to several general recommendations from the meeting (beyond recommendations that were more specific to local and state officials in Florida).

- First, preparedness officials in other states should assess whether they are poised to make the best possible use of information from human, animal, and environmental sources.
- Pre-event consideration of potential sources of information and the expertise necessary to make the best use of these data should be used to identify gaps in the ability to compile and interpret these data for the benefit of emergency response managers.
- Such consideration should focus not just on the initial stages of a crisis but the full course of a crisis given potential evolution in information needs and capacities to sustain information systems.

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REFERENCES

1. Teutsch SM, Churchill RE. *Principles and Practice of Public Health Surveillance. Activities in the Public Health Arena*. 2nd ed.. New York, NY: Oxford University Press; 2000:89–90.
2. Lombardo J, Burkom H, Elbert E, Magruder S, Lewis SH, et al. A systems overview of the Electronic Surveillance System for the Early Notification of Community-Based Epidemics (ESSENCE II). *J Urban Health*. 2004;80:I32–I42.
3. Lombardo JS, Burkom H, Pavlin J. ESSENCE II and the framework for evaluating syndromic surveillance systems. *Morbidity and Mortality Weekly Report* 2004;53(Suppl):159–165.

4. Kintz J, Gregos E, Atrubin D, Sanchez J. Syndromic Tracking and Reporting System: Overview and Example. *MMWR*. 2004;53(Suppl):246.
5. Hutwagner L, Thompson W, Seeman GM, Treadwell, T. The bioterrorism preparedness and response early aberration reporting system (EARS). *J Urban Health*. 2003;80:89–96.
6. Kristin B, Uhde C, Farrell Y, Geddie M, Leon J.C. Early detection of outbreaks using the BioDefend™ syndromic surveillance system, Florida, May 2002–July 2004. *MMWR*. 2005;54(Suppl):204.
7. Zaheer S, Winn S, Perry J, Minden V**.** Implementation of the BioDefend® syndromic surveillance system: electronic format versus Web-base data entry. ISDS Journal.org. http:// www.isdsjournal.org/article/viewFile/804/691. Accessed April 4, 2008.
8. Buehler JW, Hopkins RS, Overhage JM, Sosin DM, Tong V. Framework for evaluating public health surveillance systems for early detection of outbreaks: recommendations from the CDC working group. *MMWR*. 2004;53(RR-5).
9. Centers for Disease Control and Prevention. Updated guidelines for evaluating public health surveillance systems: recommendations from the guidelines working group. *MMWR*. 2001;50(RR-13).
10. Shaw WJ, Wang W, Rutz FC, Chapman EG, Rishel JP. *Meteorological Integration for the Biological Warning and Incident Characterization (BWIC) System: General Guidance for BWIC Cities*. Richland, WA: Pacific Northwest National Laboratory; 2007.
11. Shea D, Lister S. The BioWatch program: detection of bioterrorism. Federation of American Scientists Web site. http://www.fas.org/sgp/crs/terror/RL32152.html. Accessed April 3, 2008.
12. Yang L, Chumfong I, West T, Ammerlahn H, Yoshimura A. 2006. *Earlier detection in emergency response to an anthrax attack*. SAND2006-1740. Livermore, CA: Sandia National Laboratories. http://prod.sandia.gov/techlib/access-control.cgi/2006/061740.pdf. Accessed May 15, 2010.
13. *National Atmospheric Release Advisory Center (NARAC)*. Emergency response system: real-time operational models. NARAC Web site. https://narac.llnl.gov/modeling.html. Updated March 22, 2010.
14. National Research Council. *Tracking and Predicting the Atmospheric Dispersion of Hazardous Material Releases: Implications for Homeland Security*. National Academies Press Web site. http://www.nap.edu/openbook.php?record_id=10716&page=1. Accessed April 4, 2008.
15. Greene CM, Reehuis J, Tan C, Fiore AE, Goldstein S, Beach MJ, et al. Epidemiologic investigations of bioterrorism-related anthrax, New Jersey, 2001. *Emerg Infect Dis* 2002 Oct ;8. Available from: URL: http://www.cdc.gov/ncidod/EID/vol8no10/02-0329.htm. Accessed April 15, 2008.
16. Mann, E. Benefits of linking public health, animal health, and food safety surveillance. *Can Vet J*. 2002;43(10):796–7.
17. Stärk KDC, Regula G, Hernandez J, Knopf L, Fuchs K, Morris RS, and Davies P. Concepts for risk-based surveillance in the field of veterinary medicine and veterinary public health: review of current approaches. *BioMed Central Health Services Research*. 2006;6(20).
18. Rotz L, Hughes J. Advances in detecting and responding to threats from bioterrorism and emerging infectious disease. Nature.com. http://www.nature.com/nm/journal/v10/n12s/abs/nm1152.html. Accessed July 31, 2008.
19. Pavlin JA, Mostashari F, Kortepter MG, et al. Innovative surveillance methods for rapid detection of disease outbreaks and bioterrorism: results of an interagency workshop on health indicator surveillance. *Am J Public Health*. 2003;93:1230–5.

APPENDIX

Panel members present at the August 20–21, 2007, consultation: James Buehler, MD, Richard S. Hopkins, MD, Sa'ad Zaheer, MD MSPH, Sarah Winn, MPH, Theresa Isaac, RN, Guyon Zhang, MD MPH, Carina Blackmore, PhD, Aaron Kite-Powell, MPH, Ronald C. Burger, and Phil Lee, PhD, Iruvanti Sunitha, PhD, John Perry