Enhancing Public Health Disease Surveillance Capability: Exercising the National Capital Region Syndromic Surveillance Network

Rekha S. Holtry

Over the past decade, local, state, and national public health agencies in the United States have, to varying degrees, started using electronic disease surveillance systems. Some systems rely on traditional reporting mechanisms, but others use automatically generated electronic clinical and nonclinical health-indicator data to discern unusual disease patterns in the community. In many instances, such systems have provided valuable adjunct surveillance opportunities and established collaborations between public health practice and other public and private agencies. This article describes four simulated tabletop exercises of varying complexity conducted by using the National Capital Region Syndromic Surveillance Network. These exercises served as a tool for the public health agencies to test system capabilities and their own surveillance capacities under simulated health events, and they fostered vital interjurisdictional collaborations. The information gleaned from these exercises played a vital part in the continued refinement of the Electronic Surveillance System for the Early Notification of Community-based Epidemics (ESSENCE).

INTRODUCTION

Public health disease surveillance has a long history in the United States. Congressionally mandated health monitoring can be traced back to the late 1800s, when disease-specific information on representatives stationed abroad was collected in an effort to prevent any infections from spreading upon their return to the United States.[1] Today, public health disease surveillance includes a broad array of practices, such as sophisticated monitoring networks that collect data via several different techniques. These include systems that acquire data on state-mandated and nationally mandated specific "notifiable" diseases and large registries that collect information on particular chronic morbidities. In addition to these systems that collect information retrospectively on diseases classified by traditional

methods (usually confirmation of disease by laboratory methods or accepting certain patient presentations as fitting a "case definition" for a particular disease), new systems fueled by the urgency to strengthen public health preparedness after the terrorist events of September 2001 have begun to employ other innovative processes. Primarily, these systems use nonconfirmatory health or health-indicator data available in real time or near real time for monitoring community health patterns. This practice is commonly known as "syndromic" surveillance.[2]

Nontraditional disease surveillance technology or syndromic surveillance focuses on capturing illness presentations during the prodromal period. This period is marked by the beginning of subjective, nonspecific clinical symptoms. Assumptions are made that when these symptoms are present in particular populations in a characteristic fashion, over contiguous or epidemiologically important regions, within a given time, they may offer evidence to suggest the onset of an outbreak. To further enhance this form of surveillance, some systems also use nonclinical data as community-health indicators. Examples of nonclinical data include sales of over-the-counter (OTC) medications and school absenteeism records. Although these nontraditional data have been useful for identifying currently occurring community-health events, they are not known to be reliable for predicting future outbreaks. Those systems with advanced modeling and mapping capabilities have demonstrated some ability to show the magnitude and spread of disease and thereby attest to the impact of treatment and containment measures.[2]

As a result of the 11 September 2001 events, there have been multiple efforts by agencies at the federal, state, and local levels to enhance preparedness and response. For example, the Department of Justice and the Federal Emergency Management Agency were cosponsors of Exercise TOPOFF (Top Officials) 2000, which was held in May 2000 to assess the nation's crisis and consequence management capability.[3] Exercise TOPOFF was a multicomponent, multisite exercise incorporating command-post exercises, full-scale training exercises, tactical exercises, and several large-scale "subexercises."[3] The U.S. Department of Homeland Security's TOPOFF Exercises 2 and 3 in May 2003 and April 2005 were conducted to assess homeland security planning and to test national preparedness, respectively.[4]

In addition to these multiagency large-scale exercises, there have been other efforts (specifically by public health agencies) to enhance the *response* component at the federal, state, and local levels. These efforts have involved intense drills and exercises to gauge the public health response capability and logistics needed to get resources where they are needed. The goals of the exercises have been numerous and have included enhancing relationships among stakeholders,[5] training staff,[6] and evaluating preparedness levels.[7]

To respond appropriately and efficiently to health events in the community, public health agencies conduct routine disease surveillance. Disease surveillance is a critical component of the *preparedness* function of public health. In recent years, much effort had been expended in setting up sophisticated electronic disease surveillance systems that are designed to capture community-health events of public health significance in a timely manner while also providing situational awareness. In many regions in the United States, these systems are an integral part of disease surveillance practices and provide vital awareness capability. Although their use has become commonplace, there has been little effort to exercise the systems that employ largely nonconfirmatory data. Many users of electronic disease surveillance systems had recognized the need for such exercises: They could assist with estimating variability in data performance during an outbreak; system presentation during that event; system-user behavior before, during, and after the event; and best follow-up processes. This need was recognized by the disease surveillance technology development team at APL, who, with the collaborative efforts of the local and state health departments in Maryland, Virginia, and the District of Columbia, implemented the fully operational National Capital Region (NCR) Syndromic Surveillance Network. The network consists of independent surveillance systems within the state health departments in Maryland, the District of Columbia, and Virginia. These systems collect data, process and present results on their own state populations, and share data with a common node that covers the NCR. Fig. 1 provides an illustration of this network. As a result of this need, since the network's inception in 2004, the team has designed, coordinated, and executed multiple cross-regional public health disease surveillance simulation exercises. For the purposes of these exercises, the NCR Syndromic Surveillance Network was replicated electronically at APL. State users who would normally log into their own state site logged into the equivalent simulation site containing synthetic data with background diseases and one or more outbreaks as the signal to be discovered.

This article describes the series of four tabletop simulation exercises that served as tools for refining public health disease surveillance in the NCR. The exercises are of increasing sophistication, eventually placing the participants within their own environment and resources to collaborate on identifying and responding to public health threats.

SIMULATION EXERCISE I, WINTER 2004: TESTING THE BASIC SYSTEM CAPABILITIES AND CAPABILITIES UTILIZATION

Background

By December of 2004, the NCR Syndromic Surveillance Network had been operational for only 1 month.

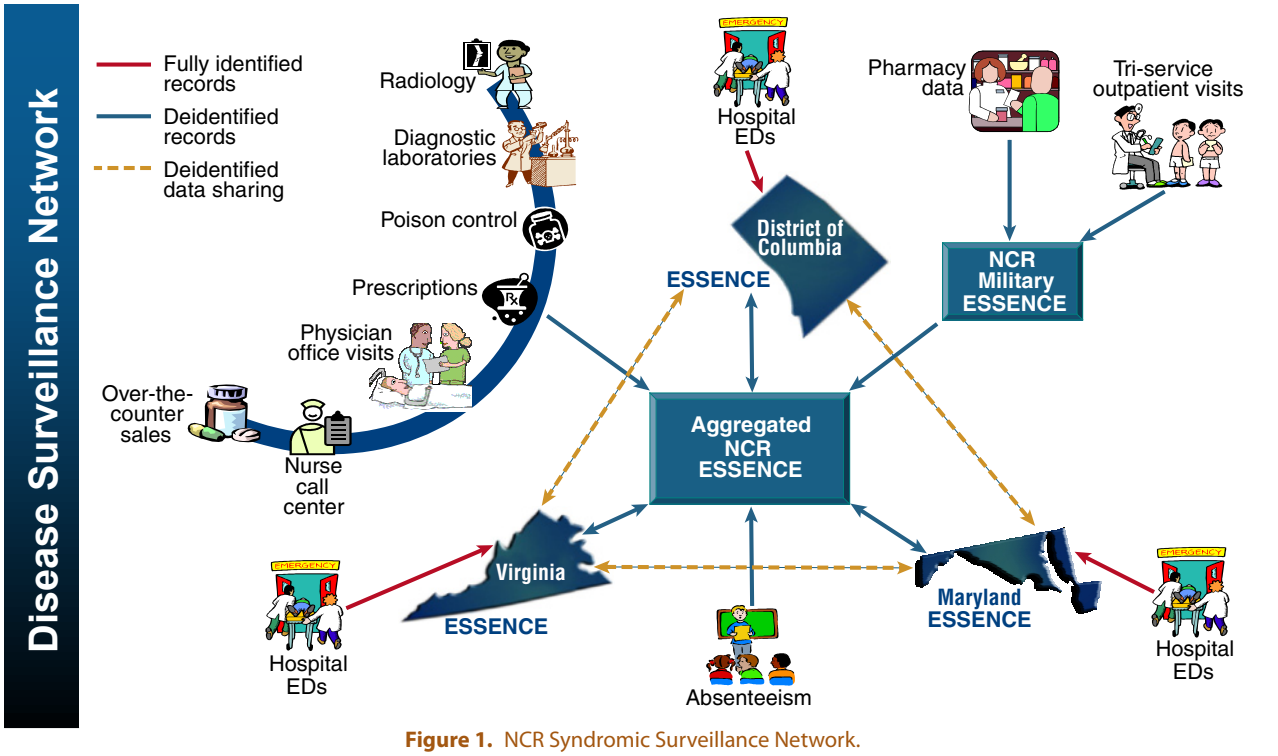

Figure 1. NCR Syndromic Surveillance Network.

Area public health users were becoming familiar with the system and how best to navigate through the large quantities of data by using some of the basic capabilities of the Electronic Surveillance System for the Early Notification of Community-based Epidemics (ESSENCE), such as statistical alerting, querying, and data-displaying features. The goals of this early exercise were modest. The team at APL designed the first tabletop exercise (TTX) to engage public health practitioners in finding unusual syndromic manifestations embedded within seasonal disease presentations and to get them accustomed to interacting with one another by communicating findings as seen in the ESSENCE system.

Scope

Because of the introductory nature of this exercise, the scope was intentionally narrow and limited to obtaining users' assessments of system utility for facilitating outbreak investigations. The number of participants was limited to the members of the Enhanced Surveillance Operating Group (ESOG), whose membership includes public health representatives from each of the NCR jurisdictions. This group was appointed at the origination of the NCR Syndromic Surveillance Network project to provide guidance on policy affecting system development and input on issues pertaining to system maintenance and enhancements.

Scenario Description

The scenario involved injecting a predetermined number of simulated ill patients showing early- to late-stage symptoms into background data. The proportion of injects was based on estimates per the attack rate of the agent, exposure estimates, and NCR population distribution and demographics factors. To make this exercise realistic, injects were introduced to partially simulated, demographically and seasonally accurate background data. The infective organism for this exercise was *Bacillus anthracis*, the causative agent for pneumonic anthrax. As evidenced in published literature about disease presentation in actual cases infected with this agent, simulated patients presented to emergency departments (EDs) in three counties in Maryland and Virginia with varying degrees of early- and late-stage respiratory signs and symptoms. Because of the natural fluctuation of seasonal respiratory illness from one year to the next, the APL team recognized that users would have to be vigilant to identify unusual variations in counts and atypical respiratory ailments among usual presentations.

During the exercise, features such as the time series, stacked bar graphs, sortable data details tables, custom chief complaints query tool, and mapping features were used to identify the unusual proportions of patients suffering from respiratory illness and unspecified infections. Some regional epidemiologists observed disproportionate distribution of cases by age group and others were able to recognize clusters of like disease characteristics occurring in particular areas.

The physical location of the exercise was artificial in that it was at a central point, and all the participants were gathered in a single room. Although customary

interjurisdictional communications were encouraged, atypical discussions made possible by the artificial setting were discouraged.

Postexercise Discussion and Highlights

During the postexercise discussion period, several participants commented that they were overwhelmed by the number of statistical alerts. This posed some concern because not all statistical anomalies represented an event of public health importance. Additionally, by default, the system computed statistical anomalies by county or by subregion level and presented them to users in tables.

Clearly, the need to present statistical aberrations at a less granular state/district level was identified. Users felt strongly enough in favor of this "aggregated" view that they were willing to forfeit sensitivity and granularity. Additionally, the discussion brought to light the fact that, during investigations requiring interjurisdictional communications, public health personnel primarily communicated with each other by email, phone, and fax. This highlighted the need for an internal communications tool to enable users to communicate findings from their investigations within the network with other users in a secure environment. This capability also had the potential to make their investigative process more efficient and minimize redundancy, especially in situations where outbreaks spanned across jurisdictional boundaries.

Plans for System Enhancements Based on User Feedback

After the exercise, the APL team began discussions on how to develop features for aggregated state-level/district-level alerting with minimal dilution of information and how best to develop an intersystem communications tool that allowed users to communicate inter- and intrajurisdictionally in a secure environment.

SIMULATION EXERCISE II, SPRING 2005: EXPANDING SCALE TO DEMONSTRATE APPLICABILITY AND REINFORCING PARTNERSHIPS

Background

As mentioned above, the first NCR Syndromic Surveillance Network simulation exercise was small in scale. It was a preliminary exercise to understand the usefulness of basic system features available to public health officials in the event of an outbreak. For the spring TTX, the decision was made, with unanimous approval by the ESOG, to conduct a larger-scale exercise that included not only ESOG members but also all ESSENCE users as well as participants in the NCR. Additionally, external participants were invited to be exercise observers. These participants included representatives from local, state, and federal emergency management agencies; the Office of the Capitol Hill Attending Physician; the State Offices of Homeland Security; and the U.S. Department of Homeland Security.

Scope

The purpose of the spring 2005 TTX was to demonstrate enhanced surveillance investigative methods that would be used if a disease outbreak resulted from a covert biological warfare agent release. The goals entailed the following: (*i*) demonstrating the application of ESSENCE within the NCR; (*ii*) reinforcing existing partnerships for an integrated response, including strengthening communications between NCR public health jurisdictions; (*iii*) familiarizing jurisdictional leaders with the ways in which public health officials used ESSENCE for timely detection and monitoring of health events of public health importance; (*iv*) identifying areas for improvement and enhancement within the system architecture; and (*v*) identifying specific education and training needs of participants.

The scale of this exercise in terms of participants was larger, and the scenario, design, and TTX facilities were tailored to promote inter- and intraregional communications typical during real-life investigations. Furthermore, effort was made to minimize the artificial in-person communications between jurisdictions that was observed in the previous exercise. Finally, the decision to include non-public health observers further expanded the scope by necessitating that a complete replica of the NCR Syndromic Surveillance Network consisting of only synthesized patient data be built for both case injects and background. However, it is necessary to point out that, although observers were an important part of this exercise, the focus remained solely on the advancement of public health disease surveillance capabilities. At the outset, the exercise developers and participants fully appreciated and acknowledged that in the event of a real act of bioterrorism, many authorities other than those simulated within this TTX would be involved in the investigative and response processes.

Scenario Description

The synthetic scenario consisted of an intentional release of aerosolized tularemia at a baseball stadium in Washington, DC. The date and time of the release coincided with a baseball game, and the agent was dispersed throughout the evening through the ventilation system located inside the men's restroom serving the predominantly affluent diamond and infield box-seat patrons. Within 2 days of the dissemination, the first of many victims began to purchase OTC medications at local pharmacies and seek care at hospital emergency rooms and military treatment facilities. These "patients" were complaining of fever/chills, nonproductive cough,

headache, sore throat, malaise, fatigue, and muscle aches; eye irritation and painful pink eye were also present in a small percentage of patients.

Given the scenario, ~4500 people were estimated to develop symptomatic infection within 10 days from release with the average incubation being 3–5 days. By using probabilistic methods, these 4500 victims were defined with respect to person, place, and time. Also by using probabilistic methods, the health behavior of the 4500 victims were presented within ED, OTC, and military data sources. Approximately 2.5 million records were created as background data for the respective data sources and were made representative of typical demographic distributions and expected seasonal disease patterns; the simulated disease-related injects for the 4500 victims were inserted into baseline data streams. The mock scenario was set up so that the simulation unfolded day by day. To depict events that would normally occur over an extended period of time within a 6-hour period, the exercise was conducted in compressed time. Exercise days ranged in length from 15 to 45 minutes or as directed by the moderator of the exercise. Although the TTX was held at a central location, each of the jurisdictions was housed in a separate classroom to simulate their geographical separation. Each room was assigned a facilitator who was responsible for managing the exercise play by providing event-related findings that would typically be available to public health investigators via media and other agencies. These event-related findings, taken from the Master Scenario Event List (MSEL), a carefully timed and coordinated listing of planned exercise events, were delivered as voice and paper injects to the participants.[8]

With each unfolding day, the participants conducted reviews of the simulated data in the mock NCR Syndromic Surveillance Network, which was built for this exercise, in the same manner that they would in their live systems. Participants made use of enhanced system features present in both mock and live ESSENCE systems. One of these was a "critical" enhancement per the feedback gathered from the first exercise, the "summary alert list," which provided a view of state-level/district-level alerts in a snapshot and additionally allowed users to easily identify patterns in data across stratifications/data sources (Fig. 2).

Postexercise Discussion and Highlights

Many participants reported that the exercise demonstrated that using the alerting capabilities of ESSENCE may help with providing an early signal of a problem.

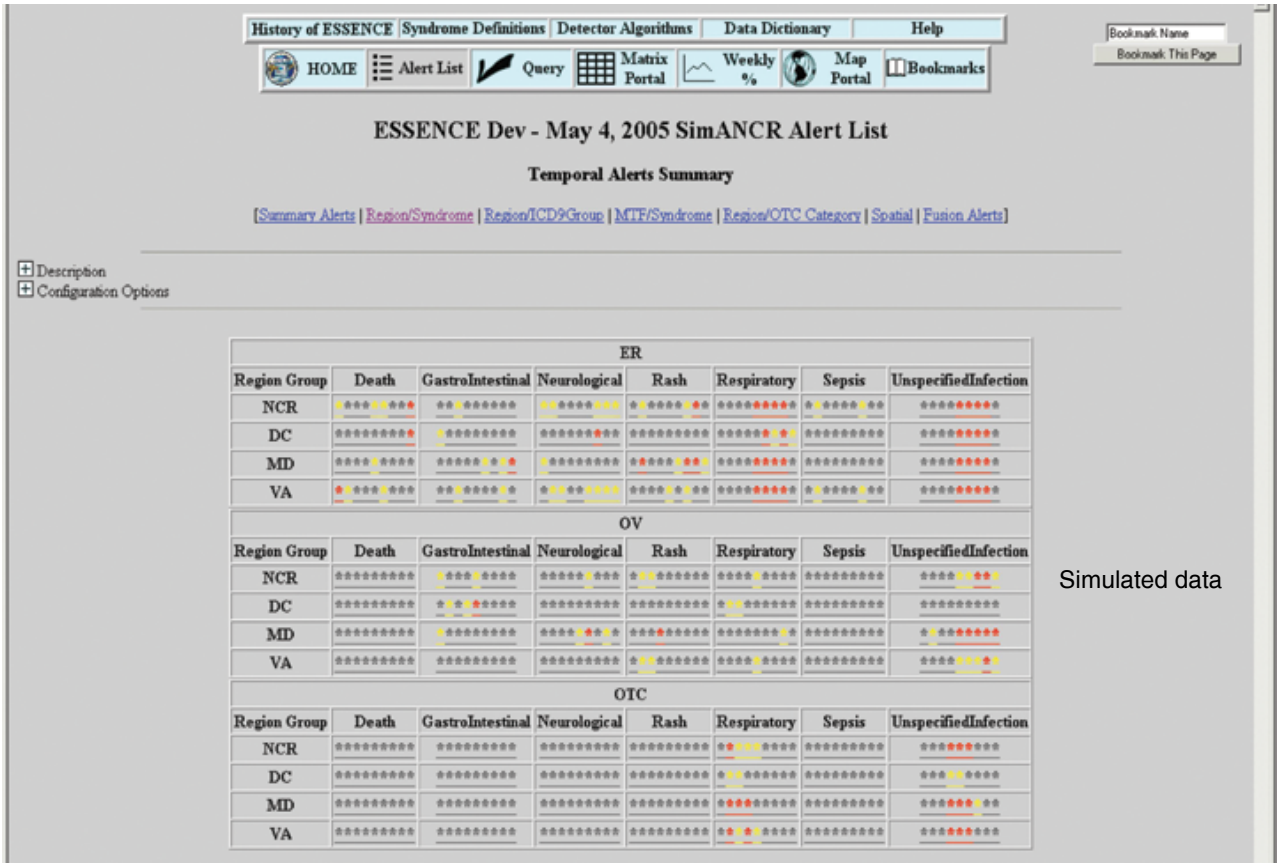

Figure 2. NCR Syndromic Surveillance Network summary alert list.

The newly incorporated summary alert list was well received; several participants commented positively on the feature, which improved system capabilities by making it possible to look at data from a regional standpoint and but still grasp the "big picture." The simulated inputs from traditional surveillance sources highlighted that ESSENCE served well as an adjunct tool for public health disease surveillance. Observers and participants agreed that syndromic presentations in the community can be used to gauge the presence of illnesses of public health importance. Furthermore, several believed that its use may be expanded to judge the effectiveness of public health response and or interventions. Generally, most participants agreed that the exercise showed sound regional communication between the participating jurisdictions. Additionally, ESSENCE provided detailed information to identify issues needing further examination, which helped with developing a case definition for the disease and focusing the investigative process. For instance, the advanced filtering capability allowed investigators to correctly recognize that males were the target gender early in the scenario.[8] In addition to the above points, opportunities for improvement with regard to enhancing communications capabilities were discussed. Several participants suggested the benefit of removing the artificiality of a central location for the exercise by allowing participants to work from their own offices, which would match a real-life situation. The need for an interjurisdictional alert response protocol was identified; this protocol would provide investigators with some guidance on the basic procedures to be followed to determine whether further investigation, follow-up, or interjurisdictional communications are warranted when a statistical alert is seen. As with previous exercises, the need for an internal communications system to be built so that users within the network could communicate findings from their investigations with other users in a secure environment was made evident. Also, the need for additional training material, perhaps material that can be embedded within the system, was discussed.

Plans for System Enhancements Based on User Feedback

User feedback after the exercise guided the APL software team efforts in further refining the newly prototyped Event Communications Component (ECC).[9] The ECC is a tool that not only allowed users to communicate inter- and intrajurisdictionally in a secure environment but also allowed developers to gather useful information about the alert-investigation process. The plans were laid out for building both in-line help manuals and help movies. The APL ESSENCE team epidemiologists brainstormed to develop an alert-response protocol and establish a working group that included public health representatives from each of the jurisdictions to assist with the process.

SIMULATION EXERCISE III, SPRING 2006: EVENT COMMUNICATIONS AND INTERREGIONAL PROTOCOLS

Background

By the spring of 2006, many of the NCR users were becoming proficient in conducting ESSENCE-based surveillance. On the basis of ongoing user feedback and comments received after the second exercise, several functionality enhancements and new features were added to the NCR Syndromic Surveillance Network. To ensure that the users were oriented appropriately to these features, multiple in-person and remote web-based training sessions were held.

Scope

The primary goal of the spring 2006 simulation exercise was to focus on a communication feature that was built in response to a high-priority need underscored during the first two exercises. This feature, referred to as the ECC, allowed users to create, discuss, track, and review user-defined events. The principal goal of this exercise was to test the application and usability of this new feature in a simulation. Also new was the method by which this exercise was to be conducted. Instead of inviting participants to gather at a centralized location, the plan was to replicate normal working conditions as closely as possible by building an NCR Syndromic Surveillance Network simulation site that would be accessed remotely via the Internet from each participant's desktop. The goals of the exercise included the following: (*i*) demonstrating the application of the ECC in the ESSENCE during a simulated event; (*ii*) identifying technical shortfalls of, or areas of improvement for, the ECC; (*iii*) identifying policy or procedural needs to enhance collaboration and communication between the health department and jurisdictions in the NCR; and (*iv*) recognizing training needs.[10]

Scenario Description

The simulated scenario consisted of the early stages of a large hepatitis A outbreak affecting target populations residing in select counties of the NCR. The setting was modeled after the largest known hepatitis A outbreak in the United States in 2003, when a restaurant served contaminated green onions, causing more than 650 confirmed cases of hepatitis A around the Commonwealth of Pennsylvania. During that event, more than 9000 people who had eaten at that restaurant received postexposure prophylaxis.[11]

For the ESSENCE spring 2006 exercise, a fictitious catering business provided buffet and family-style meals, exposing ~1000 people ranging in age from 12 to 53 years who attended multiple simulated gatherings. Approximately 3 weeks later, the first of several people attending the get-togethers began experiencing symptoms ranging

from nausea and vomiting to loss of appetite, malaise, diarrhea, fever, and abdominal pain, followed by dark urine and jaundice. During the exercise, 267 infected cases appeared in the ESSENCE simulated system.

To enhance realism, the exercise was designed to allow epidemiologists to participate remotely from their state or local offices by accessing the ESSENCE exercise web site (Fig. 3).[10] Because system users were participating in the exercise from their work locations, an exercise control cell was stationed at a central location and equipped with telephone lines to provide participants with a means to simulate communications with appropriate external agencies.

As public health participants logged on to the simulated ESSENCE site each day, it allowed them to use the capabilities of the system to demonstrate their skills for identifying a potential disease outbreak. Throughout the exercise, participants communicated their findings with other users in remote locations by using the ECC (Fig. 4).

Plans for System Enhancements Based on User Feedback

It was clear that the ECC served a need within enhanced public health disease surveillance; however, it was evident that multiple modifications were necessary to maximize its value. The ESSENCE team discussed how to prioritize modifications on the basis of the feedback received from the users. The suggestions included altering editing capabilities, facilitating intersystem communications, and making multiple changes to the ECC display screens.

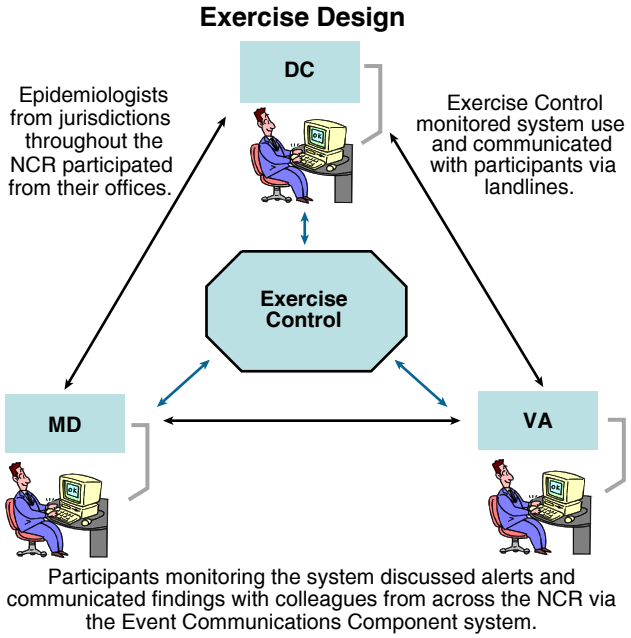

Figure 3. Design of NCR Syndromic Surveillance Network Simulation Exercise III, Spring 2006.

SIMULATION EXERCISE IV, FALL 2006: PANDEMIC FLU PREPAREDNESS

Background

With the spread of avian influenza to many parts of the world and with human cases being reported in some countries, given proper conditions for human-to-human transmission, the threat of an outbreak of pandemic proportions is very much a possibility. From the ongoing discussions with the ESOG and the public health community, the APL team decided that the fourth ESSENCE exercise should test system use during a pandemic flu outbreak simulation. During the planning stages, the team learned of a multiagency, large-scale, NCR-wide, pandemic flu preparedness effort to test public health and other agencies' response capabilities, resource availability, and distribution capacities. When the opportunity was presented to work collaboratively with those organizing the larger-scale exercise, the APL team drafted a potential scenario that tied the ESSENCE surveillance component to the larger exercise and proposed it to the planners. After several meetings with the planners of the response/resource-focused exercise, the role of the NCR Syndromic Surveillance Network within this larger-scale exercise was determined and finalized.

Scope

As mentioned, the objectives of the larger-scale pandemic flu exercise were focused on multiagency response and resource distribution plans. As such, the APL team, the health department representatives, and other agency representatives believed the best and most realistic role for the NCR Syndromic Surveillance Network to play would be to serve as the segue to the larger-scale exercise. Accordingly, the Enhanced Disease Surveillance TTX would simulate the localized spread in the first few days after initial exposure and generalized spread to adjoining regions in the subsequent days. Consequently, the larger-scale exercise occurring several days after the ESSENCE exercise would deal appropriately with multiregional response and resource issues. Using this method, the exercise planners were able to keep the objectives of the two exercises separate, yet at the same time make them relevant for all parties involved.

The goals of this exercise for the NCR Syndromic Surveillance Network included the following: (*i*) understanding how participants identified a potential and/or real simulated disease outbreak(s) occurring in the NCR and (*ii*) noting how users communicated findings to appropriate partners throughout the NCR to identify events at the earliest possible time in the scenario.

After the third exercise, ESSENCE team epidemiologists, in collaboration with the NCR jurisdictions, had developed a draft NCR syndromic surveillance anomaly response framework. Both the APL team and the ESOG

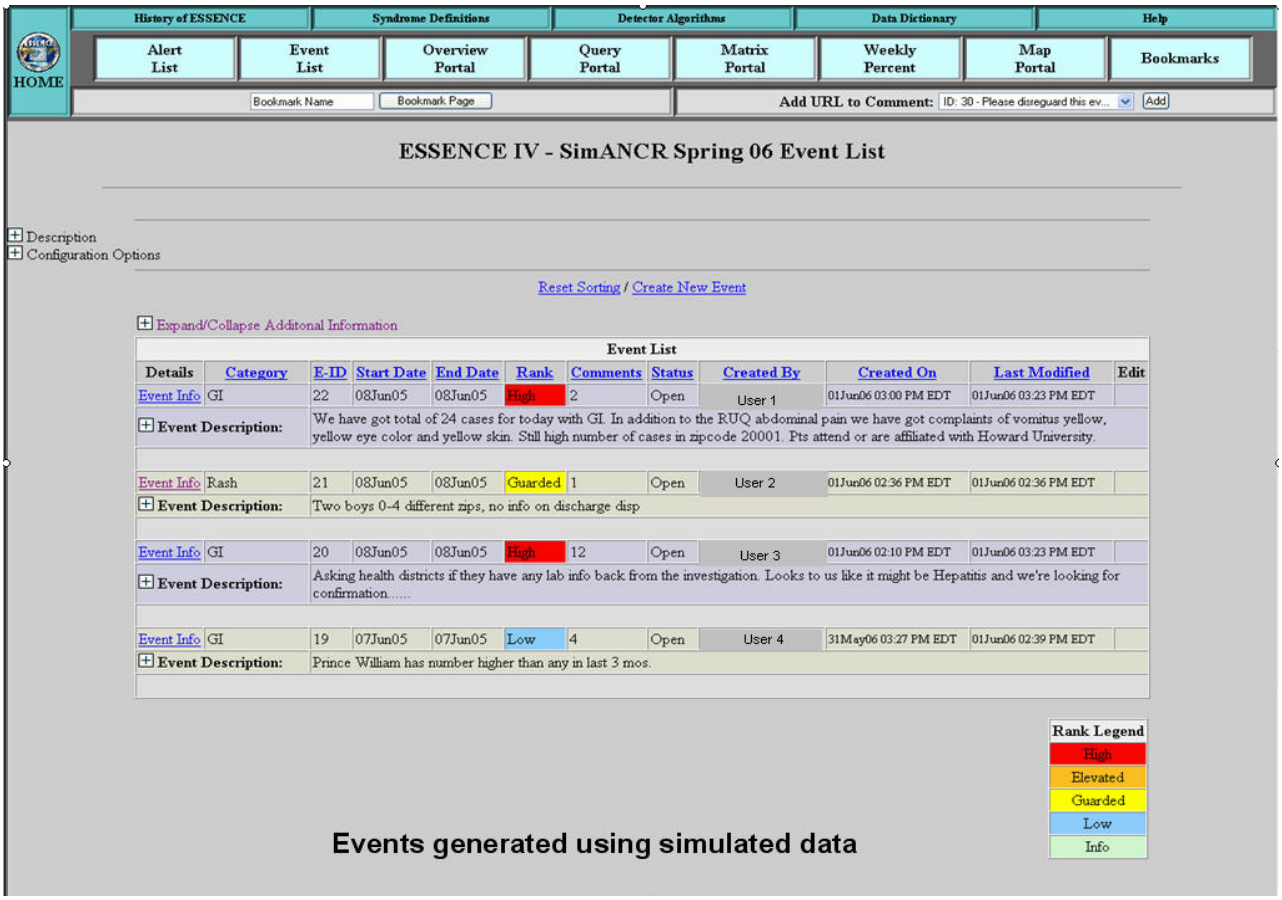

Figure 4. NCR Syndromic Surveillance Network Simulation Exercise III event list (created by participants using ECC).

believed that this would be an ideal opportunity to test the applicability of that framework. As such, the following goal was added: (*iii*) observing the use of the draft NCR ESSENCE anomaly response framework by NCR jurisdictions to note applicability and usefulness.

Scenario Description

As with Simulation Exercise III, to enhance realism, this exercise's design allowed epidemiologists to participate remotely from their work locations. Again, an exercise control cell was stationed at a central location and equipped with telephone lines to provide participants with a means to simulate communications with appropriate external agencies (Fig. 3).[10]

Before the start of the simulation exercise, participants were provided with the background scenario described below. Although it was generally known that pandemic flu cases had been reported in several Far East Asian countries and in Europe, thus far, there were no cases reported in the United States. Participants were aware that appropriate World Health Organization warnings were in place and that the United States was taking measures to prevent the spread into the country.

The scenario involved a 26-year-old man who flew into a Washington, DC, airport from Vietnam after being infected with the pandemic flu virus. Feeling well, he had avoided quarantine. His family threw a party for him at their home with more than 40 family members present; he attended, although he felt unwell.

Although several infected cases of pandemic flu from those exposed at the party were reported to area hospitals, they were hidden among the "worried well" (patients uninfected but concerned that they may be infected with the pandemic flu virus). The number of worried well increased daily because of media announcements of pandemic flu cases spreading through other parts of the world. Homogenously scattered but sustained numbers of worried patients were simulated in all the ESSENCE data streams. As is typical with the worried well, their complaints were primarily anxiety-related. After several days, however, the number of actual pandemic flu cases spreading through the community grew and were captured on ESSENCE, presenting with disease-typical signs and symptoms.

As public health participants logged on to the simulated ESSENCE site each day, they had to use many of the ESSENCE capabilities to scan through the large and unusual number of worried patients coming to local EDs, first to determine that they were indeed worried but well and second to rule out the possibility that any

real diseases may be present in them. Although some of the ESSENCE capabilities had been in place for a while, others, such as the patient-level data-details breakdown with subsyndrome-level query capability, the bookmarking feature, and the detector explanation, had been recent improvements to the NCR Syndromic Surveillance Network. As with previous exercises, participants were able to use the capabilities of the system to demonstrate their skills and identify that there were indeed cases of what appeared to be pandemic influenza hidden among the worried well. The users communicated their findings with other users in remote locations by using the ECC and other methods. When applicable, participants used the NCR ESSENCE anomaly response framework for guidance in following up on particular statistical alerts and for contacting others in local and/or adjoining regions.

Plans for System Enhancements Based on User Feedback

On the basis of the participants' responses during and after the exercise, the APL team determined that there were still several enhancements that needed to be made to the ECC to improve communications between network users. These enhancements were each discussed in detail at ESOG meetings, and potential modifications were presented in mock-up form for feedback. Furthermore, the need was identified for enhanced spatial detection capabilities, including algorithm enhancements, and plans were made for specific algorithm enhancements. Exercise participants indicated the response framework in its draft state served a useful function, but it would require additional modifications, such as listing the actual contact persons with contact information for each of the jurisdictions. The epidemiologists planned to rework the draft framework to include these requirements.

CONCLUSION

The ESSENCE development team at APL and the public health jurisdictions in the NCR realized that there was a vital need for conducting simulated outbreak exercises. Such exercises would help with recognizing system needs and understanding actual methodologies employed by users and would promote interuser communications throughout investigations and during follow-up. In response, over the course of 2 years, in four separate exercises, members of the ESSENCE team created synthetic disease surveillance sites resembling actual NCR syndromic surveillance sites and injected four carefully crafted simulated outbreaks. Each of the simulation exercises was successfully executed, and the goals for each were accomplished. From the wealth of knowledge gathered from these TTXs highlighting critical system functionality needs, it was clear that these exercises played an important role in system development. As enhancements were made to system functionality, these exercises allowed developers to observe their impact on users' surveillance capabilities in real time. Beyond accenting system needs, it was clear that these exercises served as tools by which public health practitioners could judge their skills at conducting epidemiological investigations using syndromic data. Finally, because the exercises required participants to engage in cross-regional discussions to move through the investigational process, they provided a valuable forum for enhancing intra- and inter-jurisdictional communications and collaborations. For all of these reasons, simulation exercises will continue to be a critical component of APL-developed enhanced disease surveillance systems.

ACKNOWLEDGMENTS: These exercises could not have been conducted without the expertise and support of the following APL NCR Syndromic Surveillance Simulation Exercise Team Members: Raj J. Ashar, Logan K. Hauenstein, Wayne A. Loschen, Nathaniel Tabernero, and Richard A. Wojcik (software development); Howard S. Burkom and Sean P. Murphy (mathematical modeling); Steven M. Babin, Jacqueline S. Coberly, Protagoras N. Cutchis, Brian H. Feighner, Rekha S. Holtry, Sheri Happel Lewis, and Marty L. Sikes (disease surveillance, epidemiology, medicine, and public health); Joseph S. Lombardo (program management); and Sheri Happel Lewis (project management). The ESSENCE team wishes to acknowledge the following agencies for their support of the NCR Syndromic Surveillance Network and for making these exercises possible: the Maryland Department of Health and Mental Hygiene; Departments of Health of Montgomery and Prince George's counties, Maryland; the Virginia Department of Health; the Departments of Health of Loudoun, Fairfax, Fauquier, Prince William, and Arlington counties, Virginia; the District of Columbia Department of Health; the State Offices of Homeland Security; and the U.S. Department of Homeland Security. This article was prepared under a grant from the Office of State and Local Government Coordination and Preparedness (SLGCP), U.S. Department of Homeland Security. Points of view or opinions expressed in this article are those of the author and do not necessarily represent the official position or policies of the SLGCP or the U.S. Department of Homeland Security.

REFERENCES

[1]Centers for Disease Control and Prevention, "Notifiable Disease Surveillance and Notifiable Disease Statistics—United States, June 1946 and June 1996," *MMWR Morb. Mortal. Wkly. Rep.* **45**(25), 530–536 (1996).

[2]Babin, S., Magruder, S., Hakre, S., Coberly, J., and Lombardo, J., "Understanding the Data: Health Indicators in Disease Surveillance," Chap. 2, in *Disease Surveillance: A Public Health Informatics Approach*, J. S. Lombardo and D. L. Buckeridge (eds.), John Wiley & Sons, Inc., Hoboken, NJ, pp. 43–90 (2007).

[3]The National Response Team, U.S. Department of Homeland Security, *Exercise TOPOFF 2000 and National Capital Region (NCR) After-Action Report*, Final Report (August 2001).

[4]U.S. Department of Homeland Security, *TOPOFF Exercise Series Fact Sheet*, http://www.dhs.gov/xprepresp/training/gc_1192227908698.shtm (accessed 3 Jan 2008).
[5]Richter, J., Livet, M., Stewart, J., Feigley, C. E., Scott, G., and Richter, D. L. "Coastal Terrorism: Using Tabletop Discussions to Enhance Coastal Community Infrastructure Through Relationship Building," *J. Public Health Manag. Pract.* **11**(6), S45–S49 (Suppl.) (2005).
[6]Quiram, B. J., Carpender, K., and Pennel, C., "The Texas Training Initiative for Emergency Response (T-TIER): An Effective Learning Strategy to Prepare the Broader Audience of Health Professionals," *J. Public Health Manag. Pract.* **11**(6), S83–S89 (Suppl.) (2005).
[7]Sarpy, S., Warren, C. R., Kaplan, S., Bradley, J., and Howe, R., "Simulating Public Health Response to a Severe Acute Respiratory Syndrome (SARS) Event: A Comprehensive and Systematic Approach to Designing, Implementing, and Evaluating a Tabletop Exercise," *J. Public Health Manag. Pract.* **11**(6), S75–S82 (Suppl.) (2005).
[8]Sikes, M. L., *April 27 NCR Exercise Report*, JHU/APL Memo STJ-05-075 (May 2005).
[9]Tabernero, N., Loschen, L., Coberly, J., Sniegoski, C., Holtry, R., Sikes, M., and Happel Lewis, S., "Enhancing Event Communication in Disease Surveillance: ECC 2.0," *Adv. Dis. Surveill.* **4,** 197 (2007).
[10]Sikes, M. L., *National Capital Region's ESSENCE Spring 2006 Exercise After Action Report*, JHU/APL Memo STJ-06-033 (2006).
[11]Centers for Disease Control and Prevention, "Hepatitis A Outbreak Associated with Green Onions at a Restaurant—Monaca, Pennsylvania, 2003," *MMWR Morb. Mortal. Wkly. Rep.* **52**(47), 1155–1157 (2003).

The Author

Rekha S. Holtry joined APL in 2004. She received her B.S. from Columbia Union College in 1998 and M.P.H. from George Washington University School of Public Health in 2002. Ms. Holtry has expertise in identifying and characterizing health-indicator data and interacting with data providers in both private and public agencies. Before joining APL, she worked as an epidemiologist at the Maryland Department of Health and Mental Hygiene, conducting foodborne disease surveillance in the Emerging Infectious Diseases branch. Currently, she is project leader of the National Capital Region ESSENCE Project, ensuring that the evolving needs of the public health user community are correctly defined, developed, implemented, and integrated into the operational ESSENCE system. Her email address is rekha.holtry@jhuapl.edu.

Rekha S. Holtry